

Development of a Self-Learning Mathematics Module for Primary Teachers in Schools Under the Royal Education Fund Project in Thailand

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ABSTRACT

Background and Objectives: Rural schools in Thailand, particularly those under the Royal Education Fund Project, face significant challenges that hinder academic performance, including resource shortages, limited teaching support, and low student engagement. Despite these critical issues, such schools have been largely under-researched and lack targeted developmental interventions. This study aims to address these needs by developing and implementing a self-learning mathematics module. The initiative's primary objectives are twofold: first, to improve students' mathematics performance by actively engaging them and fostering their interest in the subject; and second, to reduce teachers' workloads by shifting their roles from traditional instructors to facilitators, thereby creating a more supportive and effective educational environment.

Methodology: This research employed a two-phase research and development approach based on the ADDIE model. In the first phase, a self-learning module was designed and piloted with students from five schools in Nakhon Pathom, selected through a two-stage sampling process. The second phase employed a one-group pre-test and post-test, involving 465 students and 18 teachers from seven Royal Education Fund Project schools in Suphan Buri, selected through a multi-stage sampling process. Student performance was then analyzed using paired-sample t-tests, while teacher satisfaction was assessed with descriptive statistics.

Main Results: The findings indicate the following: (1) students' mathematics scores improved significantly across all grades after the intervention; (2) students' mathematics scores in grade 4 were the only ones that did not meet the established criterion of 70; and (3) teachers' satisfaction with the self-learning mathematics modules was rated the highest.

Discussions: This study demonstrates the positive impact of the self-learning mathematics module on both student academic performance and teacher satisfaction in Royal Education Fund schools. The module's success stemmed from its thoughtful design, which aligned with the national curriculum and incorporated engaging, interactive activities. This approach was crucial for improving student scores and fostering a positive classroom atmosphere. The findings confirmed that Grades 3, 5, and 6 met the performance benchmark, highlighting the module's effectiveness. Furthermore, the module makes a unique contribution by serving as a low-tech, practical solution to persistent

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issues, such as multi-grade classrooms and teacher shortages. However, a key limitation was the lower performance of Grade 4 students. This is likely due to language barriers, as their module focused on word problems that require a strong comprehension of the Thai language, a challenge for students from diverse linguistic backgrounds in the study area.

Conclusions: The self-learning mathematics module has demonstrated significant potential as a practical and powerful tool for enhancing primary education in resource-limited environments. To ensure its continued effectiveness and broader adoption, future research should use pilot schools that share a similar context with the target demographic and adapt language-heavy content. For this initiative to achieve its full potential, the establishment of a dedicated fund for module development, the creation of a free and accessible online repository, and the provision of robust professional training for teachers are recommended. By supporting these efforts, the module can become a sustainable solution for bridging the educational gap in underserved communities.

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Introduction

The National Education Plan of Thailand emphasizes the development of learners' 21st-century skills, with a focus on foundational literacies—the 3Rs (reading, writing, and arithmetic) alongside the 8Cs (Office of the Education Council, 2017A). However, Thailand's education system continues to struggle with maintaining consistent quality and standards. The decline in student performance is particularly evident in mathematics. According to the 2022 Program for International Student Assessment (PISA), Thai students' scores dropped from 419 in 2018 to 394 in 2022, marking a 25-point decrease and the lowest score in two decades. This trend widens the performance gap with the Organisation for Economic Co-operation and Development (OECD) average and has resulted in a significant increase in the proportion of students scoring below the minimum proficiency level. This decline stands in stark contrast to Thailand's 20-year education goal, which aims for more than 75% of 15-year-old students to achieve PISA scores at or above Level 2, comparable to their peers in OECD nations (Thongmeensuk et al., 2022). The issue is further highlighted by the 2024 National Basic Education Test (O-NET) results, which consistently show low average scores, particularly in mathematics, where they have remained at or below 30%. These results also reveal persistent disparities in student learning outcomes between urban and rural schools (National Institute of Educational Testing Service, 2023). Rural schools in Thailand primarily face challenges in accessing resources, limited teaching support, and lower levels of student engagement, all of which contribute to their lower performance compared to urban schools. These challenges led to the establishment of the Royal Education Fund Project schools by King Bhumibol, who was determined to donate His Majesty's funds to the educational sector, aiming to cultivate good citizens for the country. The project's primary goal is to establish schools in remote or disaster-prone regions, providing more significant opportunities for children in rural areas while fostering their educational and moral development. Currently, 143 schools and 12 vocational colleges across 35 provinces are under the Royal Education Fund Project.

Although the number of schools under the project has increased, there is little clear evidence to show satisfactory learning outcomes. Numerous studies have revealed that these schools face issues such as insufficient teachers or the unavailability of teachers on a full-time basis, as many teachers have additional responsibilities beyond their teaching duties. Most teachers in Royal Education Fund Project schools also face the challenge of teaching subjects outside their area of specialization. Furthermore, there is a shortage of teaching materials and learning resources, which hampers effective teaching management. These challenges contribute to ineffective learning environments, preventing students from reaching their full learning potential and resulting in low academic performance in these schools.

Given these limitations, cultivating self-learning skills is especially vital for students in under-resourced schools. Independent learning enables students to strengthen their educational experiences despite obstacles such as teacher shortages, curriculum misalignment, and insufficient resources. Humanistic learning theory posits that individuals possess an inherent motivation to learn and achieve personal growth; when this drive is constrained by external factors—such as overburdened teachers or limited institutional support—it results in a significant loss of learning potential. Consequently, developing learning tools or modules that foster self-directed learning can empower students to take greater ownership of their education. Consistent with Knowles' theory of self-directed learning, such an approach enhances student engagement by granting learners autonomy to explore and construct knowledge independently. This aligns with the principles of constructivism, which emphasizes active knowledge construction through experience, and Vygotsky's social constructivist perspective, which highlights the importance of guided interaction and scaffolding to support learners' progression toward independent mastery (Iamchan et al., 2023; Kachai et al., 2023; Srinaphom & Phorntaweekul, 2023). Numerous studies have shown that self-learning significantly enhances students' sense of responsibility and improves their self-regulation skills (Parnpheuk, 2017). Students who engage in self-directed learning tend to set more challenging goals and demonstrate greater resilience (Tanawanit, 2006; Jing et al., 2017). As a result, those who cultivate this skill have the potential to enhance their overall academic performance and foster a lifelong learning mindset.

A self-learning module was chosen to address the students' needs as an effective tool for promoting independent learning. The module enables students to study independently, regardless of external constraints, and provides a structured approach to self-guided learning. Research has consistently shown that self-learning modules significantly enhance student engagement by allowing learners to progress at their own pace, resulting in a deeper understanding of the subject and a more positive attitude toward learning. Additionally, self-learning modules do not rely on supplementary resources such as internet access, mobile phones, or electronic devices, making them particularly suitable for schools with limited access to technology, including those under the Royal Education Fund Project.

This research is novel in that it is the first to focus on developing an educational tool specifically aimed at addressing low academic performance and resource limitations in schools under the Royal Education Fund Project. To meet these needs, a self-learning mathematics module was designed to encourage students' active participation, improve their mathematics performance, and foster independent study habits. In addition, the module aimed to equip students with essential arithmetic skills, laying a strong foundation for future learning. At the same time, this initiative was intended to ease teachers' workloads by shifting their role from traditional instructors to facilitators, thereby creating a more supportive and student-centered educational environment.

Method

Population

The population of this study consisted of 513 primary mathematics teachers at Royal Education Fund Project schools.

Sample

- Eighteen mathematics primary teachers from seven Royal Education Fund Project schools in Suphan Buri Primary Educational Service Area Office 3. The sample schools were selected using a multi-stage simple random sampling method: first at the regional level (Central Region of Thailand), then at the provincial level (Suphanburi Province), and finally at the district level (District 3).
- Four hundred eighty-one Grade 3 to 6 students from seven Royal Education Fund Project schools in Suphan Buri Primary Educational Service Area Office 3.

Inclusion Criteria for Teachers

1. Teachers must be currently teaching mathematics to students in Grades 3-6 in the seven multi-staged sampling schools selected under the Royal Education Fund Project in Suphan Buri Primary Educational Service Area Office 3.
2. Teachers must be willing to participate in the research and act as a facilitator for the module.
3. Teachers must be prepared to attend module training and implement the module as a part of their regular teaching process.

Inclusion Criteria for Students

1. Students must be in Grades 3-6 from the seven multi-staged sampling schools selected under the Royal Education Fund Project in Suphan Buri Primary Educational Service Area Office 3.
2. Students and their parents or guardians must provide informed consent for their participation in the study.

Instruments

- A needs analysis survey was developed to collect data from teachers at the target schools in Suphan Buri Primary Educational Service Area Office 3. The survey, distributed via Google Forms, gathered information on teacher demographics, challenges in mathematics instruction, and preferences for educational tools. Five experts revised and validated the survey, resulting in an Index of Item-Objective Congruence (IOC) score ranging from 0.67 to 1.00, which confirmed its validity and alignment with the research objective.
- The self-learning mathematics module was developed based on a needs analysis survey and a review of relevant documents. The module covers four topics for different grade levels: Time (Grade 3), Time Word Problems (Grade 4), Decimals (Grade 5), and Fractions (Grade 6). Each topic includes key components, such as background and rationale, learning objectives, handouts, worksheets, answer keys, and pre- and post-tests. Five experts revised and validated the module, resulting in an IOC score ranging from 0.67 to 1.00, confirming its validity and consistency with the research's learning goals.
- The pre-test and post-test were designed as four-option, multiple-choice questions based on the 2008 Basic Education Core Curriculum. The internal consistency reliability of the pre-test was determined using the Kuder-Richardson Formula 20

(KR-20), which yielded the following reliability coefficients, confirming the instrument's consistency and appropriateness for the study: Grade 3 demonstrated a reliability of 0.83, Grade 4 yielded 0.72, Grade 5 showed 0.81, and Grade 6 achieved the highest reliability at 0.86. These results indicate that both tests have a high level of internal consistency reliability, confirming their suitability for measuring student performance in the study.

- The satisfaction questionnaire was developed to assess teachers' satisfaction with the educational module using a five-point Likert scale. The questionnaire focused on four key aspects: module design, content, visual design, and the module's utility. To ensure content validity, five experts reviewed the instrument, resulting in an IOC score ranging from 0.67 to 1.00, which indicates a strong consensus. The reliability of each aspect was then measured using both Cronbach's alpha (α) and McDonald's omega (ω), with all coefficients well above the acceptable threshold of 0.70. Specifically, the reliability scores were as follows: module design ($\alpha = 0.913$, $\omega = 0.917$), content ($\alpha = 0.788$, $\omega = 0.802$), visual design ($\alpha = 0.797$, $\omega = 0.811$), and module utility ($\alpha = 0.804$, $\omega = 0.816$).

Instrument validators

Five experts were selected based on their research experience, impartiality in providing feedback, academic position of at least Assistant Professor, and expertise in content, research methodology, and language use.

Procedures

This research used a two-phase, R&D approach based on the ADDIE model.

Phase 1 Module Development

- **Analysis:** The initial stage involved a needs analysis study to inform the design of the module. A questionnaire, validated by a panel of five experts (with an IOC score ranging from 0.67 to 1.00), was administered to 18 mathematics teachers at Royal Education Fund Project schools in Suphan Buri Primary Educational Service Area Office 3.
- **Design & Development:** Following the needs analysis, a self-learning mathematics module was designed and developed to address key instructional challenges. The module aligns with the Basic Education Core Curriculum 2008 and covers four topics: Time (Grade 3), Time Word Problems (Grade 4), Decimals (Grade 5), and Fractions (Grade 6). The module was designed using Canva, a web-based graphic design platform selected for its accessibility, flexibility, and capacity to produce visually engaging instructional materials. The development process began with defining instructional objectives and structuring content in alignment with the intended learning outcomes. Learning activities were sequenced from simple to complex tasks to promote scaffolded and self-paced learning, consistent with Vygotsky's (1978) concept of the zone of proximal development (ZPD), which emphasizes guided progression from supported to independent learning. A consistent visual theme was maintained throughout the module, employing appropriate color palettes, readable typography, and relevant iconography to ensure clarity and coherence. Visual aids such as illustrations, infographics, and cartoon elements were incorporated to sustain learners' attention and facilitate conceptual understanding. The overall design aimed to integrate aesthetic appeal with pedagogical effectiveness, fostering active

engagement and supporting Knowles' (1975) theory of self-directed learning in alignment with constructivist principles.

To ensure the module's validity, a panel of five experts reviewed the pilot version and its assessments, resulting in an IOC score ranging from 0.67 to 1.00. This refined module was then pilot-tested with a subset of students across five small primary schools in Nakhon Pathom, selected using a two-stage random sampling method. The pilot test results were used to calculate the Kuder-Richardson Formula 20 (KR-20) for the pre-test and post-test, confirming the internal consistency reliability of the assessments. Specifically, the pre-test KR-20 yielded the following reliability coefficients, confirming the instrument's consistency and appropriateness for the study: Grade 3 demonstrated a reliability of 0.83, Grade 4 yielded 0.72, Grade 5 showed 0.81, and Grade 6 achieved the highest reliability at 0.86.

Phase 2 Implementation and Evaluation

- **Implementation:** The final module was implemented in a one-group pretest/posttest experimental design, utilizing a sample of 481 Grade 3–6 students from Royal Education Fund Project schools in the Suphan Buri Primary Educational Service Area Office 3.
- **Evaluation:** The effectiveness of the module was assessed through a multifaceted evaluation approach. Students' learning gains were analyzed by comparing pretest and posttest scores using a paired-sample t-test. A one-sample t-test was conducted to determine whether the post-test scores met the established 70% learning criterion. This benchmark was selected because previous studies (Banhan et al., 2021; Mana et al., 2021; Runmai & Keeratichamroen, 2024) used the same standard for evaluating student learning. Its appropriateness was further validated through expert consultation. Additionally, teacher satisfaction with the module was evaluated using mean and standard deviation analysis. All findings were used to address the research questions and determine the overall impact of the module.

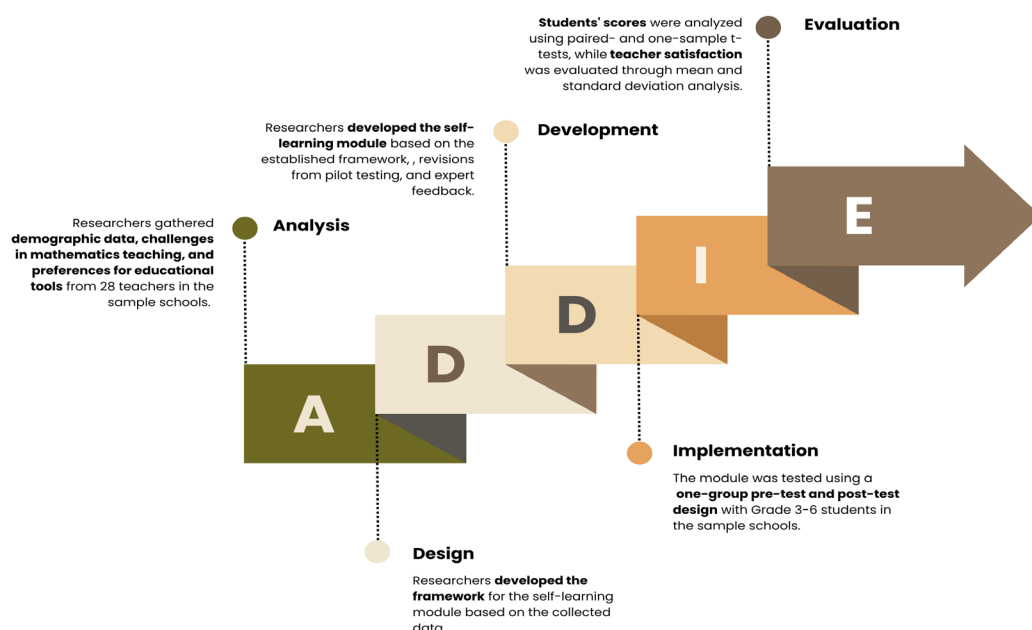


Figure 1 ADDIE Model framework

Findings and Discussion

Phase 1: The Development of the Self-Learning Mathematics Module

1. The Needs Analysis Survey

1.1 Demographic data reveal the diverse professional and academic backgrounds of teachers. The majority (83.33%) held a bachelor's degree, while 16.67% had a master's degree. The data also highlight varied teaching assignments; 44.44 % of the teachers were mathematics majors, while 27.78% were non-math majors teaching the subject. The teaching workload was equally diverse, with 38.39 % teaching 4–6 subjects, 27.78% teaching 1–3 subjects, and 33.34% responsible for 7–12 subjects. Regarding grade levels, 44.44% of teachers handled 3–4 levels, 33.33% taught 1–2, and 22.22% covered 5–6 levels. Additionally, weekly teaching hours varied significantly, with 33.33% of teachers teaching 19–22 hours, another 33.33% teaching 23–26 hours, 22.22% covering 15–18 hours, and 11.11% managing 27–30 hours. The findings suggest that teachers in our sample manage a diverse and demanding teaching load, which may pose unique challenges in their teaching practices.

Table 1. Demographic data

Demographic Variable	<i>n</i>	%
Gender		
male	5	28 %
female	13	72 %
Age		
22-26	2	11.11 %
27-31	4	22.22 %
32-36	5	27.78 %
37-41	2	11.11 %
42-46	3	16.67 %
47-51	1	5.56 %
51+year	1	5.56 %
Degree		
Bachelor's Degree	15	83.33 %
Master's Degree	3	16.67 %
Doctoral Degree	0	0
Professional Teaching Experience		
Teaching in a Major Field	8	44.44 %
Teaching Outside Major Field	5	27.78 %
Teaching Major Field with Additional Subjects outside a major field	5	27.78 %
Number of subjects taught		
1-3 subject(s)	5	27.78 %
4-6 subjects	7	38.39 %
7-9 subjects	5	27.78 %
10-12 subjects	1	5.56 %

Table 1. (Cont.)

Demographic Variable	<i>n</i>	%
Number of Grade Levels Taught		
1-2 level(s)	6	33.33 %
3-4 levels	8	44.44 %
5-6 levels	4	22.22 %
Hours of Instruction per week		
15-18 hrs/week	4	22.22 %
19-22 hrs/week	6	33.33 %
23-26 hrs/week	6	33.33 %
27-30 hrs/week	2	11.11 %

1.2 Mathematics Teaching Challenges and Expectations: The Needs Analysis Survey identified three significant teaching restrictions:

1.2.1 Students' negative attitudes towards mathematics: Students often find mathematics challenging and struggle to see its relevance to their daily lives. Teachers reported that students in their classes are less engaged with the subject, leading to a growing disinterest in mathematics. This contributes to a decline in students' performance.

1.2.2 Teachers' limited time: Teachers reported that the time allocated for teaching complex topics is insufficient for providing thorough explanations and allowing adequate practice. The limited teaching time was due to the heavy workload and the shortage of mathematics-major teachers.

1.2.3 Teaching material: Teachers reported that they need more effective activities to help students understand lessons. They emphasized the necessity of using appropriate teaching aids to enhance clarity in topics such as time word problems, decimals, and fractions. The survey also highlighted teachers' need for greater knowledge of diverse teaching techniques and engaging activities to foster positive attitudes towards mathematics and improve students' performance. Moreover, teachers noted that training courses often focus on principles rather than practical techniques that can be applied in the classroom. They suggested that training should include more relevant materials and updated teaching activities to better support their lessons. The survey further revealed that teachers agreed appropriate teaching techniques and materials can address their teaching issues. Teachers expressed the importance of having practical training in teaching techniques and materials to boost their confidence and teaching attitudes.

1.3 The preferred design of educational tools: From the surveys, teachers in the Royal Education Fund Project schools identified teaching modules and other learning activities as their preferred educational tools for primary mathematics instruction. They also suggested how the module can be suitable for their students, as follows:

1.3.1 Simple yet practical: The module's design should prioritize several key elements. It should be simplified and supported by colorful, visually appealing illustrations to enhance comprehension and maintain student engagement. The activities should be crafted to reflect and support the students' actual performance levels, providing a foundation for active learning. Furthermore, the mathematical theory in each lesson should be presented practically and engagingly, accompanied by a scaffolded progression of exercises that develop skills from simple to complex. To ensure accessibility for all primary students, the language, descriptions, and instructions must be clear and straightforward.

1.3.2 Align with the learning objectives: It is recommended that the module be developed in accordance with the Basic Education Core Curriculum 2008, ensuring that the

module's learning objectives and content are directly aligned with the required national standards for students.

1.3.3 Suit the school's conditions: The development of the instructional materials should prioritize high adaptability to the specific context of the Royal Education Fund Project schools. Given the limited access to the internet and electronic devices in these settings, there was a strong preference for non-digital materials. The resources must also be flexible enough to be used in various learning environments, ensuring that all students have equal opportunities to engage with and succeed in mathematics, regardless of the school's resources.

2. The Development of Self-Learning Mathematics Module

The module was designed using Canva to create a visually appealing and engaging experience for primary students. Its design focuses on being both interactive and intuitive, ensuring the content is accessible and fun for young learners. The module includes the following components:

2.1 Background and Rationale: This section outlines the module's guiding principles and rationale, providing a comprehensive guide for students and teachers on how to use and navigate its content effectively.

2.2 Learning objectives: This section outlines the key goals and skills students are expected to achieve by the end of the module.

- **Time:** The module on time is designed for students to learn independently. Upon completion, students will be able to:
 - 1) Tell time in hours and minutes.
 - 2) State durations in hours and minutes.
 - 3) Compare durations.
- **Time Word Problems:** The module on time word problems is designed for students to learn independently. Upon completion, students will be able to solve addition and subtraction word problems involving time.
- **Decimals:** The module on decimals is designed for students to learn independently. Upon completion, students will be able to
 - 1) Write fractions with denominators of 10, 100, or 1,000 as decimals.
 - 2) Round decimals (up to 3 decimal places) to the nearest whole number, 1 decimal place, or 2 decimal places.
 - 3) Multiply decimals (up to 3 decimal places) by whole numbers.
 - 4) Multiply decimals by decimals (with products up to 3 decimal places).
 - 5) Divide decimals (up to 3 decimal places) by whole numbers (with quotients up to 3 decimal places).
- **Fractions:** The module on fractions is designed for students to learn independently. Upon completion, students will be able to:
 - 1) Compare and order fractions.
 - 2) Add, subtract, multiply, and divide fractions.

2.3 Handout: The content covers four core topics: Time (Grade 3), Time Word Problems (Grade 4), Decimals (Grade 5), and Fractions (Grade 6). This section is specifically designed to be both visually engaging and easily comprehensible, incorporating a combination of text, illustrations, and tables. These elements work together to provide a clear, interactive learning experience for students.

2.4 Worksheet: This section is designed to help students review and reinforce the knowledge gained from the module's instructional content. These exercises serve as a preliminary, formative assessment, allowing students to practice their skills and gauge their understanding before the posttest. The content of the worksheets is directly aligned with the concepts and skills

presented in the worksheet.

2.5 Answer Key: This section provides students with a way to check their own understanding of the concepts. It serves as an answer sheet for the worksheets, allowing students to self-assess their learning and review their work for accuracy. This feature encourages independent learning and immediate feedback.

2.6 Pretest and Posttest: The pretest is administered after the learning objectives and before the Handout, while the posttest is completed after students have worked through the worksheets. Both tests are composed of multiple-choice questions, with the number of items varying by grade level: Grades 3 and 4 have 15 items each, while Grades 5 and 6 have 20 items each. To prevent test-taking familiarity, the pre-test and post-test contain different sets of questions, though they are designed to measure the same skills. The internal consistency reliability for both tests was determined using the Kuder-Richardson Formula 20 (KR-20), with the pretest yielding a value of 0.83, Grade 4 yielding 0.72, Grade 5 showing 0.81, and Grade 6 achieving the highest reliability at 0.86.



Figure 2 Self-Learning Mathematics Module Grade 4 (time word problems)

3. The Pilot Test of the Self-Learning Mathematics Module

3.1 The effectiveness of the self-learning mathematics module

The questionnaire was designed to assess teachers' perceptions of the module's overall effectiveness. It was divided into four key aspects: the effectiveness of the module's instructional design, instructional materials, pretest and posttest, and the module user manual. The evaluation was carried out by a panel of five experts, comprising two content specialists, two instructional materials specialists, and one expert in measurement and evaluation. The scores are presented in Table 2.

Table 2. The Effectiveness of the Mathematics Teaching Modules

Item No.	Evaluation Topic	Mean Score	SD	Score Levels
Effectiveness of the Module's Instructional Design				
1	The objectives of the lessons were clearly explained.	5.00	0.00	Highest
2	The activities provided were aligned with the learning objectives.	4.80	0.44	Highest
3	The lesson contents matched students' learning levels.	4.60	0.54	Highest
4	Learning activities were organized from simple to complex.	4.80	0.44	Highest
5	The teaching materials were relevant to the learning activities.	4.60	0.54	Highest
6	The exercises matched the learning objectives.	4.80	0.44	Highest
7	The illustrations and content were appropriate for the students.	5.00	0.00	Highest
8	The revision sections were suitable for self-study.	4.40	0.54	High
9	The assessment and evaluation tools had suitable criteria aligned with the learning objectives.	5.00	0.00	Highest
Average		4.77	0.36	Highest
Effectiveness of the Modules' Instructional Materials				
10	The materials were aligned with the learning objectives.	4.80	0.44	Highest
11	The materials were relevant to the lesson contents.	4.80	0.44	Highest
12	The materials were supportive and motivating for students' learning.	4.80	0.44	Highest
13	The materials were simple to use in the mathematics class.	4.80	0.44	Highest
14	The materials were appropriate for students' learning in the mathematics class.	4.80	0.44	Highest
15	The materials were durable and reusable.	4.40	0.54	High
16	The materials supported students' learning and helped them comprehend the mathematics lessons.	4.80	0.44	Highest
17	The materials provided students with real-life learning experiences.	4.60	0.54	Highest
Average		4.72	0.46	Highest
Effectiveness of Pre-test and Post-test				
18	The pre-test and post-test were aligned with the learning objectives.	4.80	0.44	Highest
19	The pre-test and post-test were relevant to the mathematics content and learning activities.	5.00	0.00	Highest

Table 2. (Cont.)

Item No.	Evaluation Topic	Mean Score	SD	Score Levels
20	The evaluation and grading criteria were suitable.	5.00	0.00	Highest
21	The number of items in the pre-test and post-test for each module was appropriate.	4.80	0.44	Highest
Average		4.90	0.22	Highest
Effectiveness of the Module User Manual				
22	The explanations provided in the manual for each module were clear and easy to understand.	5.00	0.00	Highest
23	The explanations provided in the manual were arranged in an appropriate order that served the mathematics learning processes.	5.00	0.00	Highest
24	There was a clear explanation as a guideline for using the teaching materials.	5.00	0.00	Highest
25	There was a clear explanation of the test instructions and the process of delivering the tests to students.	5.00	0.00	Highest
Average		5.00	0.00	Highest

N = 5

4.50 - 5.00 indicates the highest-level score.

3.50 - 4.49 indicates a high-level score.

2.50 - 3.49 indicates a moderate-level score.

1.50 - 2.49 indicates a low-level score.

1.00 - 1.49 indicates the lowest-level score.

As shown in Table 2, the experts expressed highly positive satisfaction with the module across various aspects. The effectiveness of the module user manual was rated with perfect scores ($\bar{x} = 5.00$, $SD = 0.00$) across all sub-aspects. This exceptional result confirms the manual's unanimous user-friendliness and comprehensive guidance. Similarly, the effectiveness of the pretest and posttest sections received a very high mean score of 4.90 ($SD = 0.22$). These assessments were highlighted for their strong relevance to the mathematics content and learning activities, as well as the suitability of their evaluation and grading criteria. The effectiveness of both the modules' instructional materials and the modules' instructional design was rated highly, with each receiving a mean score of 4.72 and 4.77, SD s of $= 0.46$ and 0.36 , respectively. These very positive results suggest that both the learning materials and the overall design are well-suited for effective teaching and learning.

3.2 The Teaching Performance Records

A questionnaire was administered to 10 primary school teachers in Nakhon Pathom Province regarding the implementation of the mathematics teaching module with 20 students. The purpose was to explore the perceptions and behaviors of both students and teachers during and after the module's implementation. The survey results were subsequently divided into two main parts, focusing separately on students and teachers, are presented in Table 3.

Table 3. The Students' and Teachers' Behaviors During and After the Teaching Intervention

Item No.	Topics of the Records	Mean Score	SD	Score Levels
Student Behaviors				
1	Students showed a keen interest in the teaching modules during the lessons.	5.00	0.00	Highest
2	Students successfully completed the tasks independently as provided in the teaching modules.	4.90	0.31	Highest
3	Students accurately comprehended each lesson in the modules with the help of the provided materials.	5.00	0.00	Highest
4	Students effectively achieved the learning objectives set for the lessons.	4.90	0.31	Highest
Teachers' behaviors				
1	Teachers effectively used the teaching modules in their classroom instruction.	~5.00	0.00	Highest
2	Teachers faced significant problems and restrictions when using the teaching modules in their classes.	~1.00	0.00	Lowest

N = 10

Table 3 indicates that students and teachers exhibited the highest levels of engagement and effectiveness when using the module. Students consistently showed keen interest and high comprehension, with mean scores of 5.00 ($SD = 0.00$) across all aspects, except for task completion after the intervention and achievement of learning objectives, which received a slightly lower mean score ($\bar{x} = 4.90$, $SD = 0.31$). Likewise, teachers effectively utilized the module, achieving a mean score of 5.00 ($SD = 0.00$). They also reported minimal problems and restrictions, as reflected in a low mean score of 1.00 ($SD = 0.00$), which further confirms the module's effectiveness in teaching and learning.

3.3 Students' Pretest and Posttest Scores

A paired-sample t-test was used to investigate the difference between the pretest and posttest scores of students in Grades 3-6, selected through a two-stage random sampling from five primary schools in Nakhon Pathom.

Table 4. Students' Pretest and Posttest Scores

Grade	<i>n</i>	<i>k</i>	$(\bar{x})$		(SD)		<i>t/W</i>	<i>p</i> -value	Effect size
			Pre-test	Post-test	Pre-test	Post-test			
Grade 3	20	15	6.20	10.50	1.44	1.36	16.40	< .001**	3.66 ^a
Grade 4	20	15	7.10	10.15	1.33	1.93	153 ^b	.051	1.00 ^b
Grade 5	20	20	9.25	14.20	1.86	1.77	10.60	< .001**	2.37 ^a
Grade 6	20	20	8.50	13.30	1.15	2.03	11.80	< .001**	2.63 ^a

* $p < .05$ ** $p < .001$ ^a Cohen's *d* (t-test) ^b rank-biserial correlation (Wilcoxon-signed rank)

According to Table 4, the results provide strong evidence of significant gains in student performance across all grade levels. All groups showed a substantial increase in mean scores from the pretest to the posttest, with the improvements being highly statistically significant ($p < .001$) for each grade. Specifically, Grade 3 scores increased from 6.20 ($SD = 1.44$) to 10.50 ($SD = 1.36$), $t(19) = 16.40$, $d = 3.66$ 95% CI [2.42, 4.89]. Grade 4 scores rose from 7.10 ($SD = 1.33$)

to 10.15 ($SD = 1.93$), $t(19) = 6.78$, $r_{rb} = 1.00$, $p = .051$ 95% CI [0.85, 2.16]. Similarly, Grade 5 scores improved from 9.25 ($SD = 1.86$) to 14.20 ($SD = 1.77$), $t(19) = 10.60$, $d = 2.37$ 95% CI [1.49, 3.23]. Finally, Grade 6 scores rose from 8.50 ($SD = 1.15$) to 13.30 ($SD = 2.03$), $t(19) = 11.80$, $d = 2.63$ 95% CI [1.69, 3.56].

Phase 2: The Implementation and Evaluation of the Self-Learning Mathematics Module

1. The Students' Achievement Scores

A paired-sample t-test was used to compare the pretest and posttest scores of students in the Royal Education Fund Project schools in Suphan Buri Primary Educational Service Area Office 3. In contrast, a one-sample t-test was used to assess whether their posttest scores met the 70% criterion.

Table 5. The Students' Pretest and Posttest Scores

Grade	<i>n</i>	<i>k</i>	$(\bar{x})$		(SD)		<i>t</i>	<i>p</i> -value	Cohen's <i>d</i>
			Pre-test	Post-test	Pre-test	Post-test			
Grade 3	118	15	7.00	11.10	1.47	1.72	15.10	<.001**	1.81
Grade 4	127	15	7.52	10.40	3.20	2.39	9.34	<.001**	1.08
Grade 5	93	20	9.98	14.64	1.70	2.21	13.90	<.001**	1.88
Grade 6	143	20	9.32	14.53	1.80	2.50	16.10	<.001**	1.75

* $p < .05$ ** $p < .001$

Table 5 presents the significant improvements in students' mathematics performance across all grade levels following the intervention. Posttest scores were significantly higher than pretest scores for Grade 3 ($t(117) = 15.10$, $SD = 1.72$, $p < .001$, $d = 1.81$ 95% CI [1.43, 2.19]), Grade 4 ($t(126) = 9.34$, $SD = 2.39$, $p < .001$, $d = 1.08$ 95% CI [0.79, 1.36]), Grade 5 ($t(92) = 13.90$, $SD = 2.21$, $p < .001$, $d = 1.88$ 95% CI [1.43, 2.31]), and Grade 6 ($t(142) = 16.10$, $SD = 2.50$, $p < .001$, $d = 1.75$ 95% CI [1.41, 2.08]), confirming the effectiveness of the intervention.

Table 6. The Students' Scores after the Intervention Compared with the Set Criterion

Posttest Results	<i>n</i>	<i>k</i>	$(\bar{x})$	<i>SD</i>	μ (70%)	<i>t</i>	<i>p</i> -value	Cohen's <i>d</i>
Grade 3	118	15	11.10	1.72	10.5	2.92	<.002**	0.35
Grade 4	127	15	10.40	2.39	10.5	-0.36	.64	-0.04
Grade 5	93	20	14.60	2.21	14	2.14	.018	0.29
Grade 6	143	20	14.90	2.31	14	3.43	<.001**	0.37

* $p < .05$ ** $p < .001$

Table 6 summarizes the students' post-test results relative to the established 70% criterion. For Grades 3 ($\bar{x} = 11.10$, $SD = 1.72$, $d = 0.35$, 95% CI [0.11, 0.59]), Grades 5 ($\bar{x} = 14.60$, $SD = 2.21$, $d = 0.29$, 95% CI [0.02, 0.56]), and Grades 6 ($\bar{x} = 14.90$, $SD = 2.31$, $d = 0.37$, 95% CI [0.15, 0.59]), the posttest means exceeded the criterion. As the assessment consisted of 15 dichotomously scored items, the 70% threshold (10.5) was not practically attainable; therefore, 11 points (73.3%) was used as the cutoff. All three grades achieved significantly higher mean scores than the criterion ($p < .05$), as supported by the respective t-statistics: $t(117) = 2.92$ for Grade 3, $t(92) = 2.14$ for Grade 5, and $t(142) = 3.43$ for Grade 6. These outcomes are further substantiated by the notable average progress scores—50% for Grade 3, 51% for Grade 5, and 53% for Grade 6. In contrast, Grade 4 students did not demonstrate a statistically significant difference from the criterion, with a mean score of $\bar{x} = 10.40$ ($SD = 2.39$), $t(126) = 0.36$, $p = 0.64$, $d = -0.04$, 95% CI [-0.27, 0.19]. This finding aligns with Grade 4's comparatively lower average progress score of 19%.

2. The Teachers' Satisfaction

Table 7. The Teachers' Satisfaction with the Self-Learning Mathematics Module

Item No.	Evaluation Topics	Means	SD	95% CI	Score Levels
Design					
1	The design of the modules is attractive and engaging for students.	4.83	0.23	[4.62, 4.95]	Highest
2	The layout of the content in the worksheet is appropriate.	4.72	0.46	[4.58, 4.92]	Highest
3	The content in each worksheet is organized in a logical progression from simple to complex.	4.66	0.48	[4.49, 4.86]	Highest
4	The design of the supplementary materials is suitable for the content.	4.77	0.42	[4.58, 4.92]	Highest
5	The design of the supplementary materials is appropriate for the student's age.	4.66	0.48	[4.49, 4.86]	Highest
Average		4.71	0.45	[4.59, 4.86]	Highest
Content					
6	The content of the modules is suitable for the students' age.	4.77	0.42	[4.62, 4.95]	Highest
7	The content of the supplementary materials in the module is suitable for the students' age.	4.77	0.42	[4.62, 4.95]	Highest
8	The content of the pre-test and post-test is suitable for the students' age.	4.66	0.48	[4.45, 4.83]	Highest
9	The details of the content are communicated clearly and simply.	4.83	0.38	[4.67, 4.97]	Highest
Average		4.75	0.42	[4.63, 4.89]	Highest
Visual Design					
10	The illustrations in the modules are appropriate.	4.77	0.42	[4.58, 4.92]	Highest
11	The illustrations in the modules are clear.	4.83	0.38	[4.72, 5.00]	Highest
12	The illustrations in the modules align with the content.	4.77	0.42	[4.62, 4.95]	Highest
13	The fonts used in the modules are appropriate.	4.83	0.38	[4.72, 5.00]	Highest
14	The use of colors in the modules is appropriate.	4.88	0.32	[4.77, 5.01]	Highest
Average		4.83	0.36	[4.73, 4.93]	Highest
Utility					
15	The modules for teaching mathematics are suitable for the students.	4.66	0.48	[4.49, 4.86]	Highest
16	When students learn through the mathematics teaching modules, they find it easy to understand.	4.61	0.50	[4.41, 4.80]	Highest

Table 7. (Cont.)

Item No.	Evaluation Topics	Means	SD	95% CI	Score Levels
Design					
17	When students learn through the mathematics teaching modules, they develop a positive attitude towards learning mathematics.	4.44	0.51	[4.27, 4.66]	High
18	The mathematics teaching modules are suitable for classroom management.	4.44	0.51	[4.23, 4.62]	High
19	Satisfaction with the use of the mathematics teaching modules for teaching mathematics.	4.55	0.51	[4.38, 4.77]	Highest
Average		4.54	0.50	[4.41, 4.69]	Highest
Overall Average		4.70	0.43	[4.61, 4.82]	Highest

N = 18

4.50 - 5.00 indicates the highest-level score.

3.50 - 4.49 indicates a high-level score.

2.50 - 3.49 indicates a moderate-level score.

1.50 - 2.49 indicates a low-level score.

1.00 - 1.49 indicates the lowest-level score.

Table 7 indicates the highly positive results in teachers' satisfaction with the module, with an overall average score of 4.70 ($SD = 0.43$). The design aspect received an average score of 4.71 ($SD = 0.45$, 95% CI [4.59, 4.86]), with high ratings for the layout of the content and the design of supplementary materials, while the design of the modules received the highest rating ($\bar{x} = 4.83$, $SD = 0.23$, 95% CI [4.62, 4.95]). The content was also highly rated ($\bar{x} = 4.75$, $SD = 0.42$), with the highest scores for the age-appropriateness of the content and supplementary materials ($\bar{x} = 4.83$, $SD = 0.38$, 95% CI [4.62, 4.95]). The visual design received the highest rating ($\bar{x} = 4.83$, $SD = 0.36$, 95% CI [4.73, 4.93]), particularly for the use of colors in the modules ($\bar{x} = 4.88$, $SD = 0.32$, 95% CI [4.77, 5.01]). Similarly, the utility aspect received the highest rating ($\bar{x} = 4.54$, $SD = 0.50$), with the highest score for the suitability of the module for teaching ($\bar{x} = 4.66$, $SD = 0.48$, 95% CI [4.49, 4.86]).

Discussion

This study demonstrates the impact of the self-learning mathematics module under the Royal Education Fund Project in improving students' mathematics performance and teacher satisfaction. Posttest scores showed significant improvements across Grades 3, 4, 5, and 6 ($p < .05$), with students in Grades 3, 5, and 6 meeting the 70% performance benchmark. Although Grade 4 students fell slightly below this criterion, their results still indicated positive learning outcomes. These findings align with previous studies (Intrasuksanti & Sararattana, 2022; Pikulsee, 2014) that highlight the effectiveness of instructional modules in enhancing mathematics achievement.

Despite being a new area of research within the Royal Education Fund Project schools, the self-learning mathematics module proved to be efficient. A key factor in its success was the thoughtful design, which aligned with the 2017 Basic Education Curriculum and was directly reflected in significant improvements in students' posttest scores across all grades. Engaging and interactive activities incorporating visually appealing content, such as colorful graphics and cartoon elements, were essential for maintaining students' interest and motivation, allowing them to address challenges and fully grasp the lessons (Intrasuksanti & Sararattana, 2022; Jaisanit et al., 2020; Ramdani et al., 2019). Additionally, the module fostered a positive

and constructive classroom environment by allowing students to learn at their own pace through progressively structured exercises ranging from simple to complex, thereby reducing stress levels. This approach also helped alleviate teachers' workload, enabling them to adopt a more relaxed and supportive teaching stance, which in turn encouraged students to express their ideas confidently and engage in meaningful peer discussions (Ramdani et al., 2019; Thanawannit, 2006). This research makes a novel contribution by focusing on Royal Fund schools, a group that is underrepresented in educational research despite significant challenges related to resource scarcity. The study's design—positioning the module as the primary instructional tool and the teacher as a facilitator—presents an innovative approach to mitigating educational inequality. Moreover, even in well-resourced schools, disparities in student performance persist; thus, fostering self-directed learning and allowing students to progress at their own pace remains essential for promoting equitable learning outcomes. The module's design is grounded in several key educational theories. It aligns with constructivism by promoting self-directed learning and positioning the teacher as a guide rather than a sole knowledge provider (Gautam et al., 2024). The module also supports Vygotsky's sociocultural theory (1978) by allowing students to work within their zone of proximal development (ZPD), completing tasks independently while having the teacher available for support.

Furthermore, the module is based on experiential learning theory (Kolb, 2001) by emphasizing hands-on activities that encourage students to learn through practice, reflect on their understanding, and apply new skills. The module's role in providing resources to bridge the educational gap also connects with the economics of education theory (Woodhall, 1987). This approach directly addresses the digital divide, providing a practical alternative to the use of mobile devices, which, despite findings from organizations like PISA on the benefits of their use for one hour per day (Organisation for Economic Co-operation and Development, 2024), are often inaccessible to students in these schools.

This study reveals several key strengths of the self-learning mathematics module, which directly address practical challenges within Royal Fund schools. The module promotes equity in educational access by providing standardized, high-quality content that is independent of a school's digital resources. The findings suggest that this low-tech approach serves as a rapid and effective solution to persistent issues such as multi-grade classrooms and teacher shortages, which are common in remote schools that are often not the preferred choice for new teachers. The research also reinforces the idea that high-tech solutions do not always correlate with high learning outcomes; for instance, the ineffectiveness of online learning platforms like Zoom during the COVID-19 pandemic highlighted the need for more adaptable and practical instructional tools.

However, despite the overall success of the module, Grade 4 students did not meet the research's established performance criteria. This finding warrants further investigation, as the Grade 4 module focused on time word problems, which demand higher language comprehension than purely mathematical calculation. In rural areas, where students often speak languages other than Thai, language barriers can hinder their ability to engage thoroughly with the material. This challenge aligns with the observations of Ramirez et al. (2019), who noted that students struggle with word problems due to difficulties translating the text into mathematical expressions. Additionally, research by Tesinthachoti (2017) and Vygotsky (1978, 1997) emphasized that external factors, such as students' language proficiency and socio-economic background, play a significant role in their learning success.

In conclusion, the self-learning mathematics module has proven to be a powerful educational tool, improving students' mathematics performance and teacher satisfaction across multiple grade levels. The module's alignment with the national curriculum, engaging design, and focus on self-learning make it a practical resource for schools, even in environments with limited resources. Although there are areas for improvement, particularly in addressing

language barriers for Grade 4 students, the findings of this study provide strong evidence of the module's potential to enhance primary education in schools under the Royal Education Fund Project.

Limitations

This study employed a one-group pre-post design, which introduces potential threats to internal validity, such as testing effects. Although the posttest items differed from those of the pretest, students may have become familiar with the test format or developed new problem-solving strategies, potentially inflating posttest scores. Another key methodological limitation is that, while the pilot schools were small, they may not fully capture the complex and multifaceted context of the Royal Education Fund Project schools. As a result, differences between the pilot schools and the target context may limit the generalizability of the findings. Additionally, the study faced potential linguistic barriers. Conducted in Suphan Buri province—a region known for its ethnic diversity—some students may not have had a strong command of the Thai language. This limitation could have resulted in an incomplete understanding of the module's content, especially on items requiring complex reading comprehension, thereby affecting student performance. Given these factors, the module appears most suitable for schools with high workloads or teacher shortages, such as those in the Royal Education Fund Project. In contrast, it may be less appropriate for schools that do not experience these specific challenges. While the module is intended to foster self-learning among students, it may inadvertently reduce opportunities for direct teacher-student interaction, which remains a crucial component of the learning process.

Recommendations

a. Based on the findings, it is recommended that future research initiatives use pilot schools that share a similar context with the Royal Fund schools. This would allow for an iterative development process, ensuring the module is more suitable for the target population. Specifically, future versions should address the language-heavy content by simplifying the language and providing additional support to help students from diverse linguistic backgrounds fully comprehend the material. The low performance of Grade 4 students on time word problems, which require a firm grasp of language, suggests that future studies should collect data on students' Thai language proficiency or nationality to better understand the role of linguistic factors in learning outcomes. Furthermore, it is suggested that future studies focus on assessing student satisfaction with the module in order to make improvements based on direct learner feedback. This research could also collect data on students' class attendance to evaluate further the module's impact on engagement and consistent participation in the learning process.

b. A multi-faceted policy is proposed to address the educational resource gap. It is recommended that educational policymakers establish a dedicated fund for the creation of standardized, high-learning-outcome modules. These modules could be integrated into the core curriculum to promote essential 21st-century skills, such as self-directed learning. Additionally, the creation of a free, easily accessible online repository of these modules is recommended. While digital access would be a primary goal, the platform should also facilitate easy printing, ensuring that the materials can still benefit schools with limited technological infrastructure. To support this initiative, policy should also emphasize the importance of providing teachers with professional training on module implementation and facilitation. Finally, fostering professional learning communities (PLCs) among teachers would provide a platform for them to share experiences and best practices, ensuring the long-term sustainability and effectiveness of these modules.

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References

- Banhan, R., Jongkonhlang, S., & Phonnong, I. (2021). A study of learning achievement and mathematics problem-solving abilities and entitled division unit for grade 2 students: Using problem-solving process with bar model. *Ratchaphruek Journal*, 19(1), 99–108.
- Gautam, Krishna Kumar & Agarwal, Reena. (2024). The concept of facilitator in constructivist teaching. *Journal of teacher education*, 13(19), 47–54.
- Iamchan, N., Chanchusakun, S., & Kitroongrueng, P. (2023). “BRIGHT Model” Mathematics instructional model based on RME and MEAs approaches: To enhance mathematical thinking for upper primary students. *Journal of Humanities and Social Sciences Nakhon Phanom University*, 13(1), 227–293.
- Intrasuksanti, R., & Sanrattana, U. (2022). The development of learning modules by using research-based learning: To enhance special education classroom research competency for student teachers in Sakon Nakhon Rajabhat University. *Journal of Santi Pracha Dhamma*, 10(7), 3129–3139.
- Jaisanit, S., Chantanapong, W., & Boonlue, W. (2020). Enhancing students' problem-solving skills in mathematics: Through reflective teaching. *Journal of Educational Research and Development*, 15(2), 112–125.
- Jing, T. T., Tarmizi, R. A., Bakar, K. A., & Aralas, D. (2017). The adoption of variation theory in the classroom: Effect on students' algebraic achievement and motivation to learn. *Electronic Journal of Research in Educational Psychology*, 15(2), 307–325.
- Kachai, P., Ugsonkid, S., Chuntra, C., & Tangkawsakul, S. (2023). The study of mathematical literacy of eighth-grade students: By using mathematics learning activities focusing on open approach. *Interdisciplinary Academic and Research Journal*, 3(5), 255–270.
- Knowles, M. (1975). *Self-Directed Learning: A Guide for Learners and Teachers*. Follett Publishing Company.
- Kolb, D. A., Boyatzis, R. E., & Mainemelis, C. (2001). Experiential learning theory: Previous research and new directions. In R. J. Sternberg & L.-f. Zhang (Eds.), *Perspectives on thinking, learning, and cognitive styles* (pp. 227–247). Lawrence Erlbaum Associates Publishers. <https://doi.org/10.4324/9781410605986-9>
- Mana, N., Chopaiad, C., Chariyamakarn, R., Prachumkayohmat, S. (2021). The comparison of learning Achievement on the Topic of Statistics of mathayom 2 Students: Learning under STAD technique of cooperative learning and learning under traditional teaching method. *Journal of Educational Studies, Sukhothai Thammathirat Open University*, 14(2) 59–74.
- National Institute of Educational Testing Service. (2023). *Report on Ordinary National Educational Test (O-NET) results*. National Institute of Educational Testing Service.

- Office of the Education Council, Ministry of Education. (2017A). *The national scheme of education B.E. 2560–2579* (In Thai). Prikwran Graphic.
- Organisation for Economic Co-operation and Development. (2024). *Students, digital devices and success*. OECD Publishing.
- Parnpheuk, P. (2017). *Factors affecting academic achievement of secondary school students: The case study of students in opportunity expansion schools, Phasi Charoen District, Bangkok* [Master's thesis, Thammasat University]. Thammasat University.
- Pikulsee, C. (2014). *The use of instructional media of primary education teachers who participated in the True Plook Panya project in schools under Chiang Mai Primary Education Service Area Office 3* [Master's thesis, Sukhothai Thammathirat Open University]. Sukhothai Thammathirat Open University.
- Ramdani, R., Syamsuddin, A., & Sirajuddin, S. (2019). Development of mathematical module: Problem-solving approach to train students' reflective thinking. *Pedagogical Research*, 4(4), 1–7. <https://doi.org/10.29333/pr/5861>
- Ramirez, G., Fries, L., Gunderson, E., Schaeffer, M. W., Maloney, E. A., Beilock, S. L., & Levine, S. C. (2019). Reading anxiety: An early affective impediment to children's success in reading. *Journal of Cognition and Development*, 20(1), 15–34. <https://doi.org/10.1080/15248372.2018.1526175>
- Runmai, Y., & Keeratichamroen, W. (2024). A study of learning achievement on addition and subtraction of numbers up to 20 learning unit and group working behaviors of grade 1 student: Using team-came tournament with bar model. *Ratchaphruek Journal*, 22(1), 129–143.
- Srinaphom, A., & Phorntaweekul, S. (2023). Developing self-management abilities through self-directed learning of grade 5 students. *Journal of Association of Professional Development of Educational Administration of Thailand*, 5(3), 65–77.
- Tanawannit, R. (2006). *The development of Thai language module lessons on reading comprehension for Grade 10 students at Joseph Upatham School, Sam Phran District, Nakhon Pathom Province* [Master's thesis, Srinakharinwirot University]. Srinakharinwirot University.
- Tesinthachoti, K. (2017). *Factors affecting academic achievement of Grade 6 students in small schools under the jurisdiction of Sakaeo Primary Educational Service Area Office 1* [Master's thesis, Burapha University]. Burapha University.
- Thongmeensuk, S., Rojsirikulchai, R., & Ariyasunthorn, A. (2022). The Implementation and Phase-out of Travel Bans: A Case Study of Thailand. *TDRI Quarterly Review*, 37(2), 3–44.
- Vygotsky, L. S. (1978). Interaction between learning and development. In M. Cole, V. John-Steiner, S. Scribner, & E. Souberman (Eds.), *Mind in society: The development of higher psychological processes* (pp. 79-91). Harvard University Press.
- Vygotsky, L. S. (1997). *Educational psychology*. St. Lucie Press.
- Woodhall, M. (1987). Economics of education: A review. In G. Psacharopoulos (Ed.), *Economics of Education* (pp. 1–8). Pergamon. <https://doi.org/10.1016/B978-0-08-033379-3.50008-5>