INTERNATIONAL JOURNAL OF TEACHER EDUCATION RESEARCH STUDIES (IJTERS)
(Open Access, Double-Blind Peer Reviewed Journal)
ISSN Online: 3049-1614



A Comparative Analysis of Innovative Pedagogical Strategies in Foundation Mathematics: An Action Research Study

Jibulal Nair[1]*, Akhilesh Kumar Mishra[1], Sherin Thomas[1]

[1] Gulf College, Sultanate of Oman

Article Information

Received: 24th August 2026
Received in revised form: 2nd September 2026
Accepted: 26th September 2026
Available online: 18th October 2026

Volume: 3
Issue: 6
DOI: https://doi.org/10.63090/IJTERS/3049.1614.0055

Abstract

Foundation mathematics requires innovative pedagogical strategies to ensure an effective teaching–learning process. As the subject often presents a significant challenge for students transitioning from higher secondary education to higher education, foundation programs must adopt appropriate approaches to strengthen essential conceptual understanding. This study examines the effectiveness of various instructional strategies and seeks to determine which methodologies most effectively enhance student performance and conceptual clarity. Using a quasi-experimental design, the study implemented Flipped Classroom, Collaborative Problem Solving, and Blended Learning approaches in a second-level foundation mathematics course. The research compares the relative effectiveness of these methods in improving learning outcomes. Data were collected through a pre-test/post-test design to measure students' cognitive gains. The results were analysed using both descriptive and inferential statistical techniques. A Comparative study has done through ANCOVA. The findings indicate that while all three approaches can be successfully used to teach this topic, Blended learning was the most effective in this study for the particular topic, underscoring the value of active, student-centered methods and the inclusion of innovative pedagogical strategies in foundation-level mathematics curricula.

Keywords:- Pedagogy, Action Research, Foundation Mathematics, Pre-test/Post-test, Higher Education

I. INTRODUCTION

At the foundational level, mathematics is more than just an academic subject; it also represents a major turning point in a student's educational journey. New college students transitioning from high school to postsecondary education often find this transition especially challenging because many of the learning strategies that they used in high school have been rendered ineffective. As mathematical concepts become more abstract and require increased amount of cognitive effort, students often lose interest in math and less confident in their ability to learn and understand math. Cognitive adjustment is a necessary component of learning in mathematics which includes additional instructional support that assists in engaging students in learning through improved understanding and participation (Biggs & Tang, 2011).

The study was conducted in response to a common problem shared by all teachers in the University. A key challenge is determining how pedagogical approaches can be revised to better support students transitioning into postsecondary education, as traditional lecture-based methods often do not sufficiently engage learners or address diverse learning needs. Recent studies of pedagogy indicate that using more student-centered and collaborative approaches can lead to significantly improved conceptual knowledge and retention for students (Freeman et al., 2014).

To be clear, this study investigates the effectiveness of three innovative teaching techniques implemented over one semester in a second-level foundation mathematics course: the flipped classroom, collaborative problem solving, and blended learning. These new teaching approaches encourage students to engage with the material of their course, work together with other students and apply what they learned in ways that are applicable in real-life contexts, which helps students change from a learning process of absorbing and receiving information to actively developing knowledge. To evaluate the degree of increase in students' understanding of concepts and cognitive ability, this study employed a quasi-experimental design using pre- and post-tests as measures of understanding.

This investigation will also assist in obtaining more specific knowledge regarding how children learn the fundamental skills needed for success in mathematics and how to best use different instructional strategies with different subject areas in mathematics. Thus, the results from this research can be used by educators to provide sound, research-based evidence-based strategies for teaching various mathematics concepts. Finally, Mostofo and Zambo (2015) further contributed to the ongoing action research dialogue by demonstrating how reflection and data-driven classroom analysis can create significant increases in student learning and success.

II. LITERATURE REVIEW

Alamri, Watson, and Watson (2021) discussed technology of learning models that provided personalized blended learning higher education. The review encompasses major enabling strategies and technologies, including adaptive systems, learning analytics, and platform-based tools that customize instruction within blended environments.

Ali, Khan, and Alouraini (2023) gave a structured comparative study that illustrates the post-COVID changes to digital instruction, emphasizing the necessity to compare online and blended learning in higher education. The results from pre-test and post-test assessments indicate that both groups improved in grammatical knowledge and skill acquisition; however, the blended learning cohort outperformed the fully online group. The authors concluded from the evidence that blended learning may provide more robust support for student performance than fully online instruction.

Bhagat Chang and Chang (2016) did a study to see if the flipped classroom model is good for helping high school students learn math concepts. They wanted to know if this way of teaching is better than the way. The flipped classroom model is different from the way of teaching. The study had 82 high school students. These students were divided into two groups. One group learned trigonometry using the flipped classroom model. The other group learned trigonometry in the way. The people who did the study used tests to compare the two groups. They found out that the students who learned using the flipped classroom model did better and were more motivated. This was especially true for students who were not doing well. The people who did the study think that the flipped classroom model is a way to teach math to high school students. They think it can be more effective than the way of teaching. The flipped classroom model can really help students learn math, the ones who are struggling. Bhagat Chang and Chang found that the flipped classroom model is an alternative, to traditional teaching.

Borba et al. (2016) Did a survey. This survey looked at research on digital technology in math education. They focused on learning, e-learning and mobile learning. They defined these three types of learning. They also explained how they fit into the picture of technology in math teaching. The paper is organized by theme. It talks about how these technologies used in math education. It also discusses the things and challenges they bring to teachers, students and researchers.

Caulfield's (2011) book is a useful guide for creating and teaching hybrid courses in college. The book also explains about hybrid mode learning. The book moves on to course planning, which includes how to find the right balance between face-to-face, online, and experiential parts of the course based on things like class size, student characteristics, subject matter, and learning outcomes. The next sections are about teaching in hybrid settings, including discussions, getting feedback from students, working in small groups, setting expectations, and using technology. The last part is based on interviews with students and successful hybrid instructors. It gives practical advice and ends with thoughts on future research and the continued growth of hybrid learning that puts students first.

Lee and Lovvorn (2016) describe how they changed a first-year seminar in computer science and software engineering at Mississippi State University into a project-based robotics experience for new students. The goal was to help them improve their computational thinking, teamwork, problem-solving, and confidence with technology. They first talk about the problems that first-year computing majors have with keeping their confidence and staying in school. Then they talk about an eight-week team project where students used a Finch robot and simple programming tools like Snap! to make and use their own open-ended robotic applications. The authors employed pre- and post-project surveys along with student reflections for evaluation. The results showed that fewer students said they were "not at all confident" and more students said they were confident in program design, programming, and software use after the project. Qualitative feedback indicated enhancements in teamwork, communication, leadership, and the application of programming to practical tasks; however, the authors observed that fostering creativity and generating ideas presented greater challenges for students than technical programming. They also say that the project's effects can't be fully separated because some students are taking programming classes at the same time.

Güler Mehmet and Bütüner (2022) performed a meta-analysis contrasting traditional classroom instruction with flipped classroom instruction in the context of mathematics education. Their analysis encompassed 37 experimental studies featuring 40 effect sizes that contrasted flipped and traditional classrooms in K-12 and postsecondary contexts. The meta-analysis showed a moderate overall effect size ($g = 0.402$), which means that flipped classroom instruction had a statistically significant effect on student achievement. The purpose of this research study is to provide those interested in creating effective environments for learning with a road map for success. Additionally, the authors explore how the use of a flipped classroom can be successfully utilized in mathematics instruction and offer suggestions for future research. Kay et al. (2018) examine how students have different learning experiences as well as how well they perform in three types of courses: traditional lecture-based, active learning, and flipped classroom. The research subjects were 2nd-semester students studying computer programming ($n = 103$) attending a mid-size college of applied arts and technology. The researchers used a convergent parallel mixed-method design to compare the three types of course delivery methods. The researchers point out how difficult it is to effectively manage time when presenting new content through traditional lecture delivery, active engagement through questions, immediate feedback through just in time, and providing enough opportunities to apply new knowledge and engage cognitively through any of the three course delivery methods. They recommend that consumers of future research on Flipped Classroom, Active Learning, and Lectures continue to identify ways to improve these three methods by manipulating the five identified characteristics of learning and measuring the effects.

Kalita and Nath (2025) present a thorough comparison of three distinctly different teaching methods, alluding to the fact that no particular teaching method will always lead to the best possible result. The authors state that many factors,

including teacher skills, educational background, and socioeconomic status, will determine each method's success in the classroom. Therefore, while the use of hybrid or blended strategies (which involve combining traditional methods, student-centered hands-on learning activities, and technology-assisted methods) have produced the most positive results thus far in mathematics education, they, also, face significant challenges including infrastructure, costs, and an equitable access to these technologies. This study contributes to the continuing effort to improve mathematics instruction so that all students can develop the skills necessary to be academically successful and become confident, analytical, and creative problem solvers. Kozikoğlu (2019) presents an analysis of the flipped learning model from various perspectives. The researcher reviewed 80 studies—34 conducted in Turkey and 46 internationally using content analysis. According to the results of the content analysis, the flipped learning approach has a positive effect on students' academic performance, motivation and metacognition, among other variables. The findings also indicated both students and teachers have positive attitudes toward the flipped learning model.

A case study by Long et al. (2016) explores the experiences and views of instructors implementing a flipped classroom. Eight faculty members participated in semi-structured interviews regarding their experience with the flipped classroom model. The study indicates the need for flexibility and comfort when providing peer support and assistance and highlights the importance of facilitating communication, mentoring, and providing feedback from peers when developing training programs for teachers. Additionally, Nantha et al. (2022) evaluated the effectiveness of flipped learning against problem-based learning and traditional instruction for Thai student teachers. Evidence showed that the flipped classroom model resulted in improved performance, problem solving, and satisfaction compared to the other approaches. Thus, the findings indicate adopting flipped learning can increase motivation and engagement resulting from quality educational experiences that promote active learning.

The research done by Pimdee, Sukkamart, and Nantha (2024) validated the impact of using a blended approach with Problem Based Learning (PBL) on student teachers in a flipped classroom model. Results indicated that the use of this blended approach promoted significant improvement in academic achievement, digital competencies, and problem-solving ability. The findings of this study demonstrate the combined use of flipped learning and PBL constitute a learner-centered, interactive environment, thereby facilitating active engagement and enhanced student understanding, while also demonstrating that creative pedagogical strategies could have a positive effect on student learning outcomes in higher education. According to John R. Savery (2006), "PBL is defined as a student-centered learning strategy that allows students to integrate learning (theory and practice) while working on actual/real-world issues." PBL encourages students to become self-directed, engaged in the learning process actively, to engage in team-based collaborative activities, and to construct their knowledge. Challenges to the implementation of PBL were discussed in the report, as well as the acceptance of PBL in multiple areas due to the success it has had in developing critical thinking and problem-solving skills in students. The article by Tan, Zakuan, and Abd Aziz (2022) entitled "Recent Trends of Blended Learning and Flipped Classroom in Malaysia" highlights how the COVID-19 pandemic accelerated the transition from traditional face-to-face instruction to blended and flipped learning approaches in Malaysian higher education. The authors review 22 recent studies demonstrating that blended learning, which integrates online and in-person methods, has gained popularity due to its flexibility and capacity to address challenges posed by remote instruction while facilitating interaction and pedagogical advancement. They conclude that successful adoption of blended and flipped classroom strategies necessitates collaboration among educators, students, and institutional stakeholders to adapt instruction for the "new normal."

The research by Sya'roni et al. (2020) examines how students develop their creative thinking skills through a mathematics course using a combination of a flipped classroom with an online component along with group projects through a "lesson study for learning communities." The results showed a significant increase in students' ability to think creatively when using both an online (flipped) method of delivery for content along with collaborative and reflective problem solving in the classroom as opposed to traditional instruction, which typically uses only one method of delivery and does not foster collaborative or reflective problem solving. When used as an instructional design, blended flipped classrooms can develop the skills required for successful students in the 21st century. The study conducted by Tabieh and Hamzeh examined the effects of blended flipped classrooms on students' development of mathematical creative thinking skills in secondary schools. The researchers utilized a quasi-experimental design to compare the performance of students receiving instruction using blended/flipped instruction with that of students receiving traditional instruction. The study's findings indicated that students in the blended/flipped classroom outperformed their peers receiving traditional instruction on all measures of mathematical creative thinking, including mathematical reasoning, fluency, flexibility, and originality. In addition, their results suggest that providing students access to both pre-class and in-class collaborative (i.e., group) projects promotes deeper cognitive processing and innovative problem-solving skills. Therefore, the authors recommend using blended flipped instruction as an effective and student-centered instructional strategy to promote higher-order thinking skills in mathematics.

III. METHODOLOGY

This study employed a quasi-experimental comparative design to investigate the relative effectiveness of three instructional strategies in teaching a selected topic in a foundation mathematics course in higher education. The research utilized pre-test and post-test measures to evaluate changes in students' conceptual understanding and overall learning outcomes after exposure to the respective teaching approaches.

The objective of the foundation program is to ensure that registered students develop the readiness required for undergraduate-level coursework, particularly in terms of conceptual understanding and problem-solving ability. Within this context, quadratic functions were selected as the focus of the study because they represent a fundamental topic in mathematics and are essential for a wide range of applications in related quantitative subjects.

The participants were students enrolled in the second-level foundation mathematics course. Three different classes, each consisting of 30 students, were assigned to different teaching strategies for the same topic. To maintain ecological validity, intact classes were used, as they reflected the institutional structure of the program and the natural classroom setting.

The three instructional strategies implemented and compared in this study were Flipped Classroom, Collaborative Problem Solving, and Blended Learning. Although the mode of delivery differed across the classes, the content covered, intended learning outcomes, and assessment methods were kept consistent throughout the same teaching period. All three instructional approaches were implemented during the third week of the teaching semester.

Table 1. Teaching strategies

Flipped Classroom	Collaborative Problem Solving	Blended Learning
Participants engaged with instructional materials, such as videos and guided notes, before class. Class time was then used for discussion, clarification, and problem-solving activities.	Participants worked in small groups to solve structured tasks under the guidance of the teacher. The teacher monitored the discussions and given timely interventions to maintain the consistency and achievement of desired outcomes.	Face-to-face instruction was combined with online and technology-enhanced interactive activities, followed by supplementary practice.

The above structure (Table 1) ensured consistency in content delivery and in the attainment of the intended learning outcomes. To support this, detailed lesson plans were prepared for each session and were discussed and approved in a prior meeting of the teachers.

The research instruments used were the pre-test and post-test scores obtained before and after the implementation of the teaching strategy. These tests assessed the students' ability to solve quadratic equations and interpret their solutions. The difficulty level and question-paper pattern were the same, and the overall consistency of the papers was maintained.

A pre-test was administered to assess students' baseline knowledge and understanding of the topic. The three teaching strategies were implemented in three different classes during Week 3 of the semester, when all classes covered the selected topic. At the end of the intervention, a post-test was administered in each class to evaluate students' improvement in conceptual understanding and to measure the effectiveness of each teaching strategy in enhancing conceptual knowledge.

IV. DATA ANALYSIS

The data collected from the pre-test and post-test were analyzed using both descriptive and inferential statistical methods. Descriptive statistics, including means and standard deviations for both tests, were used to summarize the learning gains within each group. In addition, between-group comparisons were conducted to examine the relative effectiveness of the different instructional strategies. The analysis focused on determining the most effective instructional approach for improving student achievement in the selected topic. In the data analysis section, the strategies are referred to as:

- Strategy 1 – Collaborative Problem Solving
- Strategy 2 – Flipped Classroom
- Strategy 3 – Blended Learning

4.1. Descriptive Analysis

Table 2. Descriptive Analysis

	Strategy 1		Strategy 2		Strategy 3	
	Pretest	Post-test	Pretest	Post-test	Pretest	Post-test
Mean	26.74	76.01	21.07	78.69	13.10	88.10
SD	19.90	14.88	20.94	20.47	11.45	12.55
skewness	1.54	0.18	1.21	-0.45	1.53	-0.71

The descriptive analysis results in Table 2 show that the mean scores increased from pre-test to post-test by 49.27, 56.62, and 75 for Strategy 1, Strategy 2, and Strategy 3, respectively. This indicates a significant improvement in mean scores.

Score variability was high across all three strategies in both tests, though it decreased slightly in the post-test for Strategies 1 and 3. Pre-test scores were positively skewed, indicating lower initial performance, while post-test scores were more balanced, reflecting improved student performance.

Table 3. Inferential Analysis

	n	Confidence Interval	value	p	Cohen's d_z	Remarks
Str 1	30	95%	11	<0.001	1.76	Very large effect
Str 2	30	95%	13.45	<0.001	2.46	Very large effect
Str 3	30	95%	25.39	<0.001	4.23	Very large effect

In the inferential statistical analysis, paired-samples t-tests were conducted for each strategy by comparing students' pre-test and post-test scores. The results (Table 3) show that all three instructional strategies produced statistically significant improvements in student performance. Strategy 1 was highly effective in improving students' achievement, Strategy 2 had a substantial positive impact on learning, and Strategy 3 produced the strongest improvement. Overall, the findings indicate that all three instructional strategies were effective in enhancing students' learning outcomes.

To compare the effectiveness of the three instructional strategies, an ANCOVA was conducted with post-test score as the dependent variable, strategy as the fixed factor, and pre-test score as the covariate. The following ANCOVA assumptions were checked prior to the analysis. First, the assumption of independence of observations was satisfied, as each student completed the test individually. Second, although minor deviations from normality were observed, these were not considered substantial enough to affect the analysis. Third, the homogeneity of regression slopes assumption was examined by testing the

interaction between strategy and pre-test scores, and the interaction was found to be non-significant, indicating that the assumption was met. Finally, no student attrition occurred between the pre-test and post-test administrations.
Using the ANCOVA model,

- Strategy 3 vs Strategy 1: significant, $p = .004$
- Strategy 3 vs Strategy 2: significant, $p = .048$
- Strategy 2 vs Strategy 1: not significant, $p = .313$

The pairwise comparisons showed that Strategy 3 performed significantly better than Strategy 1 ($p = .004$) and Strategy 2 ($p = .048$). In contrast, the difference between Strategy 1 and Strategy 2 was not statistically significant ($p = .313$). These findings indicate that, after controlling for pre-test performance, Strategy 3 was more effective than the other two strategies, whereas Strategies 1 and 2 did not differ significantly from each other.

V. DISCUSSION

This study shows that the type of instructional strategy really affects how well students do on their post-test, even after accounting for where they started out. The ANCOVA results make it clear: Strategy 3 outperformed both Strategy 1 and Strategy 2 by a noticeable margin. Students learned more and achieved higher scores with Strategy 3, which points to something about its methods—may be the way it gets students involved or the specific activities it uses.

What can be deduced regarding the effectiveness of Strategy 3, then? There is a high probability that Strategy 3 provides an environment that encourages students to be actively engaged, supports their ability to think critically, and increases student participation in the lesson. Such findings have been substantiated by numerous studies conducted in the field of education that concluded that an interactive learning environment facilitates the acquisition of new information.

The results of this study did not demonstrate any significant difference in the effectiveness of Strategy 1 and Strategy 2 in regard to promoting student achievement. This indicates that both Strategy 1 and Strategy 2 were equally effective in promoting student success although the two strategies were implemented differently. The implication is that both Strategy 1 and Strategy 2 produced the same instructional strategies leading to the acquisition of deep conceptual level understanding for the students and were different than Strategy 3.

Using ANCOVA to strengthen the validity of findings by controlling for the effects of students' prior knowledge through the use of pre-test scores as covariates, provides evidence that the differences found on the post-tests were more likely due to the method of instructional delivery rather than a difference in students' initial abilities.

The results indicate there is a method of implementing additional instructional strategies that could support the instructional methods used by their peers. Therefore, school districts may wish to implement additional instructional practices based on the results of this study and provide training opportunities for teachers in the implementation of these strategies.

VI. LIMITATIONS

Due to the very modest sample population for studying participants has limited generalizability; thus there should be care in drawing conclusions regarding participants in other schools, educational contexts or student cohorts than the ones studied here.

One of the reasons for limited generalizability of results is that only foundation level students participated in this study and results cannot be extrapolated to more advanced learners. It is also noteworthy that the research intervention was conducted over a relatively short time period and any potential long-term outcomes have not yet occurred; therefore any recommendations based on this research should be made with extreme caution. A limitation of this study is the variability with which instructors taught the same content as well as how classroom management was conducted; therefore the potential impact of instructional experience and classroom management on students' motivation may not be accurately captured. In addition, student motivation was not assessed by means (e.g., pre/post-tests) separate from their level of achievement so any assertions of cause-and-effect cannot be made. Other confounding variables included attendance, previous schooling, and study strategies utilized.

VII. CONCLUSION

This study examined the relative effectiveness of three instructional strategies—Flipped Classroom, Collaborative Problem Solving, and Blended Learning—in teaching a particular topic in foundation mathematics. The findings generally showed that all three strategies led to statistically significant improvements in students' performance and in the attainment of the intended learning outcomes. This demonstrates the effectiveness of each strategy in enhancing students' conceptual understanding and supporting learning in the selected topic.

The results further suggest that all three approaches can be effectively adapted for teaching this topic; however, Blended Learning appeared to be the most effective based on the data obtained in this study. This highlights the importance of adopting active, student-centered teaching approaches in foundation-level mathematics classrooms. The findings also support the integration of innovative pedagogical strategies into the curriculum.

Overall, the study demonstrates that carefully designed instructional strategies can significantly improve students' learning in foundation mathematics and play an important role in strengthening their readiness for higher education.

DECLARATION

Ethics statement

This research was conducted after obtaining prior ethical approval from the institution's Research Department (GC-RD-REC-EA-26-09). Participants' identities were kept anonymous, and they were informed of the purpose of the study. Participation in the study was voluntary.

REFERENCES

Alamri, H. A., Watson, S., & Watson, W. R. (2021). Learning technology models that support personalization within blended learning environments in higher education. *TechTrends*, *65*(1), 62–78. https://doi.org/10.1007/s11528-020-00530-3

Ali, A., Khan, R. M. I., & Alouraini, A. (2023). A comparative study on the impact of online and blended learning. *SAGE Open*, *13*(1). https://doi.org/10.1177/21582440231154417

Bhagat, K. K., Chang, C.-N., & Chang, C.-Y. (2016). The impact of the flipped classroom on mathematics concept learning in high school. *Educational Technology & Society*, *19*(3), 134–142. https://doi.org/10.30191/ETS.201607_19(3).0013

Biggs, J., & Tang, C. (2011). *Teaching for quality learning at university*. McGraw-Hill Education.

Borba, M. C., Aşkar, P., Engelbrecht, J. C., Gadanidis, G., Llinares, S., & Sánchez Aguilar, M. (2016). Blended learning, e-learning and mobile learning in mathematics education. *ZDM Mathematics Education*, *48*(5), 589–610. https://doi.org/10.1007/s11858-016-0798-4

Caulfield, J. (2011). *How to design and teach a hybrid course: Achieving student-centered learning through blended classroom, online and experiential activities*. Routledge. https://doi.org/10.4324/9781003445173

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences of the United States of America*, *111*(23), 8410–8415. https://doi.org/10.1073/pnas.13190301

Güler, M., Kokoç, M., & Önder Bütüner, S. (2022). Does a flipped classroom model work in mathematics education? A meta-analysis. *Education and Information Technologies*. https://doi.org/10.1007/s10639-022-11143-z

Kalita, K., & Nath, M. (2025). A comparative analysis of different teaching methods on student achievement in mathematics. *Shodhshauryam International Scientific Refereed Research Journal*, *8*(4), 100–117. https://doi.org/10.32628/SHISRRJ258465

Kay, R., MacDonald, T., & DiGiuseppe, M. (2018). A comparison of lecture-based, active, and flipped classroom teaching approaches in higher education. *Journal of Computing in Higher Education*, *31*. https://doi.org/10.1007/s12528-018-9197-x

Kozikoğlu, İ. (2019). Analysis of the studies concerning flipped learning model: A comparative meta-synthesis study. *International Journal of Instruction*, *12*(1), 851–868. https://doi.org/10.29333/iji.2019.12155a

Lee, S. B., & Lovvorn, H. (2016, June). Building computational thinking skills using robots with first-year engineering students. In *2016 ASEE Annual Conference & Exposition Proceedings*. American Society for Engineering Education. https://doi.org/10.18260/p.26409

Long, T., Cummins, J., & Waugh, M. (2016). Use of the flipped classroom instructional model in higher education: Instructors' perspectives. *Journal of Computing in Higher Education*, *29*(2), 179–200. https://doi.org/10.1007/s12528-016-9119-8

Mostofo, J., & Zambo, R. (2015). Improving instruction in the mathematics methods classroom through action research. *Educational Action Research*, *23*(4), 497–513. https://doi.org/10.1080/09650792.2015.1019903

Nantha, C., Pimdee, P., & Sitthiworachart, J. (2022). A quasi-experimental evaluation of classes using traditional methods, problem-based learning, and flipped learning to enhance Thai student-teacher problem-solving skills and academic achievement. *International Journal of Emerging Technologies in Learning*, *17*(14), 20–38. https://doi.org/10.3991/ijet.v17i14.30903

Pimdee, P., Sukkamart, A., & Nantha, C. (2024). Enhancing Thai student-teacher problem-solving skills and academic achievement through a blended problem-based learning approach in online flipped classrooms. *Heliyon*, *10*(7), e29172. https://doi.org/10.1016/j.heliyon.2024.e29172

Savery, J. R. (2006). Overview of problem-based learning: Definitions and distinctions. *Interdisciplinary Journal of Problem-Based Learning*, *1*(1), 9–20. https://doi.org/10.7771/1541-5015.1002

Sya'roni, A. R., Inawati, P. A., & Guswanto, E. (2020). Students' creative thinking skill in the flipped classroom-blended learning of mathematics based on lesson study for learning community. *Journal of Physics: Conference Series*, *1563*(1), 012046. https://doi.org/10.1088/1742-6596/1563/1/012046

Tabieh, A. A. S., & Hamzeh, M. (2022). The impact of blended-flipped learning on mathematical creative thinking skills. *Journal of Education and e-Learning Research*, *19*(3), 121–130. https://doi.org/10.9743/JEO.2022.19.3.15

Tan, C. S., Zakuan, N., & Abd Aziz, M. I. (2022). Recent trends of blended learning and flipped classroom in Malaysia. *Arab World English Journal (AWEJ)*, *2*(2nd Special Issue on Covid 19 Challenges), 290–301. https://doi.org/10.24093/awej/covid2.19