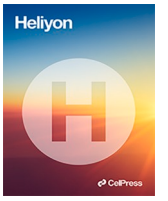
Heliyon 10 (2024) e29172

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon



Research article

Enhancing Thai student-teacher problem-solving skills and academic achievement through a blended problem-based learning approach in online flipped classrooms

Paitoon Pimdee [a], Aukkapong Sukkamart [a,*], Cherisa Nantha [b], Thiyaporn Kantathanawat [a], Punnee Leekitchwatana [a]

[a] School of Industrial Education and Technology, King Mongkut's Institute of Technology Ladkrabang (KMITL), Bangkok, Thailand
[b] Faculty of Technical Education, Rajamangala University of Technology Thanyaburi (RMUTT), Pathum Thani, Thailand

ARTICLE INFO

Keywords:
Academic achievement
Blended learning
Online flipped classroom
Problem-solving skills
Student-teachers
Thailand

ABSTRACT

The study aimed to develop a learning model that enhances Thai student-teacher problem-solving skills (PSS) and academic achievement (AA) through a blended problem-based learning (PBL) approach in online flipped classrooms. Phase 1 consisted of the design of the Flipped PARSER (problem-attempt-research-solutions-evaluation-reflect) Model (FPM) through the study of documentation and research. Phase 2 involved using nine experts to assist with the model's development and evaluation using in-depth interviews and content analysis. Phase 3 involved the application and use of the FPM by 30 student-teachers, from which their AA, PSS, and satisfaction were evaluated against the control group of 31 participants. The results from the nine experts' input on the FPM design were significant. Instructor activities included selecting content, media, materials, and their design and development. Other components included learning activities, tools, lesson delivery, and evaluation. Also, PBL methods were again confirmed as an instrumental pedagogy in teaching PSS. When combined with online learning and flipped classrooms, the study's results were higher than those using traditional classroom methods. The study contributes to the literature by determining that online teaching models effectively teach PSS and raise AA scores.

1. Introduction

Recent educational studies have explored new learning models to overcome the challenges posed by the multi-year COVID-19 pandemic [1]. In Thailand, the education sector has adopted a *New Normal*, with traditional classrooms being replaced by online courses accessible via digital devices like smartphones [2]. However, the transition to online learning could have been smoother, with many learners unhappy with the change and educators unprepared to deliver content online [3]. There are documented challenges related to rural learners' academic achievement, access to information communications technology (ICT), and reliable broadband connections [4,5].

Fortunately, the flipped classroom model has been proven to be a cost-effective solution for online learning [6], enabling learners to

* Corresponding author.
E-mail addresses: paitoon.pi@kmitl.ac.th (P. Pimdee), aukkapong.su@kmitl.ac.th (A. Sukkamart), cherisa_n@rmutt.ac.th (C. Nantha), thiyaporn.ka@kmitl.ac.th (T. Kantathanawat), punnee.le@kmitl.ac.th (P. Leekitchwatana).

https://doi.org/10.1016/j.heliyon.2024.e29172
Received 14 May 2023; Received in revised form 22 March 2024; Accepted 2 April 2024
Available online 3 April 2024

choose when, where, and how they learn. This allows FC instructors to focus on problem-solving exercises and complex content [7], leading to the emergence of the role of "knowledge facilitators" for teachers [4]. Personalized and student-centered learning becomes possible [2,8–10] when learners return to the classroom.

FCs and models like PBL are seen as a classroom engines to achieve specific goals [11]. Additionally, under the social distancing requirements and the need for online education during the pandemic, FCs and blended became even more widespread [12,13]. Researchers have found that students who spend time in FCs can master their learning, especially when combined with other pedagogies like BL and PBL, allowing learners to choose their content [14,15]. Teachers become knowledge facilitators in FC settings, leading to in-class discussions and activities with relevant materials, focusing on student-centered learning [16].

FCs use blended learning to achieve specific educational goals, especially in the context of social distancing requirements during the pandemic [11–13]. Students who spend time in FCs receive maximum value for their time and can master their learning, especially when combined with other pedagogies such as PBL [14,15]. Teachers coach and facilitate knowledge in FC settings, allowing active and collaborative student-centered learning [16]. Out-class activities are flipped into self-paced active learning using online materials, with learning management systems managing material use, communications, and assessment [17]. Stakeholders have reported positive attitudes toward FC experiences, including peer interaction, learning materials, and student assessment [18,19].

PBL is an effective pedagogy for teaching 21st-century skills such as problem-solving, especially when combined with SDL [20]. PBL lessons can be implemented in various ways, such as using the European Maastricht *seven jump* process [21,22] (Fig. 1).

2. Literature review

This section contains an overview of the theory and literature on using online flipped classrooms, problem-based learning, blended learning, problem-solving skills, and academic achievement.

2.1. Flipped classrooms (FC)

In recent years, the flipped classroom has become increasingly popular as an educational pedagogy for promoting student motivation and online learning [23]. FCs move the lecture process outside the classroom, and its core idea has been expanded and explored with newer mediums, platforms, and devices. In Thailand, FCs have effectively taught STEAM classes, computational thinking, analytical thinking, 21st-century information literacy, and online active learning [24–28]. FCs are frequently combined with blended learning as new models for both in-class and out-of-class teaching (Table 1 and Fig. 2). Flipped classroom use has increased dramatically in recent years due to the social distancing requirements established by most educational institutions during the global COVID-19 pandemic [29,30].

FCs use video clips viewed by students from home on digital devices, with the option of cloud-based platforms like YouTube or LMSs such as Schoology or Moodle Cloud. Classroom time is used for reviewing and practicing the flipped homework/lecture, replacing traditional in-class lectures. Luo et al. [32] divided out-class activities into pre-class and post-class, while Tomas et al. [31] separated teacher activities into preparation for out-class and in-class materials. Talbert [33] suggests inverting Bloom's Model for flipped-classroom environments, and the authors' adapted Bloom pyramid [34] has students develop lower-level skills at home and higher-order thinking skills through in-class activities (Fig. 2).

2.2. Problem-based learning (PBL)

Problem-based learning involves several steps: problem identification, definition, investigation, reflection, evaluation, application,

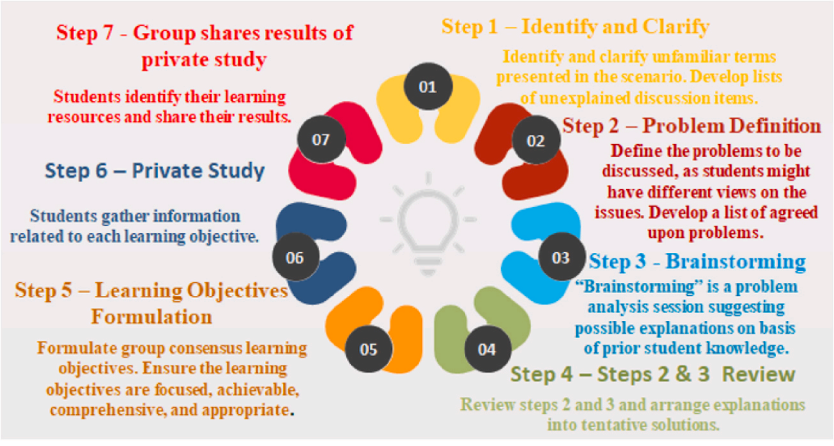


Fig. 1. The Maastricht 7-step PBL learning method.
Source: Adapted from Wood [22].

Table 1
Flipped in-class and out-class activity discussions.

Activities	Bergman and Sams [8]	Flores et al. [18]	Uskokovic [13]	Tomas et al. [31]	Luo et al. [32]
In-class	✓	✓	✓	✓	✓
Out-class	✓	✓	✓	✓	✓
Pre-class	✓	✓	✓		✓
Post-class					✓

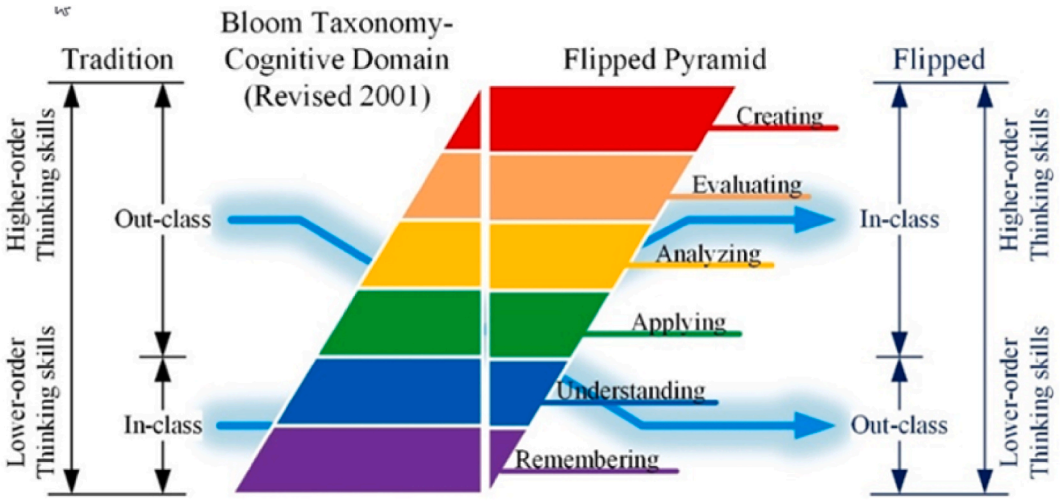


Fig. 2. Bloom's revised taxonomy - cognitive domain (revised 2001) - the flipped classroom.
Sources: [33,34].

objective definition, data collection, summarization, and synthesis [35–38]. Different researchers have suggested varying numbers of steps, with some concluding that only four steps are necessary: problem definition, research, implementation, and reflection and evaluation [39]. PBL challenges students to cope with real-life problems and motivates them to apply their knowledge to future work [40]. However, in Qatar, Al Said et al. [41] identified math teachers' difficulties in implementing PBL in their classrooms, citing a lack of confidence, issues with developing student collaboration abilities, homework issues, and limitations from school and peer support. These findings suggest a need for new forms of problems and approaches to resolving them, such as more direct instruction and greater teacher autonomy in undertaking PBL.

Other researchers have focused on PBL's implementation step in which students use their research to solve real-world problems [39,42]. However, many others have detailed how problem identification and definition are essential elements in PBL activities [35, 37,38,43]. Contemporary Thai scholars such as Chinchua et al. [9] have seen the importance of PBL and its use for increasing programming self-efficacy (PSE) through gamification.

Elsewhere, in addition to BL methods and FCs, other studies have pointed to their use in PBL [44], in online PBL in marketing research courses [7], teaching algebra [45], teaching digital photography [46], increasing PSS through educational games that teach computer programming courses [47], and robotics programming [48]. Kraiklang et al. [49] also reported that PBL use was successful when applied to Thai 9th graders in science problem-solving abilities. Panjan [50] also reported success with PBL when used in STEM promotion workshops using computational thinking and robotics for pre-engineering students.

Table 2
Problem-based learning procedures overview.

PBL Learning Steps	Guilford [36]	Weir [37]	Schmidt [38]	Woods [39]	Wood [22]	Maudsley [42]	Blayney [43]
Problem identification	✓	✓	✓				✓
Problem clarification	✓	✓	✓	✓	✓	✓	✓
Problem analysis/solutions			✓				
Investigation and research	✓	✓	✓	✓	✓	✓	✓
Objective definition			✓			✓	✓
Implementation				✓		✓	
Data collection and summarization			✓				
Data synthesis			✓				
Reflection and evaluation	✓	✓		✓	✓	✓	✓
Application	✓				✓		

Therefore, from the lengthy and detailed review of PBL literature, the authors concluded that there were ten core problem-solving skills development procedures. These were 1) problem identification, 2) problem clarification, 3) problem analysis and problem solutions using prior knowledge, 4) investigation and research of new knowledge, 5) objective definition, 6) implementation, 7) data collection and summarization, 8) data synthesis, 9) reflection and evaluation, and 10) application (Table 2).

2.3. Blended learning (BL)

According to Bizami et al. [51], BL has become a commonly accepted method for integrating face-to-face classroom learning with online learning, especially in higher education in recent years, due to Internet accessibility and more affordable ICT systems and digital devices as smartphones [52]. These points are consistent with a study from Sothayapetch and Lavonen [53], who found BL compelling when combined with online teaching for Thai and Finn primary school science students. It was also pointed out that all the teachers surveyed felt that educational technology should be used as much as possible for the learning environment to be effective. Numerous studies have also proven blended learning effective in raising student scores and increasing academic achievement, especially when combined with Internet/Web-related technologies [54], such as Moodle [55,56].

2.4. Problem-solving skills (PSS)

Schmidt and Moust [57] presented a seven-step process for learning management using problem-based methods. This involves understanding the terms and concepts in the problem, accurately capturing critical information, analyzing the problem through group brainstorming, finding explanations, setting learning objectives, searching for information from various sources, applying knowledge to analyze and correct hypotheses, and summarizing conclusions and principles.

Furthermore, Table 3 presents an overview of multiple PSS studies and which factors were the main themes in each. The authors' evaluation concluded that there were four predominant themes in the PSS literature [58–61]. These were analyzing, researching, decision-making, and planning & practice skills.

2.5. Academic achievement (AA)

In the context of Thai academic achievement, incorporating problem-based learning (PBL) and blended learning can be effective strategies for improving student outcomes. Banic and Gamboa [21] demonstrated that combining PBL with 3D design techniques in computer science courses can lead to higher academic achievement than traditional teaching methods. This highlights the importance of using innovative teaching methods and technology to engage students and facilitate their learning.

Moreover, the study conducted by Adebola and Ademola [62] in Nigeria showed that the teaching materials and learning environment also play a significant role in academic achievement, particularly in mathematics. This suggests that creating a supportive learning environment with appropriate resources and innovative teaching methods can positively impact student performance.

Blended learning, which combines traditional face-to-face instruction with online learning, can also enhance student achievement. Blended learning provides students more flexibility in terms of time and place of learning and can facilitate more personalized learning experiences [28].

Therefore, incorporating PBL and blended learning in the Thai educational system can be a promising way to address the challenges of low academic achievement and improve student outcomes [59]. By leveraging innovative teaching methods and technology, providing appropriate resources and support, and creating a flexible and engaging learning environment, students can be empowered to achieve their full potential.

2.6. Integration of blended problem-based learning and flipped classrooms

Flipped learning involves reversing (flipping) the traditional classroom model [8,63]. Normally, this involves the introduction of

Table 3
PSS literature review evaluation.

PSS	Indeed Editorial Team [58]	Organization for Economic Cooperation and Development [59]	Hapha [60]	Kruthgat [61]
Active listening	✓			
Analyzing	✓	✓	✓	✓
Researching	✓	✓	✓	✓
Creativity	✓	✓		
Communications	✓			
Dependability	✓			
Decision making	✓	✓	✓	✓
Teamwork	✓		✓	
Presentation			✓	
Application			✓	
Planning & Practice			✓	✓
Evaluation				✓

class material outside the classroom, which is often times achieved by watching video [64,65]. Class time is then used for active learning, discussions, and hands-on activities.

On the other hand, *blended learning* combines traditional face-to-face instruction with online components [28,66,67]. This approach provides flexibility for students to engage with course material and collaborate with peers online while also benefiting from in-person interactions with instructors.

Problem-based learning is an active learning method in which students learn by solving real-world problems [9,68,69]. PBL has also been a frequently used to place the student at the center of learning [70], in which they are given open-ended problems to solve which is a self-direct learning (SDL) educational approach [27,71].

In Indonesia, Kardipah and Wibawa [72] developed an undergraduate computer application course based on *PBL* and a *flipped/-blended learning* environment. The authors noted several significant improvements from the model's use. These included performance improvement, greater challenges and motivation, and the ability to free up classroom time. Similarly, in Morocco, a *blended learning model* was combined with *flipped-classroom* for use in vocational training [66]. The authors reported that the strategy also increased classroom training time and improved the efficiency and performance, needs, and self-learning skills of the pre-service teachers involved. In Ireland, a FC was used with PBL to teach a computer programming course [73]. The authors noted that a combined FC-PBL is effective in making use of new learning technologies, while supporting authentic learning though collaboration and team work.

In 2020 in a 400-student Faculty of Law program in New Zealand, researchers combined *PBL, blended learning,* and a *flipped classroom* to instruct a five-module based course [74]. Furthermore, the authors stated that learning should be student-centered which occurs in small groups. Additionally, the instructor acts as a facilitator who guides the learning process with an authentic problem before students begin their studies. Finally, the problem acts as a tool to achieve the knowledge and skills necessary to resolve problems in relevant professions, with new information being acquired through self-directed learning.

In another law program in the United States, *blended learning* was once again combined with a *FC* to deliver online law lectures. The stated advantages for this delivery method were its ability to offer both face-to-face and online elements, while reducing the faculty's delivery costs which was very attractive to the institution's administrators [65]. This then led to the school's ability to reduce graduate education costs.

In another from Indonesia, the authors commented on how the COVID-19 pandemic had changed their country's medical education system and its transition to the use of PBL methods using an online FC [64]. Moreover, the authors reported multiple student sensitives to the new process, one of which was that 1.5 h was viewed as the maximum comfortable learning time per session. From the instructor's perspective, FC teaching requires different pedagogic training from conventional classes and the learning objectives require appropriate supporting media and activities.

Furthermore, integration of PBL with a flipped-blended model usually involved several phases [64,66,72]. These include the flipped component, where students are given resources to learn about a specific topic or problem related to their course. Instead of passive learning, they are encouraged to engage critically with the material [75].

In the classroom phase, students work on real-world problems related to the topic they studied beforehand [9,68]. They collaborate in small groups to analyze, discuss, and propose solutions to these problems [25,76]. The instructor acts as a facilitator, guiding students and providing support when needed [77].

In the assessment and reflection phase, assessment is based on problem-solving abilities, critical thinking, and application of knowledge to practical situations. Students reflect on their learning process, identify areas for improvement, and refine their problem-solving skills [78].

The benefits of merging the various approaches promotes active engagement, critical thinking, and problem-solving skills. It allows for more personalized learning experiences, as students can progress at their own pace during the flipped phase. Collaboration and teamwork are emphasized in the classroom phase, preparing students for real-world challenges. However, properly structuring the flipped content and ensuring students are adequately prepared can be challenging. Faculty may require training to effectively facilitate PBL activities, while PBL assessment can be subjective and time-consuming.

The description of flipped learning, blended learning, and problem-based learning is based on established pedagogical principles and practices in higher education [72,74,75]. Integrating these approaches can be highly effective, but it's essential to design the curriculum carefully and ensure that students receive the necessary support and guidance to succeed in this environment. It's also important to align the learning objectives with the chosen model and continually assess and adapt the teaching methods to optimize student learning outcomes.

2.7. Research problem

In 2020, researchers surveyed TVET undergraduate students from southern Thailand's Yala, Pattani, Narathiwat, and Songkhla provinces to understand their needs. The participants indicated they required new solutions to improve their 21st-century skills and academic achievement. This was especially concerning given the poor economic conditions and ongoing civil unrest in the predominantly rural region. Additionally, the COVID-19 pandemic has disrupted educators' ability to teach problem-solving skills and academic achievement for over two years. As a result, a new normal in the education sector has emerged globally, with online and distance learning becoming the norm [30]. Therefore, the researchers wanted to investigate whether the online classroom model could improve problem-solving skills and student-teacher achievement given these challenges.

2.8. Research objectives

1. To conduct a qualitative literature review to identify which components of an online flipped classroom learning management model are most effective in increasing academic achievement problem-solving skills through a blended problem-based learning approach in online flipped classrooms.
2. To evaluate and assess the effectiveness of the developed learning management model through input from a student-teacher control group and an experimental group.

2.9. Research Hypothesis

Student teachers in the experimental group have higher academic achievement (AA) and problem-solving skills (PSS) than those in the control group.

3. Methods

3.1. Mixed methods research

3.1.1. Overview of mixed-methods research

The study employed a mixed-methods sequential exploratory approach, aligning with Tashakkori and Teddlie's categorization of mixed methods into four primary designs – Triangulation Design, Embedded Design, Explanatory Design, and Exploratory Design.

3.1.2. Quantitative component (Explanatory Design)

The initial phase involved a systematic review of the literature, a quantitative method aiming to identify existing support for the use of the online flipped classroom (OFC) pedagogy combined with problem-based learning (PBL) in a blended learning (BL) environment. This method contributed quantitative data to the research.

3.1.3. Qualitative component (Exploratory Design)

Subsequently, the study progressed to the qualitative phase, employing a case study approach to evaluate the learning model. This involved gathering qualitative data through interviews, surveys, and observations, providing insights into the experiences and perceptions of Thai student-teachers using the proposed approach.

3.1.4. Justification for mixed-methods approach

The mixed-methods approach was strategically chosen to obtain a comprehensive understanding of the research question. By combining quantitative data from the systematic literature review with qualitative data from the evaluation of the learning model, the study aimed to identify factors best suited for the proposed approach and assess its potential impact on problem-solving skills (PSS) and academic achievement (AA) among Thai student-teachers.

In the case of the flipped classroom research study by García-Ruiz et al. [79], the researchers used a mixed-methods approach to evaluate which factors were best suited for a learning model that could be used for increasing PSS and AA of Thai student-teachers.

The systematic review of the literature was one component of the mixed-methods approach. A systematic review is a research study that uses a structured and rigorous process to identify and analyze all relevant literature on a specific topic. In this case, the systematic review was conducted to determine whether there was existing support for the use of an FC pedagogy combined with problem-based learning in a blended learning environment. This study component was a quantitative method of data collection and analysis.

The other component of the mixed-methods approach was evaluating the learning model, a qualitative data collection and analysis method. The researchers used a case study approach to evaluate the learning model, which involved collecting data from multiple sources (e.g., interviews, surveys, and observations). The collected data from these sources were then analyzed using qualitative methods to identify patterns and themes that emerged from the data.

Using a mixed-methods approach, the researchers gathered both quantitative and qualitative data to provide a more complete understanding of the research question. The systematic literature review provided quantitative data on the existing support for the FC pedagogy combined with PBL in a blended learning environment. In contrast, the evaluation of the learning model itself provided qualitative data on the experiences and perceptions of Thai student-teachers using this approach. Combining these two methods allowed the researchers to understand the factors best suited for the learning model and its potential impact on PSS and AA of Thai student-teachers.

3.2. The qualitative research (phases 1 + 2)

The qualitative research involved studying documents and other research leading to the development of the teaching model using a combination of blended problem-based learning and flipped classrooms.

3.2.1. Phase 1 – FPM conceptual development

In Phase 1, the focus was on the conceptual development of the Flipped PARSER Model (FPM). This involved the retrieval and analysis of existing literature on flipped learning, problem-based learning (PBL), and blended learning (BL) to create a model that

enhances problem-solving skills (PSS) and academic achievement (AA) among student-teachers. Various resources such as documents, textbooks, articles, and research articles from both Thai and international sources were utilized for this analysis.

The criteria for selecting literature included documents published between 2015 and 2020, sourced from databases like the ACM Digital Library, ScienceDirect, SpringerLink, Web of Science, and Elsevier. A total of 70 items were initially identified and downloaded. Subsequently, a form was employed to conduct content analysis, and the findings were then analyzed and synthesized.

3.2.2. Phase 2 – FPM development and evaluation

Building upon the conceptual framework, principles, and methods derived from Phase 1's qualitative data and content analysis, critical information was synthesized to create a draft model. This model focused on the design and development of the Flipped PARSER Model (FPM), incorporating the elements of problem-attempt-research-solutions-evaluation-reflect.

To evaluate the effectiveness of the Flipped PARSER learning management model, it was tested on Thai student-teachers, aiming to enhance their problem-solving skills and academic achievements. The researcher collected data by collaborating with experts. The Flipped PARSER model, along with an evaluation form, was submitted to nine experts. An online small group meeting via Zoom was scheduled, during which the experts considered and provided suggestions on the model. Experts expressed their opinions by completing a form evaluating the appropriateness of the Flipped PARSER model.

3.3. Suitability analysis

3.3.1. FPM suitability evaluation

The assembled panel of experts was selected using purposive sampling and met via Zoom in 2021. The panel had expertise in technology, educational technology, communications education, measurement and evaluation, education course development, and computer engineering. All panel members had obtained a Ph.D. and had at least five years of relevant lecturing experience in a Thai higher education institution.

3.3.2. FPM suitability evaluation instruments

The research instrument was the FPM's suitability assessment form, which used a five-level scale to assess each expert's opinion on three aspects. These aspects were the model's suitability, the component's suitability, and the procedure's suitability. A typical assessment tool used for suitability assessment is the index of item-objective congruency (IOC). From the IOC use, values for the model were determined to be 0.80–1.00, which is above the recommended minimum of 0.50.

3.3.3. FPM suitability evaluation measurement criteria

Furthermore, the model's evaluation of the experts' and students' opinions used the mean average and standard deviation (SD) to assess their level of agreement [80]. The 'highest' agreement was indicated by a '5', which used 4.50–5.00. This was followed by a

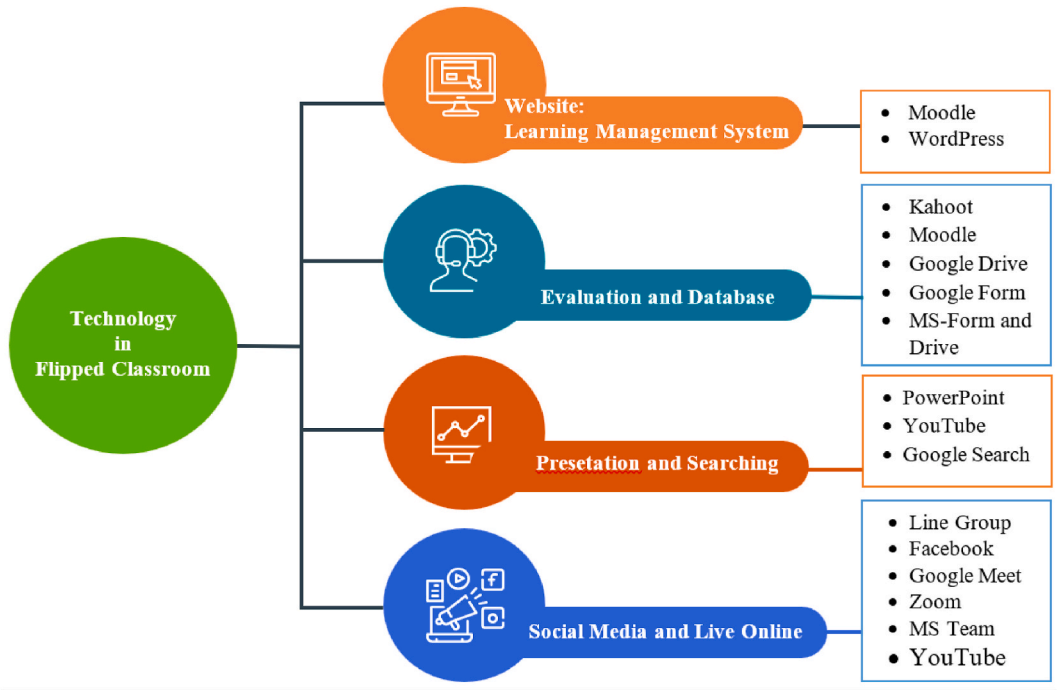


Fig. 3. Online flipped classroom technologies and environments.

'high' agreement with a '4' and 3.50–4.49 mean values. 'Moderate' agreement used a scale value of '3' and mean values of 2.50–3.49. 'Little' agreement used a '2' and mean values of 1.50–2.49. Finally, the 'no' agreement was indicated with a '1', with mean values of 1.00–1.49.

3.4. Quantitative research (phase 3)- FPM student-teacher evaluation

The model was tested with a sample group of student teachers to collect quantitative data, which is represented by the study's aspects of academic achievement (AA) and problem-solving skills (PSS).

3.4.1. Student-teacher evaluation of the FPM's use

The population for the study's model evaluation was the first-year undergraduate students in a Bachelor of Education program in a Thai private university's Faculty of Education and Liberal Arts in the 2021 academic year. Students were selected using random clusters and systematic random sampling from four disciplines for the final 61 student-teacher samples, including students majoring in the Thai language, science, society, and primary education. In the final sampling phase, a lottery method was used to select the 30-member experimental group (odd numbers) and the 31-member control group (even numbers).

3.4.2. Research tools used for student-teacher FPM use evaluation

The authors utilized various research tools to evaluate the use of the FPM in a learning innovation course using digital media (LICDM) with Thai student-teachers. First, they developed a LICDM Learning Management Plan, consisting of 20 h of content, which incorporated the FPM. The plan was expertly assessed and received the highest ranking.

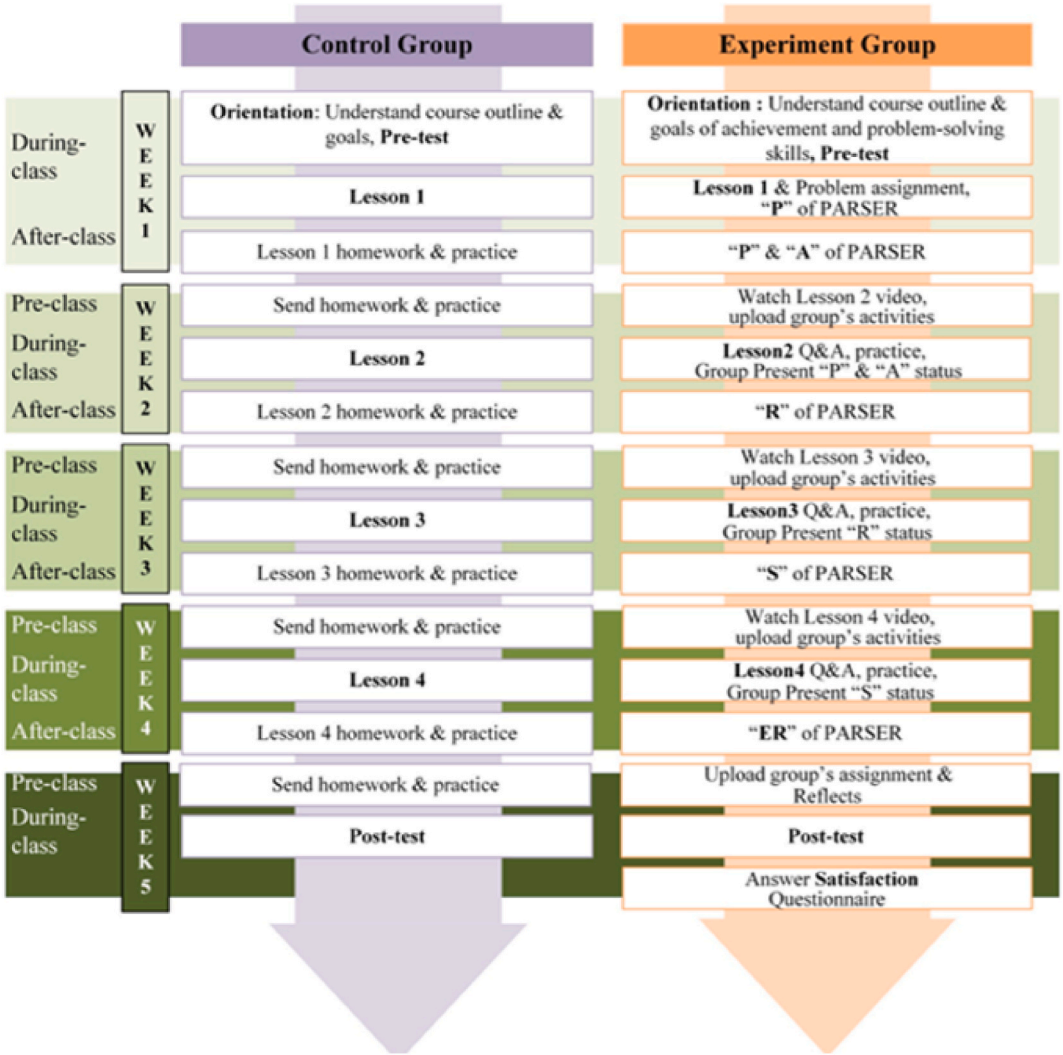


Fig. 4. Experimental activities.

The authors used the ADDIE Model to develop the course, a systematic process for developing effective and efficient instruction [81]. The ADDIE Model helps in carefully planning and designing the course, ensuring that it is tailored to the needs of the students. Moodle was the learning management system to deliver the course content. Moodle is an effective tool for both in-class and online learning, allowing teachers to create and share teaching materials, integrate cloud-based video hosting platforms, and facilitate communication through chat rooms [55,56].

The quality of the process was evaluated by a panel of educational experts and deemed to be of the highest level. Using these research tools and instructional design techniques, the authors could effectively implement the FPM in their *learning innovation course using digital media* (LICDM) and evaluate its impact on student-teacher performance (Fig. 3).

3.4.3. PSS and AA student-teacher assessment

Various cloud-based and software tools were used to assess each student-teacher PSS. These included OBS Studio, KineMaster, and their use and understanding of the Moodle LMS [55]. The learning innovation course using digital media used an academic achievement test with five options covering three levels of cognition. These included remembering, understanding, and applying [34]. Their index of conformity (IOC) was 0.67–1.00, difficulty was 0.20–0.80, and discrimination power was 0.76.

Furthermore, the learning innovation course using digital media consisted of material focused on four areas, including analysis, researching, decision-making, and planning and practice [58–61], which was characterized as a 4-level Rubrics scoring system having IOC consistency values between 0.83 and 1.00, a difficulty value between 0.23 and 0.77, and an Inter-Rater Reliability value for determining the consistency between each other with a Kappa coefficient equal to 0.73.

3.4.4. Student-teacher satisfaction assessment

The study used a student-teacher satisfaction assessment form for the FPM. According to the model, a 5-level Likert evaluation scale measured their opinions on teachers, teaching media and technology, teaching strategy, teaching activities, measurement and evaluation, and the learning process. The IOC consistency values for the form were between 08.0 and 1.00.

3.4.5. Collection and analysis of data

The experiment was conducted using Thai student-teachers in a control group of 31 individuals and an experimental group of 30 individuals who participated in a five-week learning innovation course using digital media (LICDM) in the 2021 academic year (Fig. 4). The experimental group used the FPM to learn, while the control group used a traditional lesson plan, which consisted of face-to = face teaching with lectures, PowerPoint slides, and video clips.

Before the course started and after its end, each group was given a PSS and AA assessment examination. The data input was analyzed using a one-way MANOVA analysis and descriptive statistics (mean and standard deviation) for the student satisfaction assessment of their FPM use.

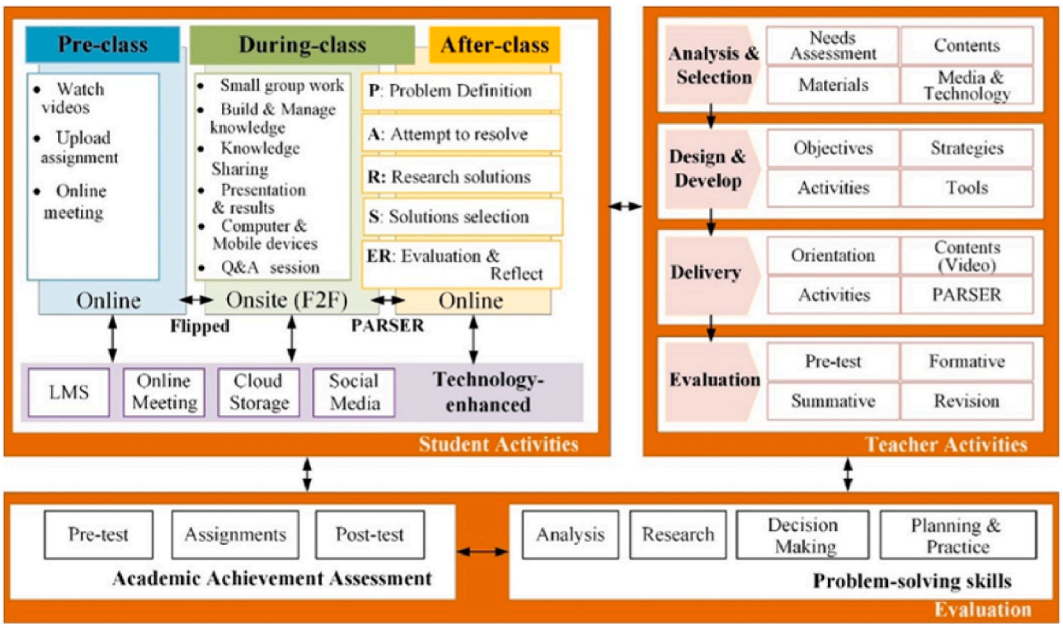


Fig. 5. The FPM for student-teacher problem-solving skills and academic achievement.

4. Results

The study's results identified three core components of the FPM class: teacher activities, student activities, and an evaluation phase. These components were determined through an online Zoom focus-group discussion with the assistance of nine educational experts. Fig. 5 visually represents the FPM class phases and associated AA and PSS activities.

4.1. Teacher activities

Fig. 6 details the FPM teacher activities and their four steps. These include a needs assessment and selection, design and development, delivery, and evaluation.

4.1.1. Needs assessment analysis

First, a needs assessment analysis is conducted for the learners' context and needs. Later, the content analysis and selection are made to define each course outline. After that, materials, media, and technology are selected for proper and efficient learning materials and technologies.

4.1.2. Design and development

Second, the instruction is designed and developed with all instruction components defined. This included the learning objectives, teaching strategy, learning activities, and learning and evaluating tools.

4.1.3. FPM instruction delivery

Third, an orientation session for the experimental group of student-teachers was used to clear all the learning objectives of the FPM and the potential learning experiences that the student-teachers might encounter both online and on-site. After that, FPM videos and content lectures were delivered to students using digital tools such as Moodle Cloud LMS, cloud storage, and social media platforms. The next FPM step was given to the group at each weekly session's completion. This allowed the student-teachers to participate in after-class activities such as online discussions, brainstorming, researching, and collaboration.

4.1.4. PSS and AA evaluation

Finally, PSS and AA evaluations are conducted during the course. There is a pre-test *(M_{AA}=34.78)*, formative assessment (exercise) *(M_{AA}=72.43, M_{PSS}=79.27)*, and summative assessment *(M_{AA}=60.14, M_{PSS}=68.77)*. After that, teachers can evaluate their instruction for revision.

4.2. Student-teacher activities

The students had three group activities (pre-class, during, and after class) (Fig. 7).

4.2.1. Pre-class orientation and FPM problem scenario assignment

The course outline and objectives were introduced to the experimental group in a student-teacher orientation session, followed by the introduction and review of online tools and learning management systems for each small group of 5–6 individuals. The students were then assigned an FPM problem scenario with procedures defined.

The pre-class activities involved watching content videos, uploading assignments, and online meetings with peers or the teacher for questioning and brainstorming. The in-class activities consisted of small work groups collaborating to gather and manage knowledge and sharing their progress through presentations on their problem-solving skills (PSS). The teacher addressed questions from the pre-

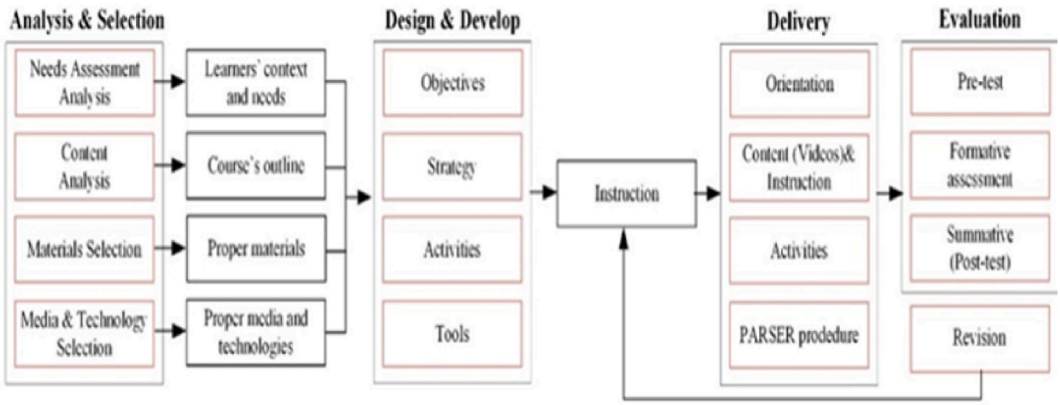


Fig. 6. The FPM teacher activities.

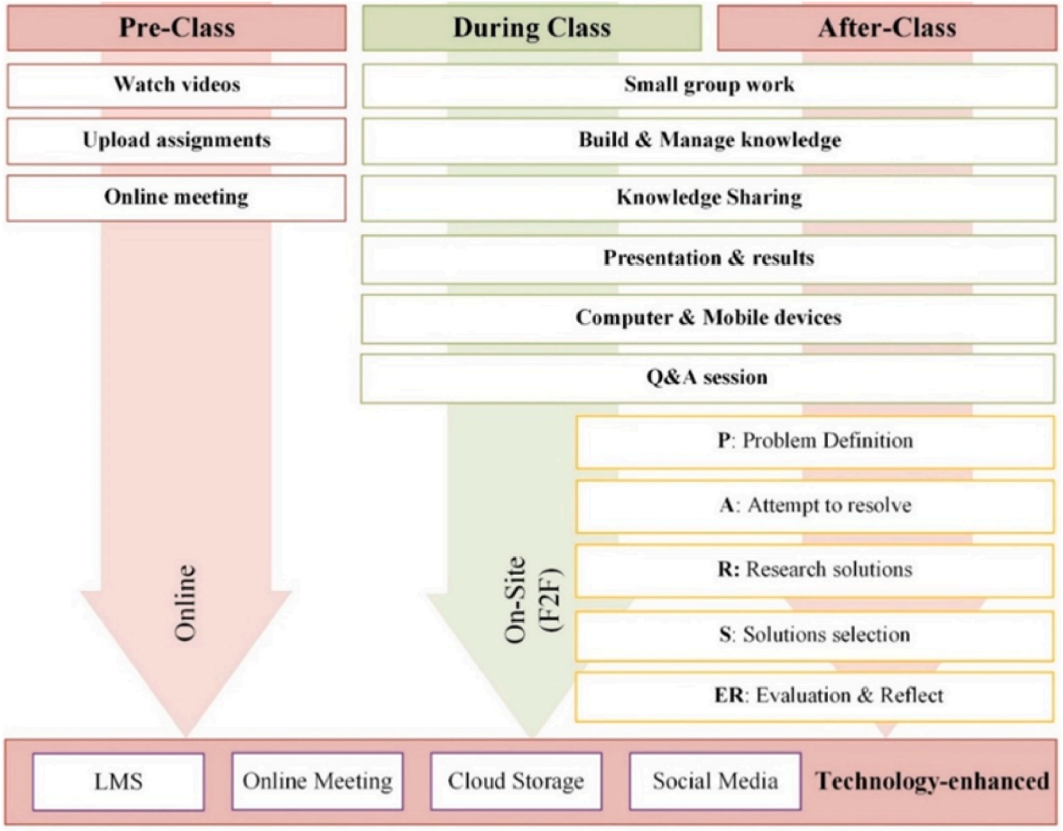


Fig. 7. The FPM student activities.

class activities during Q&A sessions.

At the end of each session, new FPM steps were assigned for the following week's class, and absent group members could review the session through Moodle LMS or social media for continued learning and interaction with peers.

The PARSER procedures included five steps to guide the experimental group's problem-solving process: problem definition, attempt to resolve, research solutions, solutions selection, and evaluation and reflection. In the problem definition step (**P**), the group worked to define the assigned problem scenario and utilized online digital tools to aid their teamwork. The attempt to resolve step (**A**) involved each member using their previous knowledge and experiences to solve the problem and exchanging knowledge with the group through discussion, analysis, and brainstorming. In the research solutions step (**R**), each member researched and explored possible solutions online, which were then shared and defended within the group. The solutions selection step (**S**) required the group to discuss and select the best solution for a group presentation to the class, where the group representative presented the selected solution and supporting evidence. The final step, evaluation and reflection (**ER**) involved the students evaluating their **PARSER** experience, reflecting on their solutions, and discussing their PSS learning process with the teacher.

4.2.2. Course details

The experimental student-teacher course titled 'Digital Media and Learning Innovation' was conducted in the 2021 academic year over a five-week period. Each week contained a 4-h session which totaled 20 h instruction and participation. The experimental group was instructed using steps as described in the Flipped PARSER model, while the control group learned using the normal teaching plan, with both groups studying all the content according to the teaching plan. The researchers then evaluated the academic achievement

Table 4
Overall and individual aspects classify the FPM's mean, SD, and suitability.

Aspects	Experts (n = 9)		Suitability Level
	$\bar{x}$	SD	
Format/method of learning management	4.08	0.10	High
Learning management model components	4.13	0.21	High
Learning management model process	4.17	0.09	High
Summation	4.13	0.19	High

(AA) and problem-solving skills (PSS) of both groups of students (Fig. 4).

4.2.3. FPM appropriateness evaluation

The FPM appropriateness questionnaire consisted of a 5-level Likert scale used to evaluate and certify the FPM by nine qualified educational experts. The assessment was undertaken using both the mean ($\bar{x}$) and SD (Table 4), from which it was determined that the overall FPM was evaluated at a *high* level ($\bar{x} = 4.13$, SD = 0.19) by the experts.

4.2.4. FPM TryOut

Table 5 shows that the experimental group's use of the FPM had higher mean scores of AA and PSS than the control group. It was also statistically significant at the 0.01 level.

However, the determination of a statistically significant increase needed to be clarified. Therefore, further testing was done using the one-way MANOVA statistic. Therefore, before the testing, the researchers conducted further testing using Table 6.

Table 7 details the ANOVA multiple testing to compare AA and PSS of the experimental and control group student-teachers.

4.2.5. FPM student-teacher satisfaction

Table 8 shows that there was overall a high level of student-teacher satisfaction with their use of the FPM ($\bar{x} = 4.41$, SD = 0.66). Of the five FPM steps, Step 5 (evaluation and reflection) was considered the most satisfying ($\bar{x} = 4.60$, SD = 0.60). This was followed by Step 3's research solutions ($\bar{x} = 4.45$, SD = 0.620).

5. Discussion

Higher education faces various challenges beyond the impact of the COVID-19 pandemic. These challenges include issues such as rural poverty, civil unrest, student protest [82], student mental health [83], unstable ICT infrastructure [4,5], high ICT costs, inadequate training for educators and students, and continued reliance on traditional, teacher-centered instructional approaches [84,85].

However, what can be directly contributed to the pandemic is the accelerated requirement for online education and distance learning [30]. However, this has thrown the teachers and students into the fire, ill-prepared to meet the challenges. Too many school systems expect the students and educators to shelf-teach' themselves into what is needed to participate in online learning.

From the pandemonium, countless educators reached out for new methods to implement the new requirements. Fortunately, numerous studies have already been conducted on newer, non-traditional pedagogies and models for use in online learning [86]. These have included flipped classrooms using various learning methods, including blended, inquiry-based, problem-based, student-centered, and online/distance learning [2,4,7,10,14,79,87].

This study highlights the importance of utilizing a combination of teaching and learning methods to address the shortcomings in problem-solving skills and academic achievement scores. The authors recognize that there is no one-size-fits-all solution and that a tailored approach is necessary. In the case of this study, the authors aimed to address these issues in Thailand, which have been on the decline even before the pandemic. Overcoming these issues is even more challenging in rural areas, where access to ICT infrastructure is limited, and civil strife has been ongoing. Thus, it is crucial to implement effective strategies that are designed for the unique needs of different regions and communities.

For proof of these statements, one does not have to look too hard in Thailand as Thailand's Programme for International Student Assessment (PISA) scores have been anything but spectacular and dropping test after test [59,88,89]. This has led to a potentially dangerous situation for Thailand's economic vitality compared to its highly competitive and aggressive ASEAN neighbors.

However, these problems are not unique to Thailand as other academics have pointed out that other Asian instructors and students have been negatively anxious concerning the use of full-online courses, which has necessitated significant support from students' FPMilies and their faculties [90], especially in female students [91].

5.1. Online flipped classrooms (FC)

It is critical to note that the effectiveness of the online flipped classroom was confirmed not only in raising academic achievement scores and problem-solving skills but also in increasing student satisfaction with the FPM. The positive feedback from student-teachers is essential, as it suggests that the flipped classroom can improve academic outcomes and student engagement.

These findings are consistent with Romero-García et al. [92], who found that the authors' flipped learning model resulted in higher student satisfaction and academic performance. This underscores the value of innovative teaching methods in promoting positive student outcomes.

Table 5
Mean and SD of student-teacher achievement and PSS classified by group.

Dependent variables	Full score	Control group (n = 31)		The experimental group (n = 30)	
		$\bar{x}$	SD	$\bar{x}$	SD
Academic achievement (AA)	100	47.83	11.85	60.14	10.32
Problem-solving skills (PSS)	100	60.42	1.55	68.77	2.05

Table 6
Statistic for preliminary examination of the agreement.

Test	Statistics	Test results
Normal distribution	Kolmogorov-Smirnov Test (Sig. $\geq$ 0.05)	Achievement, Sig. = 0.45 Skill; Sig. = 0.09
Testing Homogeneity of Covariance Matrices	Box's M Test (Sig. $\geq$ 0.05)	Box's M = 3.28, F = 1.05, Sig. = 0.37
Relationship between the dependent variables	Pearson correlation (0.20 $\leq$ r $\geq$ 0.80)	r = 0.58, Sig.<0.00

Table 7
MANOVA testing results for student-teacher AA and PSS for both the experimental and control groups.

Effect		Value	F	Hypothesis df	Error df	Sig.
Intercept	Pillai's Trace	0.999	40641.601[b]	2	58	0.000
	Wilks' Lambda	0.001	40641.601[b]	2	58	0.000
	Hotelling's Trace	1401.435	40641.601[b]	2	58	0.000
	Roy's Largest Root	1401.435	40641.601[b]	2	58	0.000
Group	**Pillai's Trace**	0.848	162.251[b]	2	58	0.000
	Wilks' Lambda	0.152	162.251[b]	2	58	0.000
	Hotelling's Trace	5.595	162.251[b]	2	58	0.000
	Roy's Largest Root	5.595	162.251[b]	2	58	0.000

Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F
Corrected Model	Academic achievement (AA)	2312.274[a]	1	2312.274	18.671
	Problem-solving skills (PSS)	1062.273[b]	1	1062.273	322.722
Intercept	Academic achievement (AA)	177720.924	1	177720.924	1435.068
	Problem-solving skills (PSS)	254442.289	1	254442.289	77300.460
Group	Academic achievement (AA)	2312.274	1	2312.274	18.671
	Problem-solving skills (PSS)	1062.273	1	1062.273	322.722
Error	Academic achievement (AA)	7306.647	59	123.841	
	Problem-solving skills (PSS)	194.204	59	3.292	
Total	Academic achievement (AA)	186723.419	61		
	Problem-solving skills (PSS)	255228.276	61		
Corrected Total	Academic achievement (AA)	9618.921	60		
	Problem-solving skills (PSS)	1256.478	60		

**Sig. $\leq$0.01, a. $R^2 = 0.240$ (Adjusted $R^2 = 0.228$. b. $R^2 = 0.845$) (Adjusted $R^2 = 0.843$).

Table 8
Mean, SD and overall student-teacher FPM satisfaction are classified by overall and individual aspects.

FPM	Students (n = 30)		Satisfaction Level
	$\bar{x}$	SD	
Step 1-Problem definition (P)	4.36	0.76	High
Step 2-Attempt to resolve (A)	4.39	0.64	High
Step 3-Research solutions (R)	4.45	0.62	High
Step 4-Solutions selection (S)	4.36	0.66	High
Step 5-Evaluation and reflection (ER)	4.50	0.60	Highest
Summation	**4.41**	**0.66**	**High**

5.2. Problem-based learning (PBL)

PBL methods were again confirmed as instrumental pedagogy in teaching PSS. When combined with online learning and flipped classrooms, the study's results were higher than those using traditional classroom methods. This is consistent with other studies which showed that FCs and PBL activated creative thinking and digital media skills [93], creative innovation skills [24], creative thinking skills [94], and problem-solving skills [95,96].

5.3. Problem solving-skills (PSS)

Multiple studies have determined that disadvantaged students in rural areas must be sufficiently prepared to balance their real life with study life in an online learning environment [97–99]. However, the COVID-19 pandemic has forced the issue, and online study has become required. Therefore, with multiple Thai PSS studies showing severe weakness in most students [25], the authors set out to

develop a model to strengthen PSS capabilities and scores.

Fortunately, in an experimental group of 30 student-teachers, success on a limited scale was achieved as their PSS scores were higher ($\bar{x} = 68.77$, SD = 2.05) than the control group ($\bar{x} = 60.42$, SD = 2.05) in post-class testing on a 100-point scale. These results were consistent with a study of university students in Saudi Arabia in which the authors remarked that the use of blended learning in an online flipped classroom had the most significant impact on acceptance within the country [100].

5.4. Academic achievement (AA)

In this study, Thai student-teacher AA was shown to improve significantly when compared to the control group. This was due to the 30-member experimental group's success in achieving a AA post-course score of $\bar{x} = 60.14$, SD = 10.32. This was significantly higher than the control group's post-course score of $\bar{x} = 47.83$, SD = 11.85 on a 100-point scale.

5.5. Blended learning (BL)

The literature review and this study's FPM application showed that BL is highly effective when used with an FC. This is consistent with other studies, such as Kang and Kim [101], who found the effectiveness of FC and BL in a public healthcare course. Cox [102] examined the differences between high-school teacher training in ten Arizona schools and the actual uses of a BL/FC environment after the training and found that hands-on use was required to be effective. Purba [103] also used a BL/FC environment and the Edmodo LMS in the author's 32-student study and determined that the LMS was an effective tool for online, home-based student learning.

5.6. Research gap analysis and novelty

While this study contributes valuable insights into the effectiveness of a flipped classroom model in enhancing student-teacher academic achievement and problem-solving skills [25,47,55,57,58,61,95,96], it is crucial to address and emphasize the existing research gaps. A comprehensive research gap analysis strengthens the novelty of this research by contextualizing it within the broader academic landscape. The current discussion has highlighted challenges faced by higher education [1], the accelerated shift to online education [2], and the positive outcomes of innovative pedagogies such as flipped classrooms and problem-based learning. However, it is essential to acknowledge that this study builds upon the foundation laid by previous research endeavours.

To fortify the novelty of this study, it is imperative to identify research gaps by reviewing existing literature [63–78]. While numerous studies have explored the impact of online learning and innovative pedagogies, there remains a gap in understanding the nuanced challenges faced in specific contexts, particularly in regions with limited ICT infrastructure [4,5] and ongoing civil strife [104,105], as education is a key component in reducing conflict [106].

The study also recognizes the need for a more in-depth exploration of long-term effects and considers variables such as socio-economic backgrounds [107,108], academic qualifications [109], ICT background/training and digital literacy in future research [110,111]. This foresight strengthens the study's foundation, paving the way for a more comprehensive understanding of the sustained impact of innovative teaching methods.

In summary, by incorporating a robust research gap analysis, this study not only positions itself within the broader research landscape but also underscores its novelty by addressing specific gaps and paving the way for future investigations.

6. Conclusion

The authors aimed to validate the effectiveness and usefulness of an online flipped classroom model in enhancing student-teacher academic achievement scores and problem-solving skills. Valuable expert input was incorporated into the Flipped PARSER Model's design, which included online and on-site activities before, during, and after classes. The instructors' role encompassed content selection, media and material design and development, learning activities and tools, lesson delivery, and evaluation. The study found that the Flipped PARSER Model was highly satisfactory for student-teachers, with positive AA scores and PSS outcomes.

7. Implications

The findings of this study have several implications for higher education, particularly in the context of addressing challenges beyond the impact of the COVID-19 pandemic [3].

The study highlights the multifaceted challenges faced by higher education, including issues such as rural poverty, civil unrest, student protests, mental health concerns, unstable ICT infrastructure, high ICT costs, inadequate training for educators and students, and a continued reliance on traditional instructional approaches. These challenges are not unique to the pandemic but have been exacerbated by it. As higher education institutions navigate these difficulties, there is a need for innovative approaches that go beyond the conventional teacher-centered methods.

The accelerated requirement for online education and distance learning, driven by the pandemic, has exposed the lack of preparedness among teachers and students to meet the challenges of this shift. The study emphasizes the importance of providing

adequate support and training to both educators and students in adapting to online learning environments. It calls attention to the risk of expecting individuals to self-teach without sufficient guidance, particularly in the context of the intensified demand for online education.

The study underscores the need for a combination of teaching and learning methods tailored to the unique needs of different regions and communities. It recognizes that there is no one-size-fits-all solution and emphasizes the importance of implementing effective strategies designed for specific challenges faced in both urban and rural settings [4,5]. This tailored approach becomes especially crucial in regions with limited access to ICT infrastructure and ongoing civil strife.

The study draws attention to the potential economic consequences for Thailand, as reflected in declining Programme for International Student Assessment (PISA) scores. The declining test scores pose a challenge to Thailand's economic vitality compared to its competitive ASEAN neighbors [59,88,89]. The implications extend beyond the immediate educational context, emphasizing the broader socio-economic impact on the country.

The study aligns with the concerns expressed by other academics regarding the anxiety among instructors and students, particularly in Asian contexts, concerning the use of full-online courses. The necessity for significant support from students' families and faculties, especially impacting female students, suggests the need for a comprehensive approach to address these anxieties and provide the required support systems.

The positive outcomes of employing innovative pedagogies, such as online flipped classrooms and problem-based learning, underscore the importance of embracing new methods in response to the challenges faced by higher education. The study advocates for the incorporation of these pedagogies to not only enhance academic achievement and problem-solving skills but also to increase student satisfaction.

The study's limitations and suggestions highlight the importance of considering long-term effects, socio-economic backgrounds, and academic qualifications in future research. This suggests a need for a more comprehensive understanding of the sustained impact of innovative teaching methods on student-teacher outcomes and the potential influence of various variables on the effectiveness of these methods.

Finally, the study emphasizes the importance of future research incorporating comparison groups that receive traditional teaching methods. This comparative analysis would provide insights into the relative effectiveness of innovative models, such as the Flipped PARSER Model, compared to traditional approaches, contributing to a more nuanced understanding of their impact on academic achievement and problem-solving skills.

8. Limitations and suggestions

First, the study was limited because the sample was from a single Thai private university in Thailand's deep south. This area is highly rural and faces significant challenges due to decades of civil strife. These conditions have combined to make ICT infrastructure challenging to obtain and costly. Other studies in a more urban and peaceful environment might find higher AA and PSS scores when FC and blended learning are used.

Second, considering the long-term effects of using the Flipped PARSER Model on student-teacher academic performance and problem-solving skills is a logical extension of this study. Future research could focus on tracking students' progress over a more extended period to determine the sustainability of the observed improvements.

Third, the study did not consider the effects of other variables, such as the socio-economic background of students and the academic qualifications of teachers, on the outcomes of the Flipped PARSER Model. Future research could examine these variables' impact on the model's effectiveness.

Finally, the study should have provided a comparison group that received traditional teaching methods. Future research could include a comparison group to determine the effectiveness of the Flipped PARSER Model in comparison to traditional teaching methods.

Funding

This article processing charge was funded by the School of Industrial Education and Technology, King Mongkut's Institute of Technology Ladkrabang (KMITL), Bangkok, Thailand.

Institutional ethics review board statement

Before the study's commencement, a study author attended a National Research Council of Thailand (NRCT) sponsored Forum for Ethical Review Committees in Thailand (FERCIT) and obtained a '*Research Ethics Training Course*' certificate of completion. After that, the authors sought study approval from their Human Ethics Committee. After approval was granted (EC-KMITL_66_023), the study's panel of educational experts and student-teacher participants were sent an explanation for the study's research via email or Line messaging. In the message, confidentially was assured. After receiving the signed agreement, the documents were securely stored in a faculty facility.

Informed consent statement

Not applicable.

Data availability statement

Data included in article/supp. material/referenced in article.

CRediT authorship contribution statement

Paitoon Pimdee: Methodology, Funding acquisition, Conceptualization. **Aukkapong Sukkamart:** Supervision. **Cherisa Nantha:** Investigation, Conceptualization. **Thiyaporn Kantathanawat:** Visualization, Validation, Supervision. **Punnee Leekitchwatana:** Visualization, Validation, Supervision, Funding acquisition.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:Aukkapong Sukkamart reports article publishing charges was provided by School of Industrial Education and Technology, King Mongkut's Institute of Technology Ladkrabang (KMITL). If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

The authors thank Ajarn Charlie for his assistance in English language editing support.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2024.e29172.

References

[1] M.K. Johari, N.Z. Jamil, Practicality of ad hoc online assessments for teaching ESP in online flipped classrooms during COVID-19, Proceedings 82 (1) (2022) 91, https://doi.org/10.3390/proceedings2022082091.
[2] P. Ruenphongphun, A. Sukkamart, P. Pimdee, Developing Thai undergraduate online digital citizenship skills (DCS) under the New Normal, J. High. Educ. Theor. Pract. 22 (9) (2022) 16–30, https://doi.org/10.33423/jhetp.v22i9.5358.
[3] The "Skip Online Learning" Campaign Launched Monday. Thai PBS, 2021. September 6). Available online: https://tinyurl.com/n8nzrnsn. (Accessed 7 May 2023).
[4] P. Phuapan, C. Viriyavejakul, P. Pimdee, An Analysis of digital literacy skills among Thai university seniors, Int. J. Emerg. Technol. Learn. 11 (3) (2015) 24–31, https://doi.org/10.3991/ijet.v11i03.5301.
[5] C. Watnayoo, S. Toonthong, N. Chalaywares, Developing the 21st-century skills on information, media, and technology on computer creativity towards learning for Grade 5 students using coaching, Thai J. Sci. Technol. 10 (1) (2019) 1–16. Available online: https://tinyurl.com/29z8dw4n. (Accessed 7 May 2023).
[6] Chudak, T. Implementation of a flipped classroom SLA model in the conditions of a language school. e-mentor 2022 3(95), 22-31. https://doi.org/10.15219/em95.1570.
[7] W.-L. Shih, C.-Y. Tsai, Students' perception of a flipped-classroom approach to facilitating online project-based learning in marketing research courses, Aust. J. Educ. Technol. 33 (5) (2017), https://doi.org/10.14742/ajet.2884.
[8] J. Bergman, A. Sams, Flip your classroom. Reaching Every Student in Every Class Every Day, first ed., International Society for Technology, Education, 2012.
[9] S. Chinchua, T. Kantathanawat, S. Tuntiwongwanich, Increasing programming self-efficacy (PSE) through a problem-based gamification digital learning ecosystem (DLE) model, J. High. Educ. Theor. Pract. 22 (9) (2022) 131–143, https://doi.org/10.33423/jhetp.v22i9.5370.
[10] S. Charungkaittikul, J.A. Henschke, Strategies for developing a sustainable learning society: an analysis of lifelong learning in Thailand, Int. Rev. Educ. 2014 60 (4) (2014) 499–522, https://doi.org/10.1007/s11159-014-9444-y.
[11] E. Ceker, F. Ozdamli, Features and characteristics of problem-based learning, Cypriot J. Educ. Sci. 11 (4) (2016) 195–202, https://doi.org/10.18844/cjes.v11i4.1296.
[12] J. Kanelopoulos, K.A. Papanikolaou, P. Zalimidis, Flipping the classroom to increase students' engagement and interaction in a mechanical engineering course on machine design, Int. J. Eng. Pedagog. 7 (4) (2017) 19–34, https://doi.org/10.3991/ijep.v7i4.7427.
[13] V. Uskokovic, Flipping the flipped: the co-creational classroom, Res. Pract. Technol. Enhanc. Learn. (RPTEL) 13 (1) (2018) 1–24, https://doi.org/10.1186/s41039-018-0077-9.
[14] H. Özyurt, Ö. Özyurt, Analyzing the effects of adapted flipped classroom approach on computer programming success, attitude toward programming, and programming self-efficacy, Comput. Appl. Eng. Educ. 26 (6) (2018) 2036–2046, https://doi.org/10.1002/cae.21973, 2018.
[15] J. Pattanaphanchai, An investigation of students' learning achievement and perception using flipped classroom in an introductory programming course: a case study of Thailand higher education, J. Univ. Teach. Learn. Pract. 16 (5) (2019) 4, https://doi.org/10.53761/1.16.5.4.
[16] T. Roach, Student perceptions toward flipped learning: new methods to increase interaction and active learning in economics, Int. Rev. Econ. Educ. 17 (1) (2014) 74–84, https://doi.org/10.1016/j.iree.2014.08.003.
[17] A. Aqqal, A. Elhannani, A. Haidine, A. Dahbi, Improving the teaching of ICT engineering using flipped learning: a personalized model and a case study, Production 27 (spe) (2017), https://doi.org/10.1590/0103-6513.227416.
[18] O. Flores, I. del-Arco, P. Silva, The flipped classroom model at the university: an analysis based on professors' and students' assessment in the educational field, Int. J. Educ. Technol. High. Educ. 13 (1) (2016) 1–12, https://doi.org/10.1186/s41239-016-0022-1.
[19] K. Wang, C. Zhu, MOOC-based flipped learning in higher education: students' participation, experience, and learning performance, Int. J. Educ. Technol. High. Educ. 6 (1) (2019) 1–18, https://doi.org/10.1186/s41239-019-0163-0.
[20] H. Leary, A. Walker, M. Lefler, Y.-C. Kuo, Self-directed learning in problem-based learning: a literature review.", in: M. Moallem, W. Hung, N. Dabbagh (Eds.), The Wiley Handbook of Problem-Based Learning, 2019, pp. 181–198, https://doi.org/10.1002/9781119173243.ch8.

[21] Banic, A.; Gamboa, R. Visual design problem-based learning in a virtual environment improves computational thinking and programming knowledge. In 2019 IEEE Conference on Virtual Reality and 3D User Interfaces (VR) (1588 – 1593). IEEE. https://doi.org/10.1109/VR.2019.8798013.
[22] D.F. Wood, Problem-based learning, BMJ Clin. Res. 326 (328) (2003), https://doi.org/10.1136/bmj.326.7384.328.
[23] K. Rajaram, Engaging learners: a flipped classroom approach, in: Evidence-Based Teaching for the 21st Century Classroom and beyond, Springer, 2021, https://doi.org/10.1007/978-981-33-6804-0_2.
[24] N. Wannapiroon, S. Petsangsri, Effects of STEMification Model in flipped classroom learning environment on creative thinking and creative innovation, TEM J. 9 (4) (2020) 1647–1655, https://doi.org/10.18421/TEM94-42.
[25] N. Sermsri, A. Sukkamart, T. Kantathanawat, Thai computer studies student teacher complex problem-solving skills development: a cooperative learning management model, J. High. Educ. Theor. Pract. 22 (16) (2022) 87–99, https://doi.org/10.33423/jhetp.v22i16.5603.
[26] B. Rodrangsee, S. Tuntiwongwanich, P. Pimdee, S. Moto, Development of an online active learning model using the Theory of Multiple Intelligence to encourage Thai undergraduate student analytical thinking skills, J. High. Educ. Theor. Pract 22 (12) (2022) 63–75, https://doi.org/10.33423/jhetp.v22i12.5463.
[27] S. Moto, T. Ratanaolarn, S. Tuntiwongwanich, P. Pimdee, A Thai junior high school students 21st-century information literacy, media literacy, and ICT literacy skills factor analysis, Int. J. Emerg. Technol. Learn. 13 (9) (2018) 87–106, https://doi.org/10.3991/ijet.v13i09.8355.
[28] K. Siripongdee, S. Tuntiwongwanich, P. Pimdee, Blended learning model with IoT-based by smartphone, Int. J. Interact. Mob. Technol. 15 (11) (2021) 166–182, https://doi.org/10.3991/ijim.v15i11.22441, 2021.
[29] S. Mallapaty, China's zero-COVID strategy: what happens next? Nature 602 (7895) (2022) 15–16, https://doi.org/10.1038/d41586-022-00191-7.
[30] UNESCO, Education minister nataphol teepsuwan on COVID-19 strategy in Thailand. 21 april 2020, Available online: https://tinyurl.com/4kev72z5. (Accessed 7 May 2023).
[31] L. Tomas, S.N. Evans, T. Doyle, K. Skamp, Are first-year students ready for a flipped classroom? A case for a flipped learning continuum, Int. J. Educ. Technol. High. Educ. 16 (5) (2019) 1–22, https://doi.org/10.1186/s41239-019-0135-4.
[32] Z. Luo, B. O'Steen, C. Brown, Flipped learning wheel (FLW): a framework and process design for flipped L2 writing classes, Smart Learn. Environ 7 (10) (2020) 1–21, https://doi.org/10.1186/s40561-020-00121-y.
[33] R. Talbert, Flipped Learning: A Guide for Higher Education Faculty, Stylus Publishing, LLC.m, 2017.
[34] L.W. Anderson, D.R. Krathwohl, A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives, Longman, 2001. Available online: https://tinyurl.com/yhcrps7x. (Accessed 7 May 2023).
[35] L. Wijnia, S.M.M. Loyens, R.M.J.P. Rikers, The problem-based learning process: an overview of different models, in: The Wiley Handbook of Problem-based Learning, 2019, pp. 273–295, https://doi.org/10.1002/9781119173243.ch12.
[36] J.P. Guilford, The Analysis of Intelligence, McGraw-Hill Book, New York, 1971.
[37] J.J. Weir, Problem solving is everybody's problem, Sci. Teach. 41 (4) (1974) 16–18. https://www.jstor.org/stable/24123495.
[38] H.G. Schmidt, Problem-based learning: rationale and description, Med. Educ. 17 (1) (1983) 11–16, https://doi.org/10.1111/j.1365-2923.1983.tb01086.x.
[39] R.D. Woods, Problem-based learning and problem-solving, in: *Problem-Based Learning For the Professions,* David B, Higher Education Research and Development Society of Australasia, 1985, pp. 19–42.
[40] A.C. Ong, D.G. Borich, Teaching Strategies that Promote Thinking, McGraw-Hill Education, 2006.
[41] R.S. Al Said, X. Du, H.A.H. Alkhatib, M.H. Romanowski, A.I.I. Barham, Math teachers' beliefs, practices, and belief change in implementing problem-based learning in Qatari primary governmental schools, Eurasia J. Math. Sci. Technol. Educ. 15 (15) (2019) em1710, https://doi.org/10.29333/ejmste/105849.
[42] G. Maudsley, Do we all mean the same thing by 'problem-based learning'? A review of the concepts and a formulation of the ground rules, Acad. Med. 74 (2) (1999) 178–185, https://doi.org/10.1097/00001888-199902000-00016.
[43] N. Blayney, Problem-based learning: a new approach in medical education, Practice 25 (2) (2003) 101–106, https://doi.org/10.1136/inpract.25.2.101.
[44] S. Srakaew, J. Polvichai, Y. Sugiyama, K. Motohashi, A. Mochizuki, K. Ohara, M. Shirouzu, Development and verification survey of human resource development program in engineering utilizing e-Learning system and project-based learning in engineering with the cooperation of Japan and Thailand for the New Normal after COVID-19, Int. J. Adv. Res. Eng. Innov. 2021 3 (3) (2021) 76–83. Available online: https://tinyurl.com/btyrjjw9. (Accessed 7 May 2023).
[45] R. Talbert, Inverting the linear algebra classroom, Primus 24 (5) (2014) 361–374, https://doi.org/10.1080/10511970.2014.883457.
[46] E. Bangthamai, The development of instructional activities model by problem-based learning to enhance problem-solving abilities on digital photography course for undergraduate students Faculty of Education, Silpakorn University, Veridian E-J. Silpakorn Univ. 11 (1) (2018). Available online: https://tinyurl.com/mww73m59. (Accessed 7 May 2023).
[47] R. Mathew, S.I. Malik, R.M. Tawafak, Teaching problem-solving skills using an educational game in a computer programming course, Inf. Educ. 18 (2) (2019) 359–373, https://doi.org/10.15388/infedu.2019.17.
[48] H.Y. Durak, F.G.K. Yilmaz, R. Yilmaz, Computational thinking, programming self-efficacy, problem-solving, and experiences in the programming process conducted with robotic activities, Contemp. Educ. Tech. 10 (2) (2019) 173–197, https://doi.org/10.30935/cet.554493.
[49] J. Kraiklang, P. Chomchid, P. Thansupho, Instructional approaching management through the problem-based learning model for enhancing students' learning achievements and their solving-problem abilities toward science of lower secondary educational students at the 9th-grade level, Eur. J. Educ. Stud. 3 (4) (2017) 447–465, https://doi.org/10.5281/zenodo.401064.
[50] S.A. Panjan, STEM robotics workshop to promote computational thinking process of pre-engineering students in Thailand: STEMROBOT, in: 25th International Conference on Computers in Education, 2017, pp. 514–522.
[51] N.A. Bizami, Z. Tasir, S.N. Kew, Innovative pedagogical principles and technological tools capabilities for immersive blended learning: a systematic literature review, Educ. Inf. Technol. (2022) 1–53, https://doi.org/10.1007/s10639-022-11243-w.
[52] P. Mozelius, C. Rydell, Problems affecting successful implementation of blended learning in higher education-the teacher perspective, Int. J. Inf. Commun. Technol. Educ. 6 (2) (2017) 4–13, https://doi.org/10.1515/ijicte-2017-0001.
[53] P. Sothayapetch, J. Lavonen, Technological pedagogical content knowledge of primary school science teachers during the COVID-19 in Thailand and Finland, Eurasia J. Math. Sci. Technol. Educ. 18 (7) (2022) em2124, https://doi.org/10.29333/ejmste/12118.
[54] V.K. Ceylan, A. Elitok Kesici, Effect of blended learning to academic achievement, J. Hum. Sci. 14 (1) (2017) 308–320. Available online: https://tinyurl.com/mbhkx5ru. (Accessed 7 May 2023).
[55] C. Nantha, P. Pimdee, J. Sitthiworachart, 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, Int. J. Emerg. Technol. Learn. 17 (14) (2022) 20–38, https://doi.org/10.3991/ijet.v17i14.30903.
[56] K. Polhun, T. Kramarenko, M. Maloivan, A. Tomilina, Shift from blended learning to distance one during the lockdown period using Moodle: test control of students' academic achievement and analysis of its results, J. Phys. Conf. Ser. 1840 (1) (2021) 012053, https://doi.org/10.1088/1742-6596/1840/1/012053.
[57] H.G. Schmidt, J.H. Moust, Factors affecting small-group tutorial learning: a review of research, in: D.H. Evensen, C.E. Hmelo-Silver (Eds.), Problem-based Learning: A Research Perspective on Learning Interactions, Routledge, 2000, pp. 19–52. Available online: https://tinyurl.com/28772v7r. (Accessed 7 May 2023).
[58] Indeed Editorial Team, Problem-solving skills: definitions and examples, Available online: https://tinyurl.com/4cn45bw6, 2020. (Accessed 7 May 2023).
[59] Organization for Economic Cooperation and Development. PISA 2015 Results (Volume V), *Collaborative Problem Solving,* PISA, OECD Publishing, Paris, 2017, https://doi.org/10.1787/9789264285521-en.
[60] N. Hapha, Effects of e-learning by using problem-based learning and value clarification for moral decision of undergraduate students, educational technology major, Silpakorn University, Veridian E-Journal 8 (2) (2015) 1749–1765.
[61] S. Kruthgat, A Model Development of Problem-Solving Skills by the Individual Teaching for Nurse Students of Praboromarajchanok Institute, Chulalongkorn University, 2014. https://tinyurl.com/3mbz749y (in Thai).

[62] O. Adebola, I.A. Ademola, School quality factors and secondary school students' achievement in mathematics in South-Western and North-Central Nigeria, The African Symposium 1 (2011) 91–100.
[63] M. Basitere, E. Rzyankina, P. Le Roux, Reflection on experiences of first-year engineering students with blended flipped classroom online learning during the COVID-19 pandemic: a case study of the mathematics course in the extended curriculum program, Sustainability 15 (6) (2023) 5491, https://doi.org/10.3390/su15065491.
[64] D. Nugroho, B.K. Hermasari, Using online flipped classroom in problem-based learning medical curriculum: a mixed method study, J. Educ. Learn. 17 (2) (2023) 294–300, https://doi.org/10.11591/edulearn.v17i2.20729.
[65] W.R. Slomanson, Blended learning: a flipped classroom experiment, J. Leg. Educ. 64 (1) (2014) 93. https://jle.aals.org/home/vol64/iss1/6/.
[66] M. El Hajji, R.D. El Bouzaidi, H. Douzi, E.H. Khouya, New blended learning strategy based on flipped-learning for vocational work-linked training, J. Educ. Pract. 7 (36) (2016). Available online: https://tinyurl.com/raw3w6rd. (Accessed 6 November 2023).
[67] J. Buhl-Wiggers, A. Kjærgaard, K. Munk, A scoping review of experimental evidence on face-to-face components of blended learning in higher education, Stud. High Educ. 48 (1) (2023) 151–173, https://doi.org/10.1080/03075079.2022.2123911.
[68] S. Pipitgool, P. Pindee, S. Tuntiwongwanich, A. Narabin, Enhancing student computational thinking skills by use of a flipped-classroom learning model and critical thinking problem-solving activities: a conceptual framework, Turk. J. Comput. Math. Educ. 12 (14) (2021) 1352–1363. Available online: https://tinyurl.com/yvv259vt. (Accessed 6 November 2023).
[69] M. Hafeez, M. Hasbi, All about learning methods: past, present and future, ETDC: Indones. J. Res. Educ. Rev. 2 (4) (2023) 14–25, https://doi.org/10.51574/ijrer.v2i4.953.
[70] J. Abdullah, W.N. Mohd-Isa, M.A. Samsudin, Virtual reality to improve group work skill and self- directed learning in problem-based learning narratives, Virtual Real. 23 (2019) 461–471, https://doi.org/10.1007/s10055-019-00381-1.
[71] I.S. Atta, A.H. Alghamdi, The efficacy of self-directed learning versus problem-based learning for teaching and learning ophthalmology: a comparative study. Advances in Medical Education and Practice, 2018, pp. 623–630, https://doi.org/10.2147/AMEP.S171328.
[72] S. Kardipah, B. Wibawa, A flipped-blended learning model with augmented problem based learning to enhance students' computer skills, TechTrends 64 (3) (2020) 507–513, https://doi.org/10.1007/s11528-020-00506-3.
[73] A.E. Chis, A.N. Moldovan, L. Murphy, P. Pathak, C.H. Muntean, Investigating flipped classroom and problem-based learning in a programming module for computing conversion course, J. Educ. Technol. Soc. 21 (4) (2018) 232–247. Available online: https://tinyurl.com/9aa2rme9. (Accessed 6 November 2023).
[74] J. Houghton, Learning modules: problem-based learning, blended learning and flipping the classroom, Law Teach. (2023) 1–24, https://doi.org/10.1080/03069400.2023.2208017.
[75] S. Elazab, M. Alazab, The Effectiveness of the Flipped Classroom in Higher Education, 2015 5th Int. Conf. e-Learn., Manama, Bahrain, 2015, pp. 207–211, https://doi.org/10.1109/ECONF.2015.34.
[76] C.E. Hmelo-Silver, S.M. Bridges, J.M. McKeown, Facilitating problem-based learning, The Wiley handbook of problem-based learning (2019) 297–319, https://doi.org/10.1002/9781119173243.ch13.
[77] M. Wongdaeng, S. Hajihama, Perceptions of project-based learning on promoting 21st-century skills and learning motivation in a Thai EFL setting, J. Stud. Eng. Lang. 13 (2) (2018) 158–190. Available online: https://tinyurl.com/3rp2w63b. (Accessed 6 November 2023).
[78] Johns S., The core four of personalized learning: The elements you need to succeed. Educ. Elem. (2018) 1-22 Available online: https://tinyurl.com/4d4z35fk. (Accessed 6 November 2023).
[79] C. García-Ruiz, T. Lupión-Cobos, Á. Blanco-López, Effects of an inquiry-based science education training program on pre-service teachers. A mixed-methods case study, Eurasia J. Math. Sci. Technol. Educ. 18 (12) (2022) em2186, https://doi.org/10.29333/ejmste/12578.
[80] P. Pimdee, P. Leekitchwatana, Appropriate Internet use behavior (AIUB) of Thai preservice teachers: a hierarchical linear model (HLM) analysis, Int. J. Instr. 15 (1) (2022) 489–508, https://doi.org/10.29333/iji.2022.15128a.
[81] L. Rahmelina, F. Firdian, I. Maulana, H. Aisyah, J. Naam, The effectiveness of the flipped classroom model using e-learning media in introduction to information technology course, Int. J. Emerg. Technol. Learn. 14 (21) (2019) 148–162, https://doi.org/10.3991/ijet.v14i21.10426, 2019.
[82] C. Kanawapee, S. Petsangsri, P. Pimdee, The importance of sharing, caring, and collaboration in Thai teacher competency development through online professional learning communities, J. Posit. Psychol. Wellbeing 6 (1) (2022) 3674–3689. Available online: https://tinyurl.com/bdd9spm9. (Accessed 7 May 2023).
[83] P. Yurayat, S. Tuklang, University student counselees' attitudes and experiences towards online counseling during the Covid-19 pandemic: a mixed methods study, J. High. Educ. Theor. Pract. 23 (4) (2023) 222–238, https://doi.org/10.5539/hes.v12n1p72.
[84] C. Vangmeejongmee, O. Naiyapatana, Competency of Thai teacher in 21st century: wind of change, J. HR Intell 12 (2) (2017) 48–63. Available online: https://tinyurl.com/284nbcyy. (Accessed 7 May 2023).
[85] W. Wongpratoom, T. Sranamkam, The effects of blended learning using collaborative learning with stad technique on MOODLE to enhance analytical thinking for grade VII students, Int. J. Learn. Teach. 5 (4) (2019) 280–284, https://doi.org/10.18178/ijlt.5.4.280-284.
[86] M. Parkes, S. Stein, C. Reading, Student preparedness for university e-learning environments, Internet High Educ. 25 (2015) 1–10, https://doi.org/10.1016/j.iheduc.2014.10.002.
[87] A. Gabriella, Inquiry-based learning in Science Education. Why e-learning can make a difference, J. e-Learn. Knowl. Soc. 9 (2) (2013) 17–26, https://doi.org/10.20368/1971-8829/831.
[88] P. Pholphirul, S. Teimtad, Living with parents and educational outcomes in developing countries: empirical evidence from PISA Thailand, J. Popul. Res. 35 (1) (2018) 87–105, https://doi.org/10.1007/s12546-017-9196-1.
[89] K. Srijamdee, P. Pholphirul, Does ICT FPMiliarity always help promote educational outcomes? Empirical evidence from PISA-Thailand, Educ. Inf. Technol. 25 (4) (2020) 2933–2970, https://doi.org/10.1007/s10639-019-10089-z.
[90] T. Pham, N. Vinh, Online learning amid Covid-19 pandemic: students' experience and satisfaction, J. e-Learn. Knowl. Soc. 17 (1) (2021) 39–48, https://doi.org/10.20368/1971-8829/1135293.
[91] A. Cadamuro, E. Bisagno, S. Rubichi, L. Rossi, D. Cottafavi, E. Crapolicchio, L. Vezzali, Distance learning and teaching as a consequence of the Covid-19 pandemic: a survey of teachers and students of an Italian high school taking into account technological issues, attitudes and beliefs toward distance learning, metacognitive skills, J. e-Learn. Knowl. Soc. 17 (1) (2021) 81–89, https://doi.org/10.20368/1971-8829/1135463.
[92] C. Romero-García, O. Buzón-García, J. Touron, The flipped learning model in online education for secondary teachers, J. Technol. Sci. Educ. 9 (2) (2018) 109–121, https://doi.org/10.3926/jotse.435.
[93] P. Srikan, P. Pimdee, P. Leekitchwatana, A. Narabin, Problem-based learning (PBL) and teaching model using a cloud-based constructivist learning environment to enhance Thai undergraduate creative thinking and digital media skills, Int. J. Interact. Mob. Technol. 15 (22) (2021) 68–83, https://doi.org/10.3991/ijim.v15i22.24963.
[94] C. Diawati, S. Liliasari, Buchari. Students' construction of a simple steam distillation apparatus and development of creative thinking skills: a project-based learning, AIP Conf. Proc. 1848 (1) (2017) 1–6, https://doi.org/10.1063/1.4983934.
[95] S. Janpla, P. Piriyasurawong, The development of problem-based learning and concept mapping using a block-based programming model to enhance the programming competency of undergraduate students in computer science, TEM J. 7 (4) (2018) 708–716, https://doi.org/10.18421/TEM74-02.
[96] C. Jewpanich, P. Piriyasurawong, Project-based learning using discussion and lesson-learned methods via social media model for enhancing problem-solving skills, Int. Educ. Stud. 8 (6) (2015), https://doi.org/10.5539/ies.v8n6p24.
[97] C. Coman, L.G. Țîru, L. Meseșan-Schmitz, C. Stanciu, M.C. Bularca, Online teaching and learning in higher education during the coronavirus pandemic: students' perspective, Sustainability 12 (24) (2020) 10367, https://doi.org/10.3390/su122410367. MDPI AG.
[98] Dhawan, S. Online learning: A panacea in the time of COVID-19 crisis. Journal of Edu. Technol. Syst. 2020 49(1), 5-22. https://doi.org/10.1177/0047239520934018.

[99] L.T.M. Que, Online teaching and learning in higher education during Covid-19pPandemic: Vietnamese students' perspective, IUP J. Inf. Technol. 17 (3) (2021) 23–48, https://doi.org/10.4324/9781003125921.
[100] I.Y. Alyoussef, Acceptance of a flipped classroom to improve university students' learning: an empirical study on the TAM model and the unified theory of acceptance and use of technology (UTAUT), Heliyon 8 (12) (2022) e12529, https://doi.org/10.1016/j.heliyon.2022.e12529.
[101] H.Y. Kang, H.R. Kim, Impact of blended learning on learning outcomes in the public healthcare education course: a review of flipped classroom with team-based learning, BMC Med. Educ. 21 (1) (2021) 1–8, https://doi.org/10.1186/s12909-021-02508-y.
[102] K.M. Cox, Teachers' Descriptions of Effective Professional Development provided to Implement a Blended Learning Flipped Classroom, Doctoral dissertation, Grand Canyon University, 2020. Available online, https://tinyurl.com/yzudjbn4. (Accessed 7 May 2023).
[103] R.A. Purba, The effective combination of blended learning and flipped classroom with Edmodo as a digital media innovation for learning from home, J. Educ. Technol. 5 (3) (2021), https://doi.org/10.23887/jet.v5i3.36210.
[104] P. Justino, Violent conflict and human capital accumulation, IDS Working Papers (379) (2011) 1–17, 2011, https://unesdoc.unesco.org/ark:/48223/pf0000190710.
[105] G. Østby, H. Urdal, K. Dupuy, Does education lead to pacification? A systematic review of statistical studies on education and political violence, Rev. Educ. Res. 89 (1) (2019) 46–92, https://doi.org/10.3102/0034654318800236.
[106] S. Pinker, The Better Angels of Our Nature: the Decline of Violence in History and its Causes, Penguin UK, 2011.
[107] A.M. Öz, N. Kala, Explorations to overcome socio-economic barriers in learning and thinking: a Flipped Classroom Study, Sci. Insights Educ. Front. 18 (1) (2023) 2759–2783. Available online: https://tinyurl.com/rztxxxd. (Accessed 17 November 2023).
[108] H. Turra, V. Carrasco, C. González, V. Sandoval, S. Yáñez, Flipped classroom experiences and their impact on engineering students' attitudes towards university-level mathematics, High. Educ. Pedagogies 4 (1) (2019) 136–155, https://doi.org/10.1080/23752696.2019.1644963.
[109] R. Estriegana, J.A. Medina-Merodio, R. Barchino, Analysis of competence acquisition in a flipped classroom approach, Comput. Appl. Eng. Educ. 27 (1) (2019) 49–64, https://doi.org/10.1002/cae.22056.
[110] L. Irianti, Teachers' perception on flipped classroom model in digital literacy era, ELT-Lectura 7 (2) (2020) 94–102, https://doi.org/10.31849/elt-lectura.v7i2.3685.
[111] G. Gómez-García, F.J. Hinojo-Lucena, M.P. Cáceres-Reche, M. Ramos Navas-Parejo, The contribution of the flipped classroom method to the development of information literacy: a systematic review, Sustainability 12 (18) (2020) 7273. https://www.mdpi.com/2071-1050/12/18/7273.