

## Research Article

# A Study of Learning Achievement Using a Flipped-Classroom Model Combined with Online Cooperative Learning in Soil Mechanics Laboratory

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The objectives of this research were (1) to assess the appropriateness, (2) to study the learning achievement, and (3) to study the satisfaction of learners of the flipped-classroom model combined with online cooperative learning in the Soil Mechanics Laboratory. The research sample are 56 students enrolled in Soil Mechanics Laboratory, semester 1/2021, Civil Engineering and Education Program; Department of Teacher Training in Civil Engineering; Faculty of Technical Education; King Mongkut's University of Technology North Bangkok. There were five experts in content and another 10 in education. The tools used in the research were online lessons and a learning achievement test. Another tool included a student satisfaction questionnaire with a flipped-classroom model combined with online cooperative learning. The statistics used in the research were percentage, mean, and standard deviation. The results showed (1) the overall suitability of the flipped-classroom model combined with online cooperative learning was at a high level of 4.30/5.00, (2) the overall mean exercise/quiz scores (E1/E2) of learning achievement with a flipped-classroom model combined with online cooperative learning were 85.18/81.01 (100), and (3) the overall learner satisfaction with the flipped-classroom model combined with online cooperative learning was at the highest level of 4.56/5.00.

## 1. Introduction

The National Education Act (1999) Amended (No. 2), 2002, Subsection 4, Section 22 states that educational management is based on the principle that all learners can learn and develop themselves, and the learners are the most significant component [1]. In the 21st century, teaching and learning methodology focuses on raising students' learning skills, working skills with others, or learning with all team members. Collaboration starts with learning, helping, working together, sharing, and taking responsibility for solving problems. Understanding one's roles and responsibilities and exchanging knowledge and experiences with each other to conclude what is acceptable to members is essential to good teamwork. At present, it can be seen that the agencies involved in education have changed the traditional learning process that focuses on memorization from instructor-centered learning to

learner-centered learning, which is flexible teaching and focusing on teaching and learning management according to actual conditions. Learners learn from real practice to help them to develop skills in learning and working together [2]. Nowadays, education management is a descriptive teaching method due to its great content and limited time. Instructors often present material that they think is necessary for implementation, but some content may need to be updated. Teaching is in a teacher-centered format. The teacher is responsible for choosing the content, a study method, and teaching time and determining which learners meet the criteria based on the teacher-created tool. Most students learn from memorization based on the content presented by the teacher. Learners do not develop their thinking and research skills until they apply the gained knowledge to their work in real life [3]. Therefore, it is necessary to apply modern learning concepts in teaching, that is, flipped classroom learning. Bergmann and Sams [4] state that

flipped learning is a student-centered instructional arrangement where information technology is applied as a tool for learners to learn independently from home and focus on learning activities between classmates and teachers in the classroom. This method, shortly defined as “studying at home doing homework at school,” improves student achievement and increases cooperation between learners, resulting in a learning process “learn by doing” [4]. Instructors change roles from lecturers to facilitators of the learning process. For example, they are activity designers for students to use as a learning tool. Encourage learners to create knowledge by themselves. Instructors only act as facilitators and guides to access knowledge through various means. Teachers changed their role from lecturer to an organizer of the learning process and activity designers for the students to use as a learning tool to build their knowledge. Instructors are facilitators and suggest a means for accessing knowledge through various methods, especially technology, to enable students to access knowledge resources quickly and efficiently. Learners can share their knowledge with their peers in the classroom. This learning process is known as *Active Learning*, which is student-centered [5]. Cooperative learning is an innovation in teaching and learning management. It focuses on students working in small groups. Using group members with different abilities to enhance each person’s learning capacity and encourage each other to help each other until the goals are achieved. It also encourages teamwork and to develop emotional intelligence, enabling students to adapt happily to others [6]. The current world situation is the epidemic of the COVID-19 virus. It had a significant impact on classroom teaching, thus resulting in educational reforms. Many Thai universities have announced online teaching methods since the COVID-19 crisis. It has severely impacted all sectors, even the education sector. On the other hand, this epidemic situation has also created an accelerated rate of education reform, especially the adoption of technology for teaching and learning. Teachers or learners will have access to education wherever they are. Online learning is highly flexible learning that can effectively solve the problem of studying in the midst of the COVID-19 pandemic [7]. Prasartsilp [8] stated that teaching through information and communication technology and other appropriate electronic media reduces time and space constraints between learners and teachers. It allows learners to continue learning according to their needs at all times. Soil Mechanics Laboratory is a course that enables students to identify the physical and mechanical properties of soil, engineering properties of soil, shear strength of soil, skills for a test laboratory technician, and a positive attitude in teamwork, the basics that can be built upon in other relevant courses, such as structural analysis that is important to the field of civil engineering.

Based on the background and significance, therefore, the researcher was interested in developing a flipped-classroom model combined with online cooperative learning, which will help support students to have thinking skills, teamwork skills, and promote students’ self-learning by adopting technologies for teaching and learning management in conjunction with ADDIE model of teaching for designing lessons. ADDIE model of teaching consists of five stages of a

development process, i.e., (1) Analysis: A, (2) Design: D, (3) Development: D, (4) Implementation: I, and (5) Evaluation: E, which helps enhance learning achievement in soil mechanics laboratory course. The study results will be useful for teaching and learning in other courses to achieve efficiency accordingly.

## 2. Objectives

To assess the appropriateness, to study the learning achievement, and to study learners’ satisfaction with the flipped-classroom model combined with online cooperative learning in Soil Mechanics Laboratory.

## 3. Methodology

**3.1. Population and Sample.** The population used in the research was undergraduate students, Bachelor of Engineering program in Civil Engineering and Education, Department of Technical Education in Civil Engineering, Faculty of Technical Education, King Mongkut’s University of Technology North Bangkok. There are three groups of population in this study that included:

Fifty-six third-year students enrolled in the field of soil mechanics operations, who enrolled in soil mechanics laboratory, semester 1/2021, five content experts, and 10 experts in education, technology and teaching materials, and cooperative learning.

**3.2. Research Instruments.** The teaching management plan with the flipped-classroom model, combined with online cooperative learning in Soil Mechanics Laboratory, consists of three online lessons, including compaction test, C.B.R. test (California bearing ratio test), and field density test. A rating scale assesses the appropriateness of the flipped-classroom model combined with online cooperative learning (used 5-point Likert scale). The achievement test is a multiple-choice test with four options: exercise (E1) and test (E2), and the student satisfaction questionnaire on the flipped-classroom model combined with online cooperative learning using Google Forms (used 5-point Likert scale). The student’s satisfaction with the flipped-classroom model was at the highest level ( $\bar{X} = 4.56$ , S.D. = 0.62).

The results of 5-point Likert rating scales according to the following details:

Mean 4.51–5.00 = highest.

Mean 3.51–4.50 = high.

Mean 2.51–3.50 = moderate.

Mean 1.51–2.50 = poor.

Mean 1.00–1.50 = least.

**3.3. Statistical Analysis.** The statistics used for data analysis were percentage, mean, and standard deviation.

The researcher has designed the lessons according to the principles of the ADDIE Model, which has a five-step development sequence [9].



FIGURE 1: Flipped-classroom model combined with online cooperative learning.

3.3.1. *Analysis: A.* Study documents and related research, and analyze with the following details, analyze students such as most of the participants are 37 men (66.00%) and 19 women (34.00%). Most of them, 34 persons (60.70%), are 20 years of age. Most GPA ranged from 2.01 to 2.50, 30 persons (53.60%), and needs for learning with a flipped-classroom model overall at the highest level ( $\bar{X} = 4.75$ , S.D. = 0.73), analysis content such as setting the topic behavioral objectives, content, teaching materials, learning activities, exercises, quizzes, and analyze time for learning management that is 12 hr in 3 weeks.

3.3.2. *Design: D.* Designing the learning process consists of three steps: the teaching preparation stage, learning management stage, and evaluation stage (the details of the learning activities from Figure 1); design the use of technology in managing online classroom learning with the Moodle program,

including tools for creating events such as assignments and quizzes, content creation tools such as resources, books, pages, and URLs, design lesson plans, including designing learning objectives, content, teaching materials, learning activities, exercises, quizzes, and design a measurement and evaluation method, divided into three parts: appropriate assessment of the flipped-classroom model combined with online cooperative learning; seven items in the form of 5-rating scales, learning achievement test, three topics classified by 29 objectives, 87 items in total in the form of four alternative choice questions. The reliability of the tests was 0.86, and the assessment of students' satisfaction toward the flipped-classroom model combined with online cooperative learning; 15 items in the form of 5-rating scales.

3.3.3. *Development: D.* Based on the assessment results of the needs of students and teachers regarding the traditional and

flipped-classroom model, the researcher developed a flipped classroom model with online cooperative learning through suitability assessment from experts. The results were applied to the soil mechanics laboratory course, which consists of three components: (a) the teaching preparation stage, (b) the learning management stage, and (c) the evaluation stage, as shown in Figure 1.

From Figure 1, the details of the learning activities are as follows:

- (A) Preparation for the teaching stage consists of
  - (1) (A-1) Planning is the orientation of learners about teaching and learning through a flipped-classroom model with other components, including cooperative learning, implementing an online classroom with Moodle, and designing teaching materials, lesson plans, learning objectives, content, materials, learning activities, exercises, quizzes, and measurement and evaluation tools.
  - (2) (A-2) Create media is to create online lesson media by focusing on video media such as video recordings of teaching and document file types such as Word, PDF, and PowerPoint.
  - (3) (A-3) Self-study online lessons means learners study online lessons by themselves through Moodle program from home or outside the class schedule beforehand.
- (B) The learning management stage consists of
  - (1) (B-1) Exchanging learning means students present problems from studying the content of online lessons and teaching materials from home. Then exchange and learn together concerning the issue of lesson content between teachers and students.
  - (2) (B-2) Teaching summary is the teacher summarizes the problems and reviews the lesson content for the learners.
  - (3) (B-3) Group activities are learners doing exercises during online learning (E1), a group activity of 3–4 students, divided into groups based on average grades and mixed with skilled, moderate, weak, and able to consult within the group. The instructors are responsible for advising and adjusting student success through online classrooms.
- (C) The evaluation stage consists of
  - (1) (C-1) Learners take the online post-test (E2) as an individual activity.
  - (2) (C-2) Assessment of learners' learning achievement (E1/E2)
  - (3) (C-3) Evaluate the satisfaction of learners towards the flipped-classroom model combined with online cooperative learning. After students study to the end of the lesson, they are asked to respond to a questionnaire. The questionnaire comes in the form of 5-rating scale, made to assess students' satisfaction towards the flipped-classroom model.

**3.3.4. Implementation: I.** An experimental set of learning management plan activities flipped-classroom model combined with online cooperative learning with an experimental group (try out) for small group learners with good, medium, and weak results, and apply the learning management plan activity set to the actual sample group (implementation) in an online form to collect data.

**3.3.5. Evaluation: E.** The results obtained from the experimental flipped-classroom model combined with online cooperative learning were analyzed and evaluated as follows: appropriateness of a flipped-classroom model was assessed using a focus group method in which there were 10 persons consisting of experts in education, experts in instructional media, and experts in collaborative learning. A 7-item questionnaire was used for the assessment. The improvement was made in accordance with experts' advice to ensure an appropriate flipped-classroom model is obtained; students' achievement assessment—after students study the content of lesson through online classes by themselves at home, they are required to do exercise E1 while studying, a group activity in which seeking and giving advice can be done in a group. Students are required to do exercise E2 after studying, an individual activity in which seeking and giving advice is not allowed. Teachers gather all scores from exercise E1 and exercise E2 to assess students' achievement and students' satisfaction assessment—after students study to the end of lesson, they are asked to respond to a questionnaire. The questionnaire comes in the form of 5-rating scale, made to assess students' satisfaction towards the flipped-classroom model.

## 4. Research Results

The results of the research are detailed as follows:

The assessment results of the learners' and teachers' needs and necessities for learning with the traditional classroom model and the flipped-classroom model are shown in Table 1.

From Table 1, there were overall needs for learning with the traditional classroom model at a moderate level ( $\bar{X} = 2.51$ , S.D. = 0.73), and there were overall needs for learning with the flipped-classroom model at the highest level ( $\bar{X} = 4.75$ , S.D. = 0.73). It can be summarized that learners need learning management in a flipped-classroom model.

From Table 2, there were overall needs for learning with the traditional classroom model at a moderate level ( $\bar{X} = 2.96$ , S.D. = 0.73), and there were overall needs for learning with the flipped-classroom model at the high level ( $\bar{X} = 4.23$ , S.D. = 0.73). It can be summarized that teachers need learning management in a flipped-classroom model.

The assessment results of the appropriateness of the flipped-classroom model in conjunction with the online cooperative learning of the experts are shown in Table 3.

From Table 3, the overall experts' opinions on the flipped-classroom model combined with online cooperative learning



TABLE 1: Results of the assessment of learners' needs for learning with the traditional classroom model and flipped-classroom model ( $n = 56$ ).

Assessment item	Assessment results		Comment level
	$\bar{X}$	S.D.	
Traditional teaching style			
1. What level are learners involved in learning?	2.75	0.44	Moderate
2. Students rarely have the opportunity to express their opinions	2.89	0.31	Moderate
3. Interaction between teacher and learner	2.20	0.40	Poor
4. Learners work together as a team	2.00	0.43	Poor
5. Learners can ask for additional knowledge from the teacher after the lesson	2.13	0.33	Poor
6. Students can review the teacher's lesson content	2.63	0.49	Moderate
7. At what level do students have difficulty doing homework?	2.98	0.30	Moderate
<b>Total</b>	<b>2.51</b>	<b>0.54</b>	<b>Moderate</b>
Flipped classroom model			
8. What is your opinion if there are ready-made lessons to study on your own before attending class on each topic?	4.52	0.50	Highest
9. To what extent do you agree if the teacher reviews the lesson before assigning students to work in class?	4.96	0.19	Highest
10. To what extent do you agree if the teaching is organized in groups (skilled, moderate, weak, in one group)?	4.50	0.57	High
11. To what extent do you agree with the cooperative learning model in group classes? It is to help weak learners be active and receive the attention of their peers and teachers	4.88	0.33	Highest
12. To what extent do you agree that the learner-centered learning model facilitates increased interaction between learners and teachers?	4.91	0.29	Highest
13. To what extent do you think online teaching management is appropriate for the COVID-19 pandemic?	4.75	0.44	Highest
<b>Total</b>	<b>4.75</b>	<b>0.45</b>	<b>Highest</b>

Bold values signify the overall needs for learning with the traditional classroom model at a moderate level and flipped-classroom model at the highest level.

TABLE 2: Results of the assessment of teachers' needs for learning with the traditional classroom model and flipped-classroom model ( $n = 5$ ).

Assessment item	Assessment results		Comment level
	$\bar{X}$	S.D.	
Traditional teaching style			
1. At what level are learners involved in classroom learning?	3.20	0.45	Moderate
2. Students rarely have the opportunity to express their opinions	3.00	0.00	Moderate
3. Interaction between teachers and students in the classroom	2.80	0.45	Moderate
4. Learners work together as a team	3.00	1.00	Moderate
5. Instructors can verify that learners are working on their assignments	2.80	1.30	Moderate
<b>Total</b>	<b>2.96</b>	<b>0.73</b>	<b>Moderate</b>
Flipped classroom model			
6. What is your opinion if there are ready-made lessons to study on your own before attending class on each topic?	5.00	0.00	Highest
7. To what extent do you agree if the teacher reviews the lesson before assigning students to work in class?	4.80	0.45	Highest
8. To what extent do you agree if the teaching is organized in groups (skilled, moderate, weak, in one group)?	3.80	0.84	High
9. To what extent do you agree that the cooperative learning model in group classrooms is helpful for weak learners to gain the attention of friends and teachers?	3.80	0.84	High
10. To what extent do you agree that the learner-centered learning model facilitates increased interaction between learners and teachers?	4.00	0.71	High
11. To what extent do you agree that online teaching management helps to improve theoretical teaching during the COVID-19 pandemic?	4.00	1.00	High
<b>Total</b>	<b>4.23</b>	<b>0.82</b>	<b>High</b>

Bold values signify the overall needs for learning with the traditional classroom model at a moderate level and flipped-classroom model at a high level.

TABLE 3: The assessment results of the appropriateness of the flipped-classroom model combined with online cooperative learning ( $n = 10$ ).

Assessment item	Assessment results		Comment level
	$\bar{X}$	S.D.	
1. The conceptual framework of the classroom model is reversed	4.50	0.53	High
2. The elements of the flipped classroom model	4.00	0.67	High
3. The steps of the flipped classroom model	4.20	0.63	High
4. The interaction between the teacher and the learner and between the learner and the learner	4.10	0.74	High
5. Tools used in teaching and learning	4.40	0.52	High
6. Evaluation	4.30	0.67	High
7. Benefit of the flipped classroom model	4.60	0.52	Highest
<b>Total</b>	<b>4.30</b>	<b>0.62</b>	<b>High</b>

Bold values signify the overall experts' opinions on the flipped-classroom model combined with online cooperative learning were appropriate at a high level.

TABLE 4: Results of index of item objective congruence (IOC) by 5 experts.

Assessment item	Compaction test		C. B. R. test		Field density test	
	Average (IOC)	Assessment results	Average (IOC)	Assessment results	Average (IOC)	Assessment results
1. Topic and behavioral objectives	1	Congruence	1	Congruence	1	Congruence
2. Behavioral objectives and content	1	Congruence	1	Congruence	1	Congruence
3. Behavioral objectives and quiz	1	Congruence	1	Congruence	1	Congruence
<b>Summarize</b>	<b>Congruence</b>		<b>Congruence</b>		<b>Congruence</b>	

Bold values signify the experts have overall opinions on three aspects; a mean index of item objective congruence is equal to 1, indicates a high level of congruence.

TABLE 5: Learning achievements with a flipped-classroom model combined with online cooperative learning ( $n = 56$ ).

Topic	Average practice scores E1 (30)	Exercise percent average E1	Average test scores E2 (30)	Average percentage quiz E2
Compaction test	25.34	84.46	24.55	81.85
C. B. R. test	25.32	84.40	24.05	80.18
Field density test	26.00	86.67	24.30	81.01
<b>Summarize</b>	<b>25.55</b>	<b>85.18</b>	<b>24.30</b>	<b>81.01</b>

Bold values signify the learning achievement in the flipped-classroom model combined with online cooperative learning.

were appropriate at a high level ( $\bar{X} = 4.30$ ,  $S.D. = 0.73$ ). The assessment item with the highest average was the benefit of the flipped-classroom model ( $\bar{X} = 4.60$ ,  $S.D. = 0.52$ ). And the topic with the lowest mean was the flipped-classroom model element ( $\bar{X} = 4.00$ ,  $S.D. = 0.67$ ).

The results of index of item objective congruence (IOC) by five experts are shown in Table 4.

From Table 4, the experts have overall opinions on three aspects; a mean index of item objective congruence is equal to 1, indicates a high level of congruence.

The results of IOC scores come from five experts, a 3-rating scale according to the following details:

- +1 means consistent,
- 0 means uncertain,
- 1 means inconsistent.

Learning achievement with a flipped-classroom model combined with online cooperative learning in Soil Mechanics Laboratory is shown in Table 5.

From Table 5, it was found that the learning achievement in the flipped-classroom model combined with online cooperative learning. The overview can be summarized as follows: The mean exercise/quiz scores (E1/E2) were 85.18/81.01.

Results of the study of student satisfaction with the flipped-classroom model combined with online cooperative learning in Soil Mechanics Laboratory subjects are shown in Table 6.

From Table 6, the student's satisfaction with the flipped-classroom model combined with online cooperative learning was at the highest level ( $\bar{X} = 4.56$ ,  $S.D. = 0.62$ ). The topic

TABLE 6: Study results of students satisfaction with the flipped-classroom model combined with online cooperative learning ( $n = 56$ ).

Assessment item	$\bar{X}$	S.D.	Satisfaction level
1. Learners have a better understanding of the lesson content	4.18	0.51	High
2. The flipped classroom learning management model is attractive	4.77	0.47	Highest
3. Self-learning and reviewing content at any time	4.96	0.19	Highest
4. Learners have more responsibility for their studies	3.82	0.54	High
5. Learners participate in learning activities	4.71	0.46	Highest
6. Encourage students to exchange knowledge and express their opinions	4.55	0.50	Highest
7. Encourage collaborative interaction in working groups among learners	4.88	0.33	Highest
8. The timing of the learning activities is appropriate	4.18	0.43	High
9. Ordering of learning content step by step	4.66	0.48	Highest
10. Be able to apply the knowledge gained from the activities	4.52	0.57	Highest
11. The online lessons are interesting and attractive to learn	4.91	0.29	Highest
12. The media helps to enhance understanding of the lesson	4.71	0.46	Highest
13. The content is concise, complete, and easy to understand	4.84	0.37	Highest
14. The size and color of the fonts are clear	4.46	0.50	High
15. Illustrations, videos, and audio narrations are clear	4.23	0.43	High
Total average	<b>4.56</b>	<b>0.54</b>	<b>Highest</b>

Bold values signify the student's satisfaction with the flipped-classroom model combined with online cooperative learning was at the highest level.

with the highest average was self-learning and review content at any time ( $\bar{X} = 4.96$ , S.D. = 0.19). The topic with the lowest average was that learners were more responsible for their studies ( $\bar{X} = 3.82$ , S.D. = 0.54).

## 5. Summarize and Discuss the Research Results

The study of learning achievement using a flipped-classroom model combined with online cooperative learning can be summarized as follows:

Appropriateness of the flipped-classroom model combined with online cooperative learning, the overall opinions of the experts were at a high level ( $\bar{X} = 4.30$ , S.D. = 0.62). Because the model has systematic learning management and reviews the lesson content at any time, there is an instructor to help during the learning process, consistent with the study results by Saenboonsong [10]. He studied the development of a flipped-classroom model using cloud technology in the teacher computing course for undergraduate students. The learning management model consisted of 3 components: (1) preparation, (2) flipped-classroom learning management using cloud technology, and (3) evaluation [10].

In terms of learning achievement, it was found that the mean exercise/quiz scores (E1/E2) were 85.18/81.01. Because the ADDIE model of teaching for designing lessons, which consists of five stages of a development process, i.e., (1) Analysis: A, (2) Design: D, (3) Development: D, (4) Implementation: I, and (5) Evaluation: E, The learning achievement results obtained in this study are consistent with those reported by Bilbai [11], which stated that the ADDIE Model is a popular instructional system model used in the design and development of

teaching materials. It is a simple format with clear steps. Compatible with multimedia design and development, especially the development of multimedia [11].

The mean value for the overall level of satisfaction of learners was ( $\bar{X} = 4.56$ , S.D. = 0.54), due to the technology used to manage to learn online. Studying the content anytime, anywhere, reviewing it repeatedly, and doing homework or class activities is convenient. This model supports self-learning and helps each other among learners within groups. The study was consistent with Surachat Artsub's study [12], which mentioned that online lessons via Moodle program had higher learning effectiveness or equivalent to regular learning. Moreover, the model also helped learners to practice, review, and develop themselves and enhance teaching and learning activities develop at a reasonable level. Moodle is an open source of e-Learning platform. It provides a variety of learning-enhancing programs, such as quizzes, questionnaires, chats, polls, etc. A plug-in or an add-on or extension can be added to stimulate students' interest, making students have fun and enjoy learning [12].

## Data Availability

Online classroom: <http://surawut27.ttc Moodle.com/> Please use this username and password for access to the online classroom. Username: hindawi, Password: Hindawi@1. Data analysis and research results: [https://drive.google.com/drive/folders/15wFqG1bAYQj10L3UnlE6RFaXoRhoI GRH?usp=share\\_link](https://drive.google.com/drive/folders/15wFqG1bAYQj10L3UnlE6RFaXoRhoI GRH?usp=share_link).

## Conflicts of Interest

The authors declare that they have no conflicts of interest.

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