

Flipped Classroom Learning with Critical Problem-Solving Activities for Undergraduate Students

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This study presents a guideline for flipped classroom learning with critical problem-solving activities for undergraduate students. The literature review synthesises research related to flipped classroom learning and critical problem-solving. The procedure for flipped classroom learning consists of five steps, namely learning introduction, learning through electronic media, formative, learning activities organisation, and summative. The flipped classroom learning procedures area is integrated with the critical problem-solving procedure, which consists of six steps, which are preparation, problem analysis, problem-solving design, problem-solving conducting, problem-solving evaluation, and presentation. This guideline integrates learning from both outside and within the classroom. For learning outside the classroom, students can learn by themselves through online media. Meanwhile, in-classroom learning involves learning activities which focus on critical thinking and problem-solving skills through active learning and evaluate both formative and summative to stimulate students to change themselves to reach their achievement targets.

Keywords: *Flipped classroom, Active learning activities, Problem-solving, Critical thinking, Undergraduate students.*

Introduction

The flipped classroom is a 'flipped' model of learning management which utilises the concept of home study and school-based homework. The flipped classroom concept was developed in 2007 by Jonathon Bergmann and Aaron Sams, both highschool chemistry teachers at Woodland Park School, Colorado, United States. Bergmann and Sams found that the available study time was insufficient to teach everything in class. This lead to them

recording their teaching and assigning students to learn by themselves at home. The students were then required to use that knowledge in class through practice and by raising questions in class. This method ensured that students could learn deeply through mastery learning and gain experience from learning. The flipped classroom concept has since become widespread with many teachers interested in the method (Bergmann and Sams, 2012). Traditional classroom teaching has been changed to self-learning through the online video, in which learning students outside the classroom are stimulated by focusing on important learning activities from classroom teaching (Slomanson, 2014). When students have learnt through online video before, they develop knowledge in class, are motivated and have more confidence to participate in classroom activities and are more active discussants in class. Additionally, it can be used to assess the readiness of students and their responsibility for self-learning before class (Evseeva, and Solozhenko, 2015).

During the class, teaching involves class activities in the form of learning by doing (Dewey, 1963) which is student-centred. During learning, students participate in both individual and team activities, collaborative learning, and help each other, which stimulates the students' thinking and curiosity (Office of Instruction and Assessment [OIA], 2019). Moreover, it enhances high-order thinking according to Bloom's Taxonomy in terms of analysing, evaluating, and creating (Bloom, Englehart, Furst, Hill, and Krathwohl, 1956) and builds skill development in the 21st century to support students towards critical thinking, problem-solving, communication, and collaboration skills to respond to the rapidly changing society, especially in terms of critical thinking and problem-solving, understanding, analysing, and responding to different situations (The Partnership for 21st Century Skills, 2009). For learning design, teachers must apply strategies and teaching techniques, including evaluating learning outcomes after learning (Dick and Carey, 1985). To design a learning activity, teachers should consider how students understand new things and which knowledge and skills are to be developed by the learning activities (Bransford, Brown, and Cocking, 2000). Teachers must find suitable activities to use in the teaching and evaluate the students' obtained outcomes. Using a guideline for flipped classroom learning with critical problem-solving activities, the steps cover learning management according to the objectives and increase the efficiency of learning. Meanwhile, undergraduate students who are able to learn by themselves and collaboratively in activities can be taught in a way which supports critical thinking and problem-solving.

Literature Review

Flipped Classroom Learning Management

Bergmann and Sams (2012) defined the 'flipped' concept as "that which is traditionally done in class is now done at home, and that which is traditionally done as homework is now completed in class" (p. 13). The learning design of the flipped concept combines online

learning and learning inside and outside the classroom, or through online video by themselves over the internet. The flipped concept is a flexible learning approach that allows students to manage their time and be responsible for preparing themselves before class. Moreover, they can apply their knowledge in mastery learning and participate in class activities by interacting with teachers and classmates by asking and answering questions as well as team exercises. Teachers can also make suggestions to each student and change their role from presenter to a coach who provides suggestions and facilitates students closely.

The Flipped Learning Network (FLN) (2014) defined that “Flipped Learning is a pedagogical approach in which direct instruction moves from the group learning space to the individual learning space, and the resulting group space is transformed into a dynamic, interactive learning environment where the educator guides students as they apply concepts and engage creatively in the subject matter”. An important component of the flipped classroom is that it is supported by the four following pillars. First, various learning models, the flexibility of students’ learning time, and suitable learning evaluation (flexible environment). Second, learning management which focuses on students as the centre and students are able to learn more deeply, have learning opportunities by participating in the creation of knowledge in the class, and students are evaluated individually (learning culture). Third, searching for a teaching model to make students understand theories and be fluent in processes through student-centred teaching, the use of active learning strategies depending on the class level and topics that teachers want to teach (intentional content). Finally, the role of the teacher is to observe the learning, provide suggestions to students, evaluate work performance, connection, offer feedback and rectification, control learning in the class, and regularly improve their teaching (professional educator).

Long, Cummins and Waugh (2016) explained that flipped classroom learning involves teachers combining learning models with technology according to the Technological Pedagogical Content Knowledge (TPCK) concept, including knowledge in content, teaching, and the use of technological knowledge to increase learning and teaching efficiency both within and outside the classroom. For Technological Knowledge (TK), teachers should know and be able to apply each technological tool to flipped classroom teaching, while Technological Content Knowledge (TCK) and Technological Pedagogical Knowledge (TPK) should be used in the learning and teaching. Teachers must therefore select technology which is suitable for the content and their teaching when creating a flipped classroom.

Technology is a useful tool to manage the flipped classroom learning environment and distribute knowledge. Students can create knowledge by themselves through developing a deep understanding and interactions. Sultan (2018) and Pradubthong et al (2019) explained that the flipped classroom concept is a learning approach which is easy to understand and can be applied with technology and active learning. Teaching outside the classroom is a learning

approach that utilises technology such as lecture videos, documents, and problem-solving exercises, while teaching inside the classroom is in the form of active learning through various group activities to provide learning opportunities in which teachers provide learning and work suggestions to the students. Activities can include learning activities, interaction, discussion, and related examples which enhances high-order thinking and creative thinking processes.

Table 1: *Guideline for Flipped Classroom Learning.*

Authors	Flipped classroom procedures
Bergmann and Sams (2012)	<ol style="list-style-type: none"> 1) Explain the flipped classroom learning model in terms of the learning guidelines, evaluation, and benefits of this approach to students and parents. 2) Teach students through video in a similar way to textbooks and pause/rewind the video to emphasise important issues, take notes, ask questions, and conclude what they learned. 3) Students ask questions from the video and find answers in the class. 4) Created the flipped classroom and change the traditional classroom by teaching through various activities. 5) Students manage their own time and prioritise the work assigned to them. 6) Supports collaborative learning, with the classroom as the learning centre. Students learn and work together to achieve their targets. 7) Create a suitable evaluation to measure students' learning according to the curriculum using a pre-test and a post-test.
Buil-Fabregá, Casanovas, Ruiz-Munzón, and Filho (2019)	<ol style="list-style-type: none"> 1) Content preparation: collect content from learning resources and create individual and group activities through online learning via Moodle, Office, and Drive. 2) Learning environment development through online learning on Moodle. Understand content in video, pictures, and answer questions from teachers. In the class, students do team exercises, answer questions, learn together, and share their opinions before class. 3) During the class, students are divided into groups to discuss and support collaborative learning and analyse details from the examples or problems they face. Then, details are adjusted from team exercises and feedback is provided to get conclusions of related content.

Authors	Flipped classroom procedures
	4) Students prepare for their final exam from what they learned from the online system, during the class, and group activities.
Hung (2017)	<p>1) Individual learning activities: before class, students study through an online video provided by teachers and do exercises to prepare for the class.</p> <p>2) Evaluation during the class: 20 minutes. Students participate in warm-up activities and answer basic questions based on the video to evaluate students during the class and receive suggestions from classmates with the teacher guiding.</p> <p>3) Learning activities: 20 minutes. After students review content before the class, students discuss and share opinions in the group while teachers have the role of facilitating each group of students.</p> <p>4) Conclusion and assessment: 10 minutes. Finally, students do an exercise to evaluate their learning achievement. Help and suggestions are provided later.</p>
Na-Songkhla (2018)	<p>1) Lesson introduction approximately 2-3 minutes. Students study through tools such as video, direct information sources, or technology.</p> <p>2) Q&A session of approximately 10-15 minutes to ensure that students have studied, which leads into class activities such as exercises.</p> <p>3) Class activities are organised to allow students to think and practice, including feedback for about 60-75 minutes such as question answering, discussion, work creation and collaborative activities, and so on.</p> <p>4) Evaluation can be done in different ways depending on the teacher to evaluate students' understanding of the content and can be used for further evaluation.</p>

Table 1 is a synthesis of the procedure for flipped classroom learning, which consists of five steps: 1) learning introduction; 2) learning through electronic media; 3) formative; 4) Learning activity organising; and 5) summative.

The flipped classroom learning approach requires organisation for it to be effective and can include a variety of different types of learning. Teachers must systematically plan their teaching and apply their knowledge to design activities with clear objectives to make students

learn as expected (Gagné, Wager, Golas, and Keller, 2005, p. 1). Teaching and learning management with technology systems and learning activities requires critical thinking and problem-solving as well as evaluations undertaken both in class and after class. Furthermore, teachers must facilitate students and control the teaching to ensure efficient learning.

Critical Problem-Solving Concept

Polya (1962) explained that, “solving a problem means finding a way out of a difficulty, a way around an obstacle, attaining an aim that was not immediately understandable” (p. v). This is in accordance with what Krulik and Rudnick (1987) defined as problem-solving, namely “the means by which an individual uses previously acquired knowledge, skills, and understanding to satisfy the demands of an unfamiliar situation. The student must synthesise what he or she has learned and apply it to a new and different situation” (p. 4).

Newell and Simon (1972) mentioned problem space that consisted of the initial state, goal state, and set of operators to search for problem-solving guidelines (search process) in problem space from the initial state by using logic and reason for problem-solving from one situation to another situation (set of operators) until the problem is solved (goal state).

DeBono (1991) presented a problem-solving concept by using outside the box thinking which is a good problem-solving guideline. The guideline said that most problems require different perspectives to be successfully solved. DeBono (1991) presented four components of problem-solving which were outstanding idea selection from the problem awareness, different solution searching, strict idea releasing, and opportunities to receive knowledge from other sources.

Md. (2019) explained that skills for 21st century students include problem-solving, creativity, innovation, metacognitive, and communication. Problem-solving is a process related to systematic observation and critical thinking by a proper method to achieve an intended goal. The scope of problem-solving consists of two main skills, namely observation skills to collect data, understand, and interpret data, and then critical thinking related to individual skills to define concepts, use of strategical reasoning, use of strategy, critical thinking, decision making, and synthesis for problem-solving.

Snyder and Snyder (2008) stated that critical thinking is different from problem-solving, in that critical thinking is an analytical process which can be used with problem-solving. When problems occur and there are many options, critical thinking can be used to efficiently solve the problem.

Table 2: *Synthesis of the Critical Problem-Solving Process*

Critical problem-solving process	Bloom (1956)	Guilford J.P (1967)	Polya (1975)	Facione (2015)	National Research Council (NRC) (2012)	Conclusion
1) Preparation	✓	✓	✓	✓	✓	✓
2) Problem analysis	✓	✓		✓	✓	✓
3) Problem-solving design	✓		✓		✓	✓
4) Problem-solving conducting	✓	✓	✓	✓	✓	✓
5) Problem-solving evaluation		✓	✓	✓	✓	✓
6) Presentation					✓	✓

Table 2 is a synthesis of the critical problem-solving process which consists of six steps: 1) preparation; 2) problem analysis; 3) problem-solving design; 4) problem-solving conducting; 5) problem-solving evaluation; and 6) presentation.

It can be concluded that problem-solving is the finding of suitable problem-solving methods systematically by analytical thinking, reasoning, thinking, and problem-solving practice until the expected outcomes are obtained. This is achieved by learning through activities which stimulate students to undertake problem-solving activities for in-depth learning in which they are challenged by problems, and that their thinking skills are promoted, publishable outcomes are achieved, and accumulated experiences acquired for further problem-solving.

Methodology

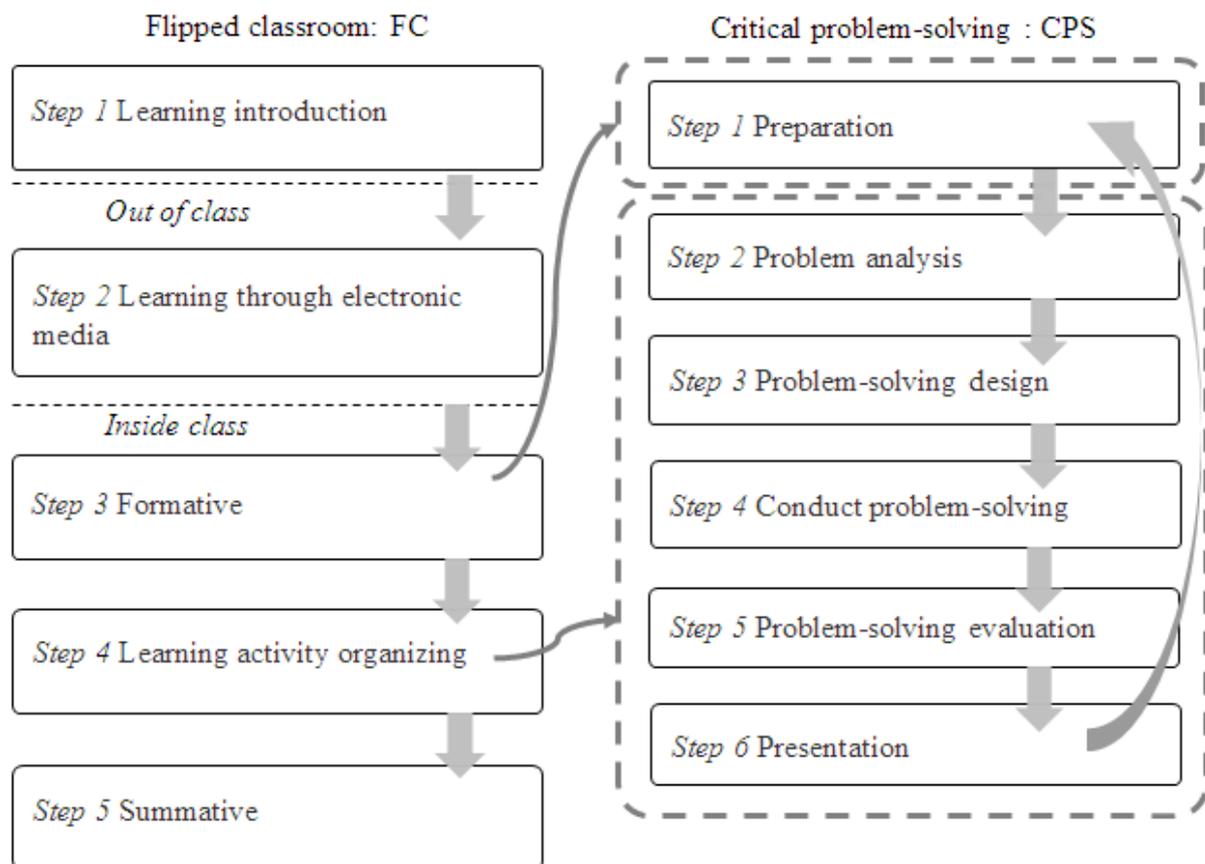
This study uses qualitative research. The author reviewed the relevant literature for flipped classroom learning and critical problem-solving activities for undergraduate students, both domestically and internationally, from 41 sources. The sources can be separated into two sections: 1) flipped classroom learning; and 2) critical problem-solving activities. Content analysis consists of categorising, comparing, and extracting theoretical conclusions from the literature (Cohen, Manion, and Morrison, 2007) by using the keywords ‘flipped classroom,’ ‘active learning activities,’ ‘problem-solving,’ and ‘critical thinking’. The author concluded by creating a guideline for the flipped classroom learning model and critical problem-solving activities.

Results

The author synthesised the learning procedures of the flipped classroom using flipped classroom guidelines (Buil-Fabregá et al., 2019; Hung, 2017; Bergmann and Sams, 2012; Na-Songkhla, 2018; Pradubthong et al, 2018, 2019), problem-solving (Bloom, 1956; Guilford, 1967), Polya’s problem-solving process (Polya, 1975), critical thinking general problem solving process (Facione, 2015), and engineering design processes (National Research Council (NRC), 2012).

By synthesising guidelines for flipped classroom learning in Table 1 and the critical problem-solving process in Table 2, the author concluded the guideline of flipped classroom learning with critical problem-solving activities for undergraduate students, as follows.

Figure 1. The Flipped Classroom Learning with the FC-CPS Critical Problem-Solving Model.



From Figure 1, the flipped classroom learning with FC-CPS critical problem-solving model can be concluded with the following table.

Table 3: The Flipped Classroom Learning with the Critical Problem-Solving Process

Flipped classroom learning	Critical problem-solving	Flipped classroom learning with the critical problem-solving process
1) Learning introduction	-	Introduce the flipped classroom concept, clearly inform objectives, learning processes consist of two parts: 1) self-learning outside the class; and 2) activities in the classroom, including what students must prepare for the learning and evaluation method
2) Learning through electronic media	-	Students learn through online video media which is provided by teachers and conduct interactions and exercise activities on the system, such as online Q&A, online exercises, etc.
3) Formative	1) Preparation	20 minutes: before the lesson, a pre-test is taken to evaluate students on whether they have studied. Conduct warm-up activities to review the content and raise issues such as through Q&A and playing games etc. Before the learning through activities, raise issues related to the content
4) Learning activity organising	2) Problem analysis 3) Problem-solving design 4) Problem-solving conducting 5) Problem-solving evaluation 6) Presentation	45 minutes: Group students to help each other, or five students per group in problem analysis activities. Select the best guideline for problem-solving and problem-solving design for problem-solving. Teachers visit each group to make suggestions. The group with the fastest and most correct problem solution presents the problem-solving process and receives special scores
5) Summative	-	15 minutes: Conduct a post-test and then teachers conclude and evaluate the class

Discussion

The flipped classroom learning with FC-CPS critical problem-solving model for both inside and outside the classroom combined with the critical problem-solving process begins from Step 1 of the learning introduction. In *Step 1*, teachers should suggest reasons to use the flipped classroom, objectives, and learning methods according to the flipped classroom approach so that students can understand and help them to understand and prepare for the

learning, measurement, and evaluation methods (Bergmann and Sams, 2012). For **Step 2**, learning through electronic media involves self-learning outside the classroom. Students study through online video media provided by the teacher on their own and have interaction via the online system. General practice is that these are short videos, with a duration of 10-15 minutes being suitable for each topic (Schmidt and Ralph, 2016) and making the online teaching interesting. **Step 3 and Step 4** are learning inside the class after learning outside the class. Students apply the knowledge they learn by themselves in activities related to critical problem-solving according to the following critical problem-solving steps: 1) preparation; 2) problem analysis; 3) problem-solving design; 4) problem-solving conducting; 5) problem-solving evaluation; and 6) presentation which focuses on active teaching according to what Bonwell and Eison (1991) defined as “anything that involves learners in doing and thinking about what they are doing”. **Step 3** Formative is a review of students’ knowledge. Teachers can learn how much the students studied themselves and can plan and proceed with the learning in the class properly. Moreover, this evaluates their self-learning responsibility before the class through activities and makes it possible to raise issues about the content. **Step 4** Learning activity organising, refers to learning activities in the class in accordance with active learning by the critical problem-solving process which emphasises critical thinking and selection of a suitable option in the challenge of problem-solving (Brookfield, 1987), which consists of four components: 1) critical thinking; 2) learning responsibility; 3) open-end activity participation; and 4) learning activities of teachers (Berry, 2008). Student methods which can solve problems the fastest and most accurately get special scores to stimulate the students. Finally, **Step 5** Summative is the final step in which teachers conclude information from the teaching, evaluate the students, and inform the students about what the teacher must consider to develop their teaching in the flipped classroom. This involves gathering information observations, evaluations, and asking for suggestions to make the learning more efficient. All the processes encourage undergraduate students to research and study by themselves when they are outside the classroom. The approach ensures that teachers are trained to think critically, and problem solve better than from traditional lectures, allowing them to have deep understanding, learn how to learn cooperatively, and how to live in society. This conforms with Gullayanon (2014) who applied the flipped classroom concept when teaching engineering mathematics to undergraduate students in a large class by assigning students to learn by themselves outside the class and prepare for problem-solving activities in the class. After that, the same teacher conducted surveys and interviews with each student individually to compare the flipped classroom and the traditional classroom. It was found that the flipped classroom resulted in more efficient and supported self-learning skills and teamwork. This is similar to Kloppers, Magda, Vuuren, and Jansen van Vuuren (2016) who argued that promoting critical thinking is related to the mathematical calculation by using the flipped classroom concept. Students studied the content in the video outside the class in which students could pause the video and talk to each during the problem-solving practice via video. They then had group activities in the classroom. As a result, students were better able



to solve mathematical problems. Serin and Khabibullin (2019) applied the concept of the flipped classroom to college students to support skills in the 21st century so that students could create knowledge by themselves, and to promote learning participation, information searching, and transferring, as well as enabling the use of technology in learning.

Conclusion

The use of flipped classroom learning with critical problem-solving activities allows students to learn by themselves outside the class and participate in classroom activities. In this case, it emphasises active learning activities related to problem-solving. Students can proceed to promote their knowledge with others. This enhances high-order thinking, conducting critical thinking, problem-solving skills, and learning with digital technology. Therefore, students are able to gain a deep understanding and accumulate skills and experience through their learning. Teachers must be ready in every aspect, from defining objectives and targets through to designing the teaching, resource preparation, teaching techniques, strategy, control, and facilitating the whole teaching process.



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