The Effect of Flipped Classroom to The Higher-Order Thinking Skills and Chemical Engineering Students' Perception on Environmental Issues

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Abstract:
The flipped classroom approach has been reported to enhance higher-order thinking skills in chemical engineering students, as evidenced by studies conducted over the past decade. These skills are crucial for addressing environmental issues and developing innovative solutions. However, many students struggle to articulate their thoughts and opinions on given topics. The flipped classroom method allows students to prepare in advance and make the most of their learning time, as outlined in the course information. This study aimed to evaluate student achievement and perceptions of the flipped classroom method, comparing it to the conventional teaching method to determine its effectiveness in improving higher-order thinking skills. A quantitative approach was employed, involving pre-tests and post-tests for unbalanced groups. Data analysis included mean calculations, paired t-tests, and ANCOVA tests. The results indicated that there was no statistically significant difference in student achievement between the flipped classroom and conventional teaching method groups. However, the ANCOVA test revealed that the treatment group showed an increase in higher-order thinking skills. Additionally, students perceived that the flipped classroom improved their knowledge, encouraged creative thinking, and reduced the time required to learn. Despite both methods enhancing thinking skills, the flipped classroom was more effective in helping students answer questions systematically and concisely.

Keywords: Flipped classroom, Teaching method, Higher order thinking, Perception

Introduction

Teaching is one of ways to deliver knowledge and skills to people. Decades ago, traditional teaching method has been implemented in the whole world, where only teacher gives the knowledge. It is a one-way communication, or we called it, teacher-centred learning. In the teacher-centred learning, teacher is the primary authority and source of knowledge (Ghafar, 2023). As time change, teaching method might also be change. Other than teacher-centred method, there are leaner-centred, content-focused method and interactive/participative method. All these new methods encourage students to be actively participate in the classroom and teacher is not the only source of knowledge. In line with industrial revolution (IR) 4.0, teaching methods

must be adapted to prepare the students with skills such as attitudes to analyse, evaluate and propose the solution of problems (Afrianto, 2018). All the skills can be grasped by students if teachers can adapt themselves with technology advancement, where teachers are increasingly anticipated to weave computing into the fabric of the curriculum, as these skills are deemed instrumental for future triumphs. This integration holds significance not solely for individuals embarking on post-secondary education but also for those who opt to forgo college and directly immerse themselves in the workforce (O'Neal et al., 2017).

Various instructional approaches such as process drama (Danckwardt-Lilliestrom et al., 2024), cooperative learning, group discussion, independent study (Bassachs et al., 2020), portfolio development (Cifrian et al., 2020) and produce innovative ideas and products (Ramly et al., 2024). Nowadays undergraduate students face intense challenge to apply higher-order thinking skills as listed in the Bloom's cognitive domain such as solving problems, predicting outcomes, and dealing with environmental issues (Lim, 2017). The flipped classroom approach offers a teaching design to guide students to be a problem solver.

In general, flipped classroom is opposite to traditional or conventional classroom where students need to study the content prior to class so that class time can be an active learning activity (Fauteux-Lefebvre, 2019). Study before entering the class or known as pre-learning was stated in Student's Learning Time (SLT) and flipped classroom is a method to help students use their allocated time systematically (Hew & Lo, 2018). During the class time, students will be discussing in group the topic that they prepared according to the course outline. Lecturer engaged with students as a facilitator to observe their understanding and give an extra information within the topic.

Background

Flipped learning represents a transformative pedagogical paradigm that upends traditional classroom dynamics. In this innovative approach, students engage with learning materials prior to attending class, thereby allowing precious classroom time to be devoted to enriching comprehension. This is achieved through collaborative discussions with peers and problem-solving endeavors, all expertly guided by educators (Akçayır & Akçayır, 2018; McNally et al., 2017). In conventional educational settings, students absorb knowledge within the confines of the classroom, subsequently tasked with the synthesis, analysis, and evaluation of that information in isolation. Conversely, the flipped classroom model empowers students to grasp foundational concepts prior to class, transforming classroom time into a dynamic arena for practice and application. Here, learners engage in meaningful interactions with both peers and educators, fostering a collaborative environment that enhances understanding and retention of ideas. Following the class, students engage in introspective reflection on the feedback they have received, utilizing it as a catalyst to propel their learning forward. This process not only deepens their understanding but also cultivates a mindset geared towards continuous improvement and self-directed growth. Previous studies have proved that flipped classroom could improve the higher order thinking among undergraduate students at the higher institution education. Kim and Jang (2017) show that the implementation of the flipped learning methodology has markedly enhanced students' higher-order thinking skills, particularly within the realms of critical care and emergency scenarios in both paediatric nursing courses

and general paediatric nursing curricula. This innovative approach fosters a deeper cognitive engagement, enabling learners to navigate complex clinical situations with greater acuity and confidence. Therefore, the effort to implement flipped classroom method in order to improve the higher order thinking is a necessary among the undergraduates' students, especially when they involved with problems that need a special attention.

Higher-order thinking skills among the chemical engineering students is important to develop students in dealing with various issues concerning of environment (Aubrecht et al., 2020). These skills can help students proposed innovative solutions to the environmental problems. From the past semesters, it was found that students cannot give a good answer as given by the answer scheme in test or examination regarding to the environmental issues. Most of them show a difficulty to elaborate and express their opinion to the given issues. Environmental issues are categorised as higher-order thinking questions because it need each student to analyse and evaluate the issue before they can suggest solutions to the problem. In order to write a good answer, each student have to gain more knowledge from their own reading and searching. The previous students were taught by conventional classroom approach where almost of them depends on notes and knowledge given by the lecturer. Therefore, flipped classroom can be a good platform to help them gain more ideas through active learning in the class.

The learning pyramid, conceptualized by the National Training Laboratory, posits that a mere 10% of information gleaned from textbooks is retained by students. In stark contrast, the retention rate soars to nearly 90% when learners engage in teaching others. This striking disparity underscores the profound impact of active participation and peer instruction on the learning process, illuminating pathways to more effective educational strategies (Letrud, 2012). Because of that, flipped classroom will force students to read and search information from any sources such as internet, documentaries video, lecturer's teaching video and others before they enter the class. During the class, students will discuss in a small group about environmental issues, change their opinion or teach other students. By this way, each student will gain more knowledge and can prepare themselves to answer the higher-order thinking questions well. Therefore, the effort to implement flipped classroom method to improve the higher-order thinking is a necessary among the undergraduates' students, especially when they involved with problems that need a special attention.

Theoretical Framework

The flipped classroom involves the component of Piaget's theory of cognitive development (1952), Flipped-Mastery classroom model proposed by Bergmann and Sams (2012) and Revised Bloom's Taxonomy by Anderson and Krathwohl (2001). In alignment with Piagetian cognitive constructivist theory, attaining elevated levels of learning necessitates that students engage in meaningful interactions with their peers, facilitating the accommodation of knowledge. The flipped learning model adeptly amalgamates various pedagogical strategies, drawing upon principles such as student-centred learning, constructivism, problem-based learning, and peer-assisted learning. This multifaceted approach not only enriches the educational experience but also cultivates a collaborative environment where learners can thrive (Bishop & Verleger, 2013). Flipped classroom approach can be a site to develop student's high

level cognitive in their learning process. Bergmann and Sams (2012) write in their book that flipped classroom requires the instructor (teacher) create an inquiry-based teaching environment. This opinion is supported by Awidi and Paynter (2019) that flipped session comprised pre-recorded, online quizzes and in-class group activities in the course design. Lorin Anderson and David Krathwohl has revised Bloom's Taxonomy into two level of cognitive i.e. lower order thinking skill and higher-order thinking skill. Higher-order thinking is stated as cognitive level 5 (evaluate) and level 6 (create) in Bloom's Taxonomy (Nkhoma et al., 2017). Students need to evaluate a problem by checking and critiquing, then they must create their own idea to solve the problem. Each undergraduate student will be evaluated based on every cognitive level in Bloom's Taxonomy along their studies. The result will be visualized as a perfect spider web diagram to display the ability of remembering, understanding, applying, analyzing, evaluating and creating (Yusof et al., 2017).

Research Questions and Hypothesis

The purpose of this study was to investigate the implementation of flipped classroom in enhancing the higher-order thinking skills and it is also to study the perception of undergraduate students on flipped classroom method against the environmental issues. Therefore, the research questions and hypothesis can be developed as:

1.Is there a significant difference between the mean achievement of the student performance on higher-order thinking question of the treatment group and the control group in the pretest?

Ho1: There is no significant difference between the mean achievement of the student performance on higher-order thinking question of the treatment group and the control group in the pretest.

2.Is there a significant difference between the mean achievement of the student performance on higher-order thinking question of the treatment group in the pre- and post-test?

Ho2: There is no significant difference between the mean achievement of the student performance on higher-order thinking question of the treatment group in the pre- and post-test.

3.Is there a significant difference between the mean achievement of the student performance on higher-order thinking question of the control group student in the pre- and post-test?

Ho3: There is no significant difference between the mean achievement of the student performance on higher-order thinking question of the control group student in the pre- and post-test.

4.Is there a significant difference between the mean achievement of the student performance on higher-order thinking question of the treatment group students and the control group students in the post-test?

Ho4: There is no significant difference between the mean achievement of the student performance on higher-order thinking question of the treatment group students and

the control group students in the post-test.
5.Is there a significant difference between the mean achievement of the student performance on higher-order thinking question of the treatment group and the control group students in the pre- and post-test?

Ho5: There is no significant difference between the mean achievement of the student performance on higher-order thinking question of the treatment group and the control group students in the pre- and post-test.

6.What are the students' perceptions of the flipped classroom?

Literature Review

Flipped Classroom and Higher-Order Thinking Skills

The flipped classroom approach affords educators increased instructional time, thereby fostering enhanced interactions within the classroom. This paradigm not only cultivates a more vibrant and engaging atmosphere but also contributes to the establishment of a supportive learning environment. By prioritizing collaboration and active participation, the flipped classroom empowers both teachers and students to thrive in their educational pursuits (Lee & Lai, 2017). It also shows that most students could analyse task requirements and designed models in creative ways. Supiandi et al. (2019) state that there is an increase in higher-order thinking skills after the implementation of an Instagram-based flipped classroom learning model. This innovative approach leverages social media as a dynamic platform for engagement, facilitating deeper cognitive processes and encouraging critical analysis, synthesis, and evaluation of information. As a result, learners are better equipped to navigate complex concepts and apply their knowledge in meaningful ways. The active and reflexive learning from flipped classroom methodology makes students more committed to sustainable development. This research would be useful to anyone interested in applying the flip the class teaching methodology as an integrated form of thinking and training in the curriculum of sustainable development for higher education students (Buil-Fabregá et al., 2019). The flipped classroom pedagogy has emerged as a highly effective methodology for enhancing higher-order thinking skills within higher education. This innovative instructional strategy has demonstrably improved learner performance, establishing itself as a beneficial approach particularly within engineering courses. By fostering active engagement and critical thinking, the flipped classroom not only enriches the educational experience but also equips students with the analytical skills necessary for success in their fields (Priyaadharshini & Vinayaga Sundaram, 2018). Study by Baytiyeh and Naja (2017) find that engineering students reveal that using flipped classroom can also enrich students' learning experience and help develop the professional skills needed for successful careers in engineering, including self-learning, problem-solving, critical thinking, self-confidence and teamwork.

Flipped Classroom and Student's Perception

Previous studies have delved into students' perceptions of the flipped classroom method in relation to their learning styles. Notably, a study conducted by Musallam (2010) examines the efficacy of screencasts video recordings of a computer screen, with or without accompanying narration as a pre-training technique for high school chemistry students. The findings reveal that the use of screen casting significantly

alleviated intrinsic cognitive load while simultaneously enhancing performance on assessments. This underscores the potential of multimedia resources in optimizing learning outcomes within a flipped classroom framework and shows that students give a positive respond at flipped method.

Another survey done by Owens and Strayer (2007) on university students find that students who undergo flipped classroom treatment is preferred and experienced a higher level of innovation and cooperation in their classroom compared to students who received conventional instruction. Shih and Tsai (2017) find that in their investigation, the students' perceptions of the flipped classroom model as a facilitator of online project-based learning in a marketing research course at a technical university have undergone a notable transformation. This pedagogical approach has significantly bolstered learning effectiveness, heightened motivation, and sparked greater interest in the subject matter. Furthermore, it has fostered collaboration, and the development of diverse skill sets among students, thereby enriching their educational experience and preparing them for real-world challenges in the marketing field.

Methodology

This study employed quantitative method and divided into two main sections, the quasi-experimental design which involved pre and post-test and a survey on the student's perceptions after using the flipped classroom method. This approach was chosen because it provides data in the form of numbers (Borusyak et al., 2018) and can demonstrate comprehensive information, differences, and impact findings (Grabbe, 2015). The quasi-experimental design in this study was adapted from Jaidi et al. (2014), where it used pre and post-test for unbalanced groups (non-equivalent groups). The study design was shown in Figure 1 below.

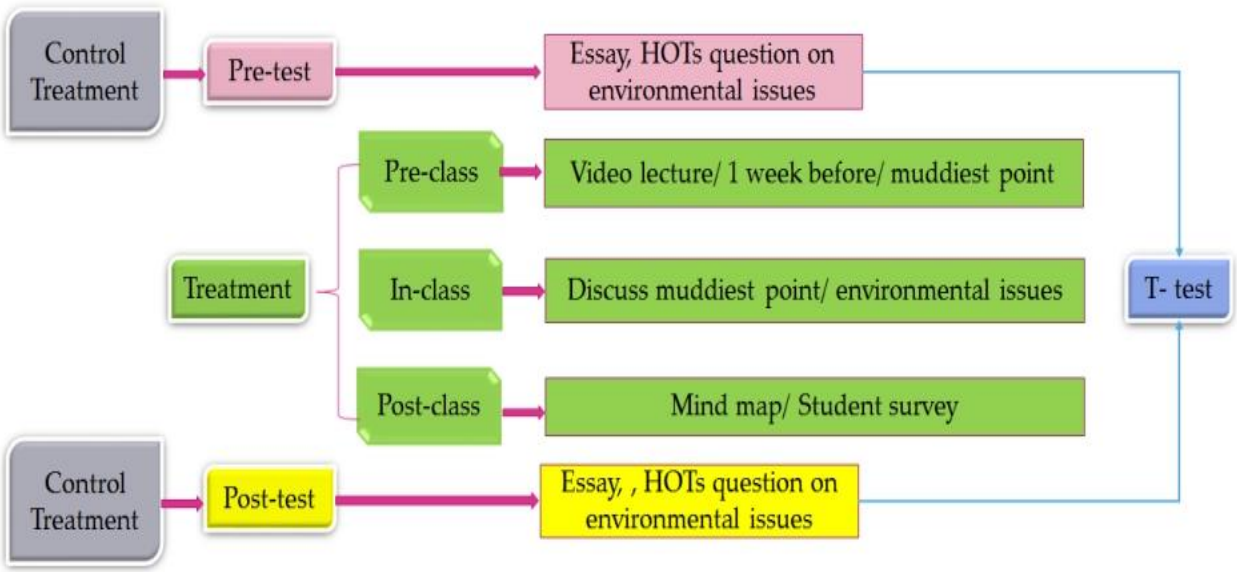

Figure 1: Research Design

This study encompasses two distinct types of variables: the independent variable (IV) and the dependent variable (DV). The independent variable identified in this research was the flipped classroom method, which served as the primary intervention. Conversely, the dependent variable was the students' achievement in responding to the higher-order thinking skills questions on environmental issues. The questions consist of three main questions about pollutions and waste. This framework allows for a comprehensive analysis of how the flipped classroom approach influences students' cognitive performance and critical thinking capabilities to answer the given questions.

The respondents in this study are students who have registered for the Basic Environmental Science course in the current semester. The total respondents were 28 and divided into two groups, the control group and the treatment group using conventional sampling. Each group undergone pre-test and post-test. Pre-test (T1) was done at the beginning of the study that is before the implementation of flipped classroom (FC) approach. Meanwhile, the respondents in control group only received regular learning during conventional classroom. At the end of the treatment, both groups undergone post-test (T2) to identify there is a change in their higher-order thinking skills. This study was conducted online, both synchronise and asynchronies using Microsoft Teams platform.

Flipped Classroom Treatment

Video Lecture

Recorded lecture's video for not more than 15-minutes on the particular topic of environmental issues was done using Microsoft PowerPoint 365. Studies show that span time for student in learning through video must less than 15-minutes (Brame, 2016). Lecture was delivered like conventional method using PowerPoint presentation and digital pen. All the materials were uploaded in class group that had been created in Microsoft Team.

Assessment Tools

Students were evaluated using formative evaluation during three session activities that can be divided into pre-class activities, online in-class activities, and post-class activities. Formative assessment is a tool to measure the ability and understanding of students in their learning environment. Several techniques were applied in this study such as muddiest point, simple summary, and concept map of the environment's problem solution. Muddiest point need students to write down the unclear point quickly after they were watching the video lecture. Whereas simple summary enforces students to write a short summary of the given topic in the video. Concept map allowed student to write the cause, effect, and solution of given environmental problem.

Student Survey

A survey was conducted to evaluate students' involvement and perception of flipped classrooms. It included 11 questions about students' previous experiences with flipped classrooms, views on watching video lectures, in-class activities, and their opinion on flipped instruction. Interpretation of the perception level of student acceptance in this study was done on three levels as shown in Table 1.

Table 1. Interpretation of Student's Perception

Mean score	Level
3.67 – 5.00	High
2.34 – 3.66	Medium
1.00 – 2.33	Low

Source: Ahmad (2002)

Validity and Reliability

Total respondent were 28 students from chemical engineering program in Universiti Teknologi Mara, Pulau Pinang Branch. According to Sekaran (2003) (in Bacotang, 2014) a simple experimental study involving comparison can be implemented to at least 10 respondents. The methods of this study were reviewed by two expert lecturers in the fields of Basic Environmental Sciences and in the field of level of cognitive questions according to the Test Specification Table.

Implementation

Pre-class activities: Students were given video lectures a week before online in-classroom activities as shown in Figure 2. They were also asked to write down the muddiest point and simple summary at the end of each video. Students needed to submit their work a day before their online in-classroom activities through Microsoft Teams.

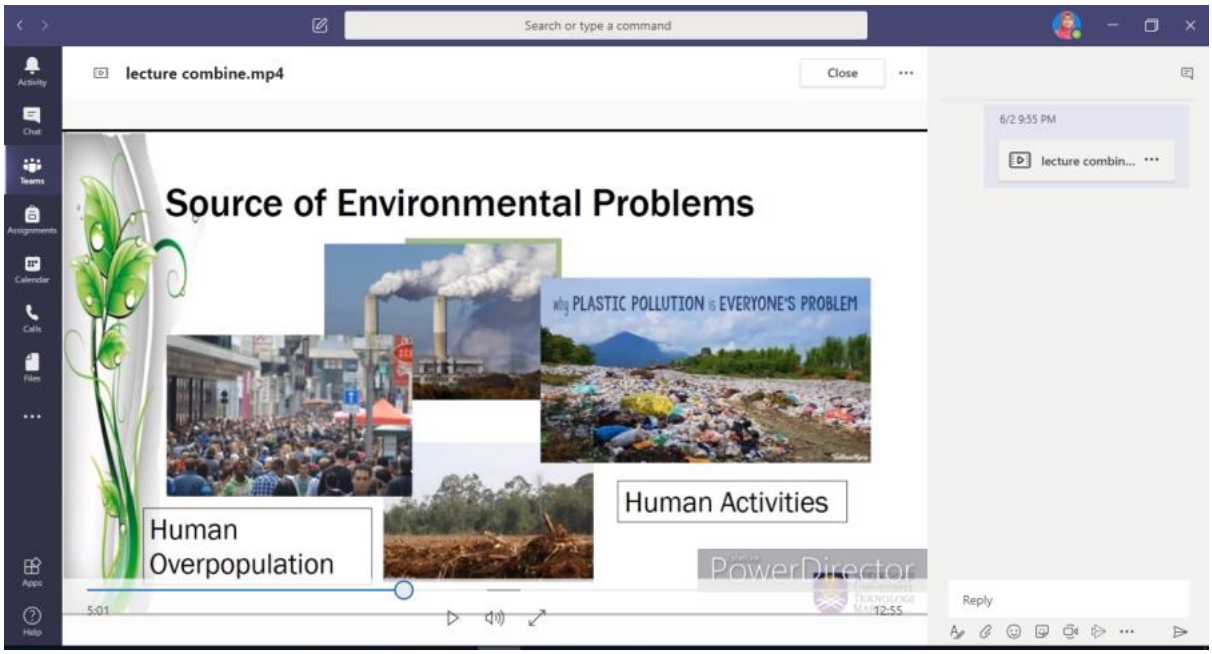

Figure 2: Sample of Video Lecture Given in The Pre-Class Session

In-class activities: In-class activities were conducted through Microsoft Teams Meeting synchronized with every group of students. Treatment group was allocated for one hour to make discussion amongst them and lecturer who react as a facilitator. During the session, muddiest points were discussed. The students were given environmental issues, and they were allowed to draw a concept map consist of causes, effects and solutions to the problems as shown in Figure 3. They were also guided on writing a systematic answer to explain the causes, effects and solutions to

the environmental problems question.

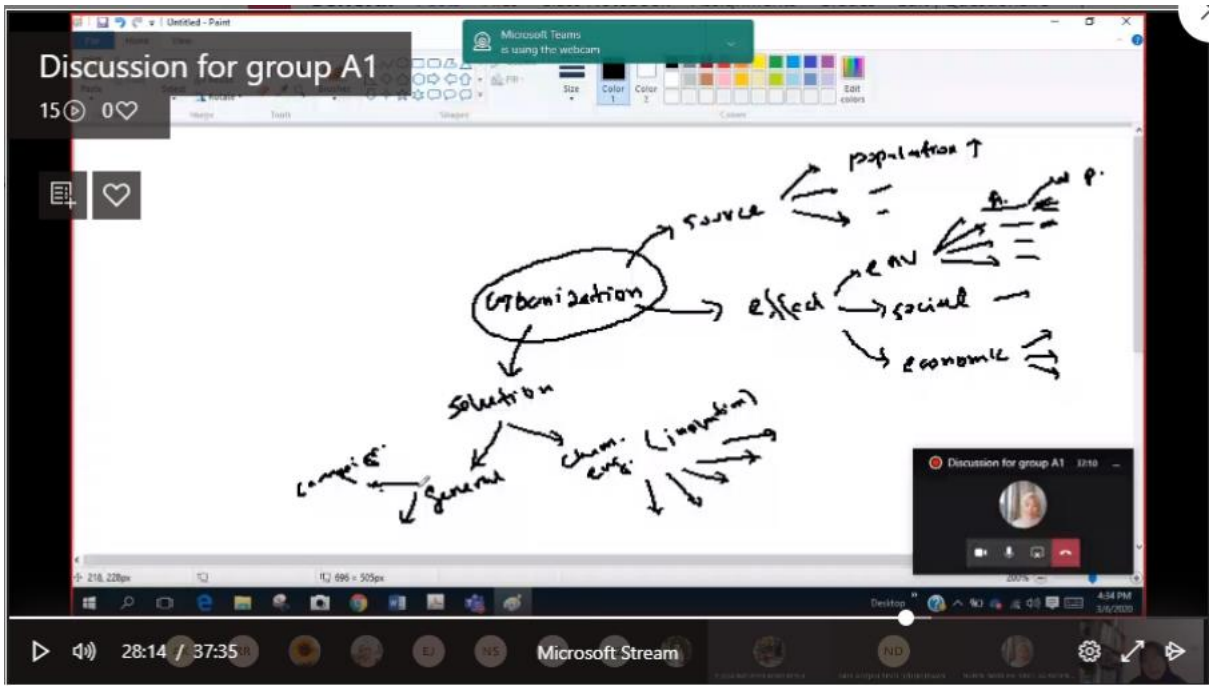

Figure 3: Sample of Mind-Map Activities During In-Class Discussion Session

Post-class activities: A homework assignment was distributed to the students, which was essentially to finalize the concept map of the given problem. Each student was asked to upload their homework individual within a week into the Microsoft Teams. At the end of the session, students were asked to complete a survey on their perception of the flipped classroom method.

Data Analysis

All collected data were analysed using Data Analysis Microsoft Excel 2016 as it is efficient and fast to perform statistical analysis work. The process of analysing the data used inference statistics where a paired sample t-test was carried out to compare the pre-test and post-test achievement scores. A one-factor ANCOVA was conducted utilizing IBM's Statistical Package for Social Science (SPSS) Version 26 to ascertain whether the post-test achievement scores of the control and treatment groups exhibited significant differentiation when controlling for pre-test achievement scores. Despite the absence of a significant difference in pre-test scores, ANCOVA was employed on the post-test achievement scores to mitigate the influence of any mean disparities. This analytical approach ensures a more accurate evaluation of the treatment's impact on student performance. The pre-test achievement scores were used as a covariate. The following hypotheses of ANCOVA were fulfilled Talan and Gulsecen (2019):

i. The groups were independent of one another, ensuring that the results from one group did not influence the other.
ii. The scores for the dependent variable across the groups exhibited a normal distribution, satisfying a key assumption for the analysis.
iii. The variances of the groups' scores for the dependent variable were homogeneous, indicating that the spread of scores was consistent across groups.

iv. A linear relationship existed between the dependent variable and the covariate, reinforcing the appropriateness of the ANCOVA model.
v. The regression coefficients among the groups were equal, affirming that the relationship between the covariate and the dependent variable was consistent across the different groups.

Results and Discussion

This part focuses on the findings obtained from the pre-test and post-test achievement scores of the students in the control and treatment groups and perception levels of flipped classroom method.

Quantitative Assessment
Based on Table 2, it was found that the mean achievement achieved by treatment group was 3.21 (std. dev = 0.70). The mean score by control group was 3.58 (std. dev = 1.09). The mean difference between two group in pre-test was 0.37.

Table 2: T-test for Mean, Standard Deviation Between Control and Treatment Group in Pre-test

Group	N	Mean	Std. dev	t	p
Control	14	3.58	1.09	-1.66	0.12
Treatment	14	3.21	0.70		

T-test analysis revealed that there is no significant difference between the mean of the treatment and control groups, t (28) = -1.66, p > 0.05. This means, that statistically the students in both groups have similar achievements before they are given the treatment. Based on Table 3, it was found that the mean achievement achieved by treatment group in pretest was 3.21 (std. dev = 0.70) and in post-test was 7.86 (std. dev = 0.66).

Table 3. T-test for Mean, Standard Deviation Between Pre and Post-test for Treatment Group.

Test	N	Mean	Std. dev	t	p
Pre	14	3.21	0.70	-33.34	0.00
Post	14	7.86	0.66		

The above findings indicate that there was a significant difference between the mean of the achievement for the treatment group students in the pre- and post-test with t (28) = −33.34, p < 0.05. This means that the treatment provided is effective in improving student achievement in answer the higher-order thinking question. Based on Table 4, it was found that the mean achievement achieved by control group in pre-test was 3.57 (std. dev = 1.09) and in post-test was 4.93 (std. dev = 0.83).

Table 4. T-test for Mean, Standard Deviation for Control Group in Pre and Post-test

Test	N	Mean	Std. dev	t	p
Pre	14	3.57	1.09	-11.16	0.00
Post	14	4.93	0.83		

The above findings indicate that there was a significant difference between the mean of the achievement for the control group students in the pre- and post-test with $t(28) = -11.16$, $p < 0.05$. This means that the conventional approach still can improving student achievement in answer the higher-order thinking question.

Based on Table 5, it was found that the mean achievement achieved by treatment group was 7.86 (std. dev = 0.66). The mean score by control group was 4.93 (std. dev = 0.83). This means that the students in the treatment group had the ability to articulate content related to the environmental issues compared to control group.

Table 5. T-Test for Mean, Standard Deviation Between Control and Treatment Group in Post-Test

Group	N	Mean	Std. dev	t	p	Cohen's d
Control	14	4.93	0.83	-11.16	0.00	3.91
Treatment	14	7.86	0.66			

The above findings indicate that there was a significant difference between the mean of the achievement for the control and treatment group in post-test with $t(28) = -11.16$, $p < 0.05$. It was also shows that the effect size between control and treatment group was 3.91. As seen in Table 6, it was found that there were significant differences between the students' post-test achievement scores in the treatment group when their pre-test achievement scores were controlled [$F(1, 25) = 450.664$, $p < 0.05$]. In other words, there were differences between the flipped classroom and the conventional learning methods to increase the students' higher-order thinking achievement.

Table 6: The Results of ANCOVA Regarding The Post-Test Scores Based on The Corrected Pre-test Scores

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	91.894[a]	2	45.947	238.283	.000	.950
Intercept	19.043	1	19.043	98.756	.000	.798
Pretest	16.322	1	16.322	84.648	.000	.772
Group	86.899	1	86.899	450.664	.000	.947
Error	4.821	25	.193			
Total	1178.000	28				
Corrected Total	96.714	27				

a. R Squared = .950 (Adjusted R Squared = .946)

The findings indicate that there was no significant difference in students' achievement regarding the enhancement of their higher-order thinking skills between the control group, which continued with the conventional instructional method, and the treatment group, which was taught using the flipped classroom approach. This suggests that, in this particular context, the flipped classroom method did not yield a measurable advantage over conventional teaching practices in fostering higher-order cognitive development. Although both approaches still can help students improve their thinking skills, but there was a large difference in mean between the two groups. The mean difference between two groups in post-test was calculated to be 2.93. Cohen (1992) suggests that effect size, as measured by Cohen's d can give an information on how big an impact of independence variable has on the dependence variable. The finding shows that the d is 3.91, which is considered strong. The difference in mean indicates that the FC method is more effective in enhancing higher-order thinking skills due to more active student engagement compared to conventional methods. In the FC approach, students are required to engage in reading and research before attending lectures in class. This encourages students to think more deeply about a topic or problem prior to the start of in-class discussions. Therefore, the method used in this study has strong effect on the student's achievement. Furthermore, ANCOVA analysis also found that there was significant difference between the two teaching methods in improving student's higher-order thinking skills.

Even though the two teaching methods can improve the student's thinking skills, students in the treatment group successfully answered the higher-order thinking question systematically compared to the control group. Their answers were written in order, because they had more time to discuss with lecturers during the in-classroom sessions. Studies show that active leaner during classroom discussion, can improve the student's learning performance, thus, it will enhance the students writing skills (Armbruster et al., 2009; Eison, 2010). According to Aziz et al. (2014), students with information and knowledge, can improve their self-directed learning skills as they have to be more autonomous in defining the problem, deciding what should be learnt, collect information and determine the best approach to solve the problem.

Even though there are previous studies reported that flipped classroom can enhance the higher-order thinking skills (Alsowat, 2016; Talley, 2013; Zuraidah et al., 2014), but many studies show that there was no statistically significant between flipped classroom and conventional teaching method (Blair et al., 2016; Clark, 2015). There are few factors that may be contributed to the results, such as, students do not prepare for the materials given by the lecturer during pre-classroom session (Gillette et al., 2018), complexity of flipped lesson paradigm (DeSantis et al., 2015) and conventional method give enough time and opportunity to give individual attention, clarify the doubts of everyone and match the instruction with every learner's need/s (Mohanty & Parida, 2016).

Student's Perception

Table 7 shows the average score and standard deviation of each question in the survey answered by the treatment group. There are three questions shown at medium level, whereas others shown at high level.

Table 7: Level of Students' Perception Against Flipped Classroom Teaching Method

No.	Questions	Average	SD	Level
1	I prefer flipped classroom over conventional lecture.	2.94	0.77	M
2	Flipped classroom improve knowledge/ learning.	3.81	0.98	H
3	Online lectures were easy to access and view.	3.31	0.87	M
4	The online lecture video quality was good.	3.63	1.15	M
5	The online lecture audio quality was good.	4.19	0.91	H
6	The online lecture content increased knowledge.	4.06	1.12	H
7	Online face to face discussion enhanced knowledge.	4.13	1.09	H
8	Time spent viewing online lectures appropriate.	4.13	1.39	H
9	The flipped learning encourages me to have creative thinking and evaluation.	4.44	1.46	H
10	The flipped learning reduces time required to learn.	3.81	1.44	H
11	Flipped classroom help me to answer higher-order thinking question systematically.	4.50	2.07	H

Based on the Table 7, it was found that medium level of students' perception preferred flipped classroom teaching method compared to conventional method. It also found that high level of student's perception that flipped classroom improve their knowledge and learning ability; encouraged them to be creative thinking and evaluation; it reduced time required to learn and helped them answered higher-order thinking question against environmental problems systematically. They were also showed high level perception on the quality of audio as well as content in the video increased their knowledge during pre-class session; online face to face discussion also enhanced their knowledge. But students showed medium level of perceptions to the ability on accessing the video lecture and the quality of the video given in the pre-class session.

According to the findings, majority of the students found that flipped classroom encouraged them to have a creative thinking and evaluation. Preliminary study for this work also shows that flipped classroom can give a positive effect to the thinking skills among engineering students (Mokhtar, 2019). It also helps them to answer the higher-order thinking question systematically. Other similar studied also shows the same result (Al-Zahrani, 2015; White et al., 2017). This study also found that, many students agreed that flipped classroom method improve their knowledge against the environmental problems and in line with research done by Galway et al. (2014). Moreover, students who participated in the flipped teaching method were taught to implement mind-map in their learning process. According to Saleh & Mazlan (2019), students who were exposed to the mind-map concept showed higher understanding in their learning process.

This study also shows that some students agreed that flipped classroom reduces time required to learn. All materials were given in the pre-class session, in one hub, and they can refer to the materials easily. It will reduce their time searching and point out the main area with correct keywords using internet database engine. Flipped classroom also can guide student step by step in their learning (Awidi & Paynter, 2019; Pannabecker et al., 2014). However, medium level of perception among the student that accept flipped classroom as a good medium for their learning. According to Akçayır and Akçayır (2018), there were some challenges of flipped classroom, which make students preferred the traditional method such as time consuming, workload increase, resistance to change and so on.

Conclusion

Overall, both flipped classroom and conventional teaching method can improve student's higher-order thinking skills. But, flipped classroom can help students in their learning process. Students can be trained to increase their knowledge before they enter the class for discussion. Discussion session can be a good platform to transform a passive to active student, enhance their communication skills, add more knowledge, teach them to be creative and increase their confident level. But some aspects must be improved in this study for the future such as enlarge the sample size, extend the experimental period and diversify the materials in the pre-class session to give a big impact of flipped classroom to the student's achievement.

The researchers recommend that future studies explore the impact of the flipped classroom method on both gender and student attitudes within the classroom setting. It is assumed that participants responded truthfully to the survey questions and that the data accurately represents the geographical region surveyed. However, this study was limited to a single higher education institution and focused solely on a group of Bachelor of Engineering (Hons.) (Chemical) students majoring in Environment. Consequently, it is challenging to ascertain whether these students engaged in additional reading or research via the internet or books prior to participating in the online classroom sessions. Future research should consider these limitations and expand the scope to include diverse educational settings and student groups to enhance the generalizability of the findings.

The findings of this study have several implications for educational practice. Firstly, the potential benefits of the flipped classroom method suggest that educators should consider incorporating this approach to enhance student engagement and learning outcomes. By integrating higher-order thinking skills into the flipped classroom model, educators can further challenge students to analyse, evaluate, and create, thereby deepening their understanding and application of the material. Additionally, the study highlights the importance of ensuring that students have access to resources and support for independent learning, which is crucial for the success of using flipped classroom. Educational institutions should invest in training and resources to support educators in implementing innovative teaching methods like the flipped classroom, thereby improving the overall quality of education.

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