Flipped Classroom Pedagogy Using Open Educational Resources in Engineering College: Implementation Modalities and Efficacies

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Declaration

We declare that the work is carried out by the author alone. Whole or any part of the work has not been submitted before as a research proposal. The content of the paper is the result of work which has been carried out since the approval of this research program. All the ethics procedures and guidelines have been followed properly while preparing the research.

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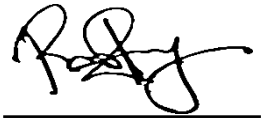

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Abstract

To achieve the goal of a "Smart Bangladesh" by 2041, current study has been proposed a case study of implementing Flipped Classroom Pedagogy (FCP) using Open Educational Resources (OERs) and newly designed customized Flipped Classroom Learning Management Tool (FCLM) to evaluate its effectiveness in an engineering course at Sylhet Engineering College. It is suggested that the slogan "Flipped Classroom-Smart Education-Smart Bangladesh" be adopted by the government of Bangladesh to smarter the Education and to smarter the country. The current government's strong policies towards ICT development have resulted in technological advancement and high-speed internet access, leading to an increase in online activities such as freelancing and online learning resources. However, the effectiveness of online learning without teacher guidance is debated. The flipped classroom approach, which combines face-to-face and online teaching methods, is considered the most effective teaching strategy to enhance student engagement.

The Basic Electronic course at Sylhet Engineering College applied the flipped classroom model to 20 second-year Under Grad students in the department of EEE. A fundamental topic as the foundation for electronic theory has selected and used OERs and a newly designed customized FCLM tool to incorporate the advantages of the FC approach. The FCLM tool allowed students to access their pre-class, in-class, and post-class materials tasks conveniently. The study had three research questions, and data was collected from students, teachers, and instructional design experts using various methods, including KII, FGD, and semi-structured questionnaires. The research design used both quantitative and qualitative analysis.

To analyze the effectiveness of the FC approach, two feedback sessions were conducted in weeks 2 and 5 with the students. Intermediate feedback received during weeks 2 and 5 indicated a consistently high mean value (>4) and a strong agreement level, particularly regarding perceptions of understanding the main content, preference for the flipped format than traditional one, and effectiveness of the newly designed FCLM tool. These results demonstrate the internal strength of the approach. One feedback session was also conducted with the teachers to determine if the FC approach provided a flexible environment for developing a learning culture and Professionalism. Additionally, a final assessment showed that the FC group outperformed the Traditional group.

Furthermore, the survey conducted on the implemented FC approach showed a consistently positive attitude and high agreement level regarding effectiveness, engagement, preference, and quality improvement among students. The use of OERs and the customized FCLM tool with the FC approach provides a new direction for those interested in implementing this approach in their course and contributes to the development of a smart education system for a smart Bangladesh.

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Introduction of the Study

1.1 Introduction

In a time of explosive technological advancements, there is a pressing need to dramatically transform the approaches used to deliver education, particularly in the field of engineering, in order to equip future generations of engineers with the necessary skills to confront the challenges of a world characterized by ever-increasing changes. (Bhat, 2020).

All researchers in the field of engineering education are grappling with the persistent question of how to deliver education to modern-day millennial learners in a manner that is both cost-effective and time-efficient. Some institutions have made strides in this area by integrating digital tools into the classroom, resulting in a hybrid mode of instruction that combines traditional in-class methods with on-the-go learning. Nevertheless, the integration of digital technologies into engineering education teaching (Kerr, 2015), where it is arguably essential, has progressed rather unremarkably.

Frequently, educational environments where students are deeply engaged in the learning process are likely to have a significant impact on their academic progress. Recent research in engineering education has demonstrated that instructors who implement active learning techniques tend to achieve better outcomes compared to those who rely on conventional classroom lectures (Karabulut-Ilgu, 2018). As a result, educators are encouraged to create instructional materials that encourage greater student participation in the classroom.

To put it differently, the flipped classroom approach seems to be better suited to the current era and learners than the traditional course setting. Consequently, there is a growing trend towards gradually shifting to new technology-based approaches like the FC in education. The FC approach provides teachers with an excellent opportunity to utilize the available technology both inside and outside the classroom to enhance teaching and learning effectiveness and flexibility. Regarding technology involvement, Francl (2014) argued that the FC, with its recorded lectures accessible at any time and place, can gain a competitive advantage in capturing students' attention over other technological distractions.

Currently, it is more convenient to link the concept of the flipped classroom with Bloom's taxonomy (Brame, 2013). Bloom's taxonomy is a system of classification that is used to differentiate and categorize various levels of human cognition such as thinking, learning, and understanding. Verbs that are commonly used in Bloom's taxonomy today include remember, understand, apply, analyze, evaluate, and create or design. In the context of flipped learning, the lower levels of Bloom's taxonomy, which mostly involve remembering and some level of understanding, are typically covered at home when students are first exposed to the material. On the other hand, the higher levels of Bloom's taxonomy, such as applying, analyzing, and even creating, can be achieved in the classroom with sufficient time. Therefore, the flipped classroom model allows for the lower levels of Bloom's taxonomy to be addressed at home where students can be introduced to the material, while the higher levels of Bloom's taxonomy can be tackled in the classroom. For more clarification see Appendix D.

The use of Open Educational Resources (OER) is considered as an exciting and promising educational innovation in higher education, according to Li (2017). OECD defines OER as "digitized materials that are freely available for educators, students, and self-learners to use and reuse for teaching, learning, and research" (OECD, 2007, p.10). The worldwide OER movement began with MIT's Open Courseware (OCW) project in 2001 and gained more momentum with the emergence of massive open online courses (MOOCs) in 2011 and 2012, and online programs based on MOOCs from top universities such as Stanford, MIT, and the University of Michigan. OER encompasses the following:

- **Learning Content:** Full courses, courseware, content modules, learning objects, collections and journals.

- **Tools:** Software to support the development, use, re-use and delivery of learning content including searching and organization of content, content and learning management systems (LMS), content development tools, and on-line learning communities.

- **Implementation Resources:** Intellectual property licenses to promote open publishing of materials, design principles of best practice, and localization of content.

The most available used free OERs, especially for engineering teaching, such as NPTEL (https://nptel.ac.in/), Coursera (https://www.coursera.org/), edX (http://www.edx.org/), Udemy (https://www.udemy.com/), Khan Academy (https://www.khanacademy.org/). Besides this, free LM tools are Facebook, Google Classroom, Quizzes, Messenger, WhatsApp.

Using OER makes it simple for people to access learning resources, provides flexible and open learning opportunities, and increases participation in education. OER can be utilized not only in e-learning or distance learning but also in traditional classroom settings to enhance the learning experience. By sharing learning resources, teachers can receive continuous feedback from their students, allowing them to update and improve the materials, thereby enhancing their efficiency and quality (Nistal, 2017).

Blended learning is a new concept in Bangladesh's education system when compared to other countries. Although there is evidence of its effectiveness, most Higher Education Institutions (HEIs) in Bangladesh do not fully implement blended learning. This can be attributed to teachers' resistance to online teaching tools and a lack of awareness of innovative teaching pedagogies. Teachers in Bangladesh's HEIs have limited opportunities to incorporate online tools into their teaching process, usually only posting teaching materials and submitting grades online. The aim of this research is to examine the implementation and effectiveness of the flipped classroom pedagogy using OERs in an engineering college. The report explores the benefits and challenges of using OERs in flipped classroom pedagogy, student and faculty perceptions of the model, and its impact on student learning outcomes. The findings offer insights into the effectiveness of this teaching model and provide practical recommendations for engineering colleges interested in adopting the flipped classroom pedagogy using OERs.

1.2 Statement of the problem

According to various studies, the flipped classroom teaching model has proven to be effective in enhancing learning (Cho, 2021). This model has been found to have a positive impact on students' self-efficacy and intrinsic motivation, leading to increased engagement and readiness for higher-order academic activities, such as problem-solving (Thai, 2017; Bishop, 2013; Gilboy, 2015). Moreover,

the flipped classroom approach has been shown to have a better impact on the achievement of student learning outcomes compared to traditional classroom teaching (Albert & Beatty, 2014; Roach, 2014). In fact, some studies have reported that students who undergo flipped classroom teaching demonstrate better academic performance compared to those who experience traditional classroom teaching (Lax, 2017; Mason, 2013).

The flipped classroom model has been extensively implemented in higher education, and there is an increasing body of research on its effectiveness in various fields (Albert, 2014; Bishop, 2013; Kerr, 2015; Mason, 2013; O'Flaherty, 2015; Simpson, 2015; Thai, 2017; Yough, 2019). However, the literature has revealed a limited use of FC pedagogy in engineering courses, particularly in courses related to EEE (Haase, 2022; Lo, 2019; Sánchez-Azqueta, 2019; Kerr, 2015; Yelamarthi, 2015). Only one study has been conducted on the implementation of OER-based flipped classroom practices in an undergraduate engineering course (Li, 2017).

The available literature on the flipped classroom lacks in-depth discussion of methodological and theoretical perspectives, as highlighted by Karabulut-Ilgu (2018). Previous studies have mainly concentrated on students' satisfaction and perception of the flipped classroom, and there is a need for more research to evaluate the actual performance of students in this approach, as pointed out by Kim (2014). Additionally, research should incorporate the opinions and perspectives of more students to provide a better understanding of their perceptions of the flipped classroom. Furthermore, there is a need for instructors to implement the flipped approach in engineering courses.

Currently, there is limited research conducted on the Flipped Classroom approach in higher education in Bangladesh, with only a few studies available (Chowdhury, 2019; Khan, 2021). Moreover, there is no research available on the implementation of the Flipped Classroom approach using OERs in engineering courses in Bangladesh. Despite the growing popularity of the Flipped Classroom Pedagogy using OERs, its effectiveness in engineering colleges remains unexplored. While this teaching model has the potential to enhance students' active learning, critical thinking, and collaboration, there is a lack of understanding of its efficacy in the context of engineering education.

According to Iqbal (2022), research has been conducted on the feasibility of implementing the flipped classroom approach in four engineering colleges under the supervision of the Directorate of Technical Education (DTE) in Bangladesh. The research findings are summarized in two perspectives including available scopes and facilities for implementing FC in engineering colleges. The research by Iqbal also found that most of the teachers, students, and principals have a positive attitude towards this approach and 100% teachers & 84% students are capable of adapting FCP. The study also shows that the majority of students have personal laptops/desktops, smartphones, access to the internet with moderate speed, and are familiar with social media, Google Forms, email services, YouTube, and Google. In addition, the study reveals that 87.5% of students use personal computers or laptop PCs, and a moderate-speed internet connection is available to 81.9% of students.

On the contrary, according to Chowdhury (2019), successful implementation of technology-enhanced learning requires reliable hardware, user-friendly software, a high-speed network, as well as adequate knowledge and skills. In addition, having a common LM system is crucial for implementing the FC approach. Although Google Classroom is a popular platform with a simple design and user interface, more sophisticated tools like BLACKBOARD, CANVAS, MOODLE, BB COLLABORATIVE and SEQTA are often too expensive for many institutions. Therefore, developing a cost-effective and sophisticated learning management system is essential for implementing FC pedagogy using OERs.

Despite the benefits of using OERs in the flipped classroom, including cost-effectiveness and flexibility, it is unclear how effectively these resources are integrated into the teaching and learning process, and what challenges may arise during implementation. These gaps in the literature suggest a need for further research and highlight the statement of the problem.

1. There is a dearth of research on the implementation of flipped classroom pedagogy in engineering courses using open educational resources.
2. There is absence of customized online platforms to implement flipped classroom pedagogy.
3. There is a lack of research on evaluating the efficacy of flipped classroom pedagogy in engineering courses as well as OERs.

More importantly, the research on flipped classrooms needs a theoretical framework to explain why implementing the flipped approach works in large-lecture engineering courses. Our study bridges the gaps in current research.

1.3 Conceptual Framework

The flipped classroom model is an approach that emerged from various educational trends in recent years. These trends aim to reduce the time students spend passively listening to lectures and increase the time they spend actively learning material through various activities that cater to different learning styles and promote deep learning (Saitta E 2016). Additionally, the flipped-blended approach is based on the concept of experiential learning, which was first proposed by Dewey (Wibawa, B. et al 2018). When it comes to engineering education, the flipped-blended approach represents a novel learning paradigm and an innovative way to improve student performance.

The current study is based on a conceptual framework derived from the research findings of Amresh (2013), Chao (2015), Chiang (2015), Fowler (2014), Kalavally (2014), Lemley (2013), Mason (2013b), McGivney-Burelle (2013), Ossman (2014), Papadopoulos (2010), Redekopp (2013), Schmidt (2014), Swithenbank (2014), Thomas (2012), and Yelamarthi (2015), Johnson (2013) and Jaster (2017), all of which support the effectiveness of the flipped classroom as a teaching and learning approach.

Karabulut-Ilgu, A. (2018) stated that the adoption of flipped learning by engineering educators became popular after 2012. The literature review found that research in engineering education mainly focused on describing the design and development process and sharing initial results and feedback from students. However, there is still a need for further research that investigates various aspects of flipped learning implementation, guided by well-established theoretical frameworks and evaluation methods, to establish the effectiveness of this pedagogy in teaching engineering.

In Bangladesh, the flipped classroom approach is new for engineering colleges and their students. There is no guideline available for teachers and students to implement this pedagogy. This study aims to explore the process and effectiveness of using Open Educational Resources (OER) for flipped classroom practice, which is also a new concept for teachers and students in Bangladesh. Although teachers and students have become familiar with free online learning management tools during the COVID-19 period for conducting online classes, there is no such tool available for implementing the flipped classroom approach, which involves a blend of face-to-face and online activities. To address this issue, a sophisticated and dedicated flipped classroom pedagogy learning

management tool has been integrated into the conceptual framework. The flipped-blended conceptual framework (Figure 1.2) is based on several sources of inspiration.

- Choose open educational resources for engineering courses.
- Design a customized, based on FC concept, user-friendly LM tool and use it.
- Teacher develops the flipped-blended instructional model and implements it.
- Online learning for out class activities.
- A more active learning in class activities.
- Teacher assist, assess, and motivate students in flipped- blended learning environment.

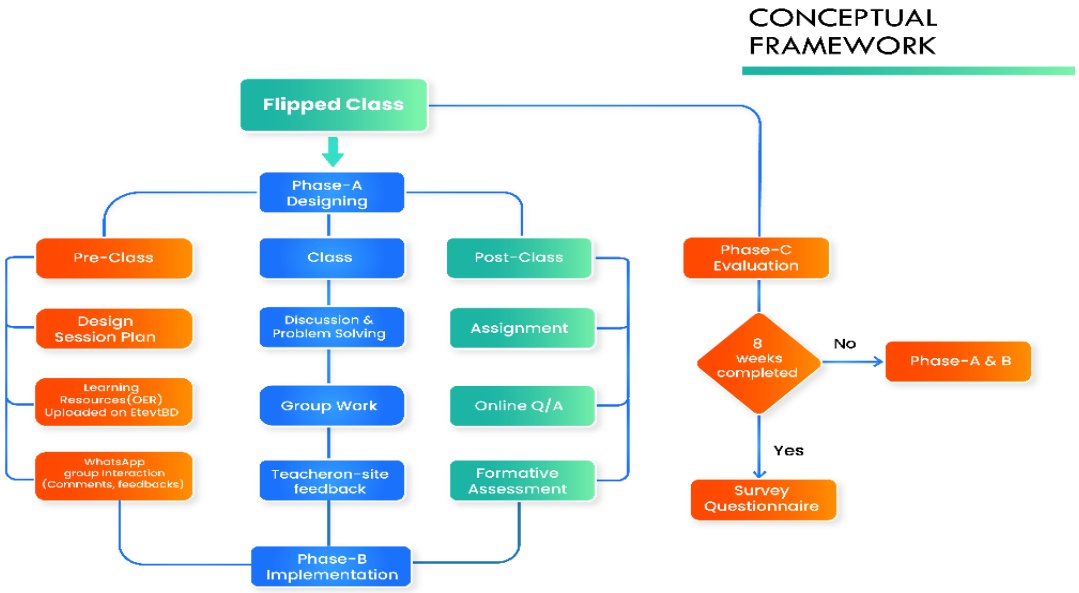


Figure 1.1: Conceptual Framework of the Study

A case study was conducted for a duration of 8 weeks to investigate the impact of implementing a flipped classroom approach on a group of undergraduate students in the field of Electrical and Electronic Engineering (EEE). This information is depicted in Fig.1.1. The study involved transitioning from a traditional lecture-based model to a flipped classroom model, which required students to engage in activities outside of class and participate in interactive learning activities during class time. The evaluation methods used helped prepare students for in-class interventions.

To facilitate the implementation of flipped classroom pedagogy, a learning model using Open Educational Resources (OERs) was developed in Phase A, and a tool for implementing the approach was created with the help of an IT expert in Phase B. An intermediary assessment was conducted through feedback forms in Phase C, followed by a final assessment through surveys at the end of the experiment. Based on the data gathered, teachers can access resources and make plans to incorporate active learning methodologies in their own classrooms with the aid of technology.

Engineering colleges, in particular, have shown a growing interest in adopting flipped classroom pedagogy due to the opportunities it offers students to develop critical thinking skills, collaborate, and apply their knowledge to real-world problems. The availability of OERs online has made it more accessible and cost-effective to implement this approach.

1.4 Purpose of the Study

Current study's overarching goal is to investigate the implementation modalities and efficacies of flipped classroom pedagogy using OERs in engineering colleges. Specifically, the research report has addressed the following objectives:

- ✓ To Conduct a case study for implementing FCP for a Basic Electronic course.
- ✓ To design a customized online platform to implement FCP through E-training app-based web EtvetBD.
- ✓ To evaluate effectiveness of FCP as well as OER.

In order to clarify the objective of the study, 03 (three) research questions were formulated to establish the practicability of implementing and evaluating of the FC technique in engineering college. The research questions are listed below:

1. How to design a model learning module using OER to implement FC pedagogy?
2. How to design a customized online platform to implement flipped classroom pedagogy through E-training app-based web EtvetBD?
3. To what extent, the new instructional design using OER is effective to achieve enhanced student engagement?

After formulating the research questions for the study, a set of questionnaires was developed based on the underlying hypotheses of each question.

1.5 Methodology

This section aims to provide comprehensive information about the process of implementing the flipped classroom approach, enabling a clear understanding of its implementation methods. Therefore, the data analysis methodology has been explained in detail to create a clear understanding of the implementation and evaluation of the FC approach.

1.5.1 Strategy of the Study

The research is of an exploratory nature and combines both quantitative and qualitative data. It is focused on providing a descriptive and empirical account. The researcher was assigned a randomly selected class of the third semester for AY2021-2022 for the department of EEE at Sylhet Engineering College. To gain a better understanding of the participants, a background questionnaire was distributed to the entire class, which collected information on demographics (such as age, gender, hometown, major, and program), first-semester GPA, computer usage, and experience with the flipped classroom approach. No identifying information was gathered to ensure participant anonymity. The research has been divided into three phases to gain deeper insights and understanding. To mitigate potential biases and to ensure the credibility of the study's findings, the researchers divided the students in the same class into two groups, namely the FC group and the traditional group. This division was based on the odd and even registration numbers of the students. As a result, the FC group consisted of 20 students.

Table 1.1: Strategy of the Study

RQs	Focus on Research Questions	Types of Data	Data Sources	Tools of Data	Overall Strategy of Inquiry
1	How to design a model learning module using OER to implement FC pedagogy?	Qualitative & Quantitative	Teacher IDE	KII	Multi Method Design
2	How to design a customized online platform to implement flipped classroom pedagogy through E-training app-based web EtvetBD?	Qualitative & Quantitative	Teacher Student IDE IT Expert	FGD & KII	
3	To what extent, the new instructional design using OER is effective to achieve enhanced student engagement?	Qualitative & Quantitative	Teacher Student IDE	Survey Questionnaires, KII & FGD	

To collect data, a multi-method approach was used, with semi-structured questionnaires used to gather concise responses from students, while Key Informant Interviews (KII) were used to obtain detailed answers from teachers, instructional design experts, and IT experts regarding the various modes of flipped classroom implementation. Additionally, a focus group discussion was held with a traditional group of students to analyze the different aspects of the study. A summary of the foregoing discussion is presented in Table 1.2.

1.5.2 Sample and Sampling

The hypothesis of each research question led to the design of different questionnaires, depending on the nature of the data collection source. For the first two research questions, data was collected from teachers and IDE for the purpose of developing a model learning module using OER and a customized LM tool. Meanwhile, data for the second research question was collected from teachers, IDE, students, and IT experts. For the third research question, three feedback forms were used for intermediary assessment, and three survey questionnaires were designed for the final assessment after completing experiments to evaluate the efficacy of the implemented FC approach. Purposive sampling strategy was used to select 20 FC group students, 02 teachers, 01 Instructional Design Expert (IDE), 01 IT Expert, and 20 Traditional group students throughout the research process.

Table 1.2 : Sampling Plan

Phases	Designation	Institute	Sample Size	Sampling type	Total Sample
Phase A	Teacher	SEC	2	Purposive Sampling	03
	Instructional Design Expert	Australia	1		
Phase B	Teacher	SEC	2		23
	Students		20		
	IT Expert	Root Soft IT	1		
Phase C	Teacher	SEC	2		23
	Students		20		
	Instructional Design Expert	Australia	1		

It is important to mention that a minimum number of sample units were required from various sources to ensure meaningful data analysis. Table 1.3 displays the total number of samples collected from each category.

1.5.3 Data Analysis Technique

The aim of this report was to investigate the ways in which flipped classroom pedagogy utilizing Open Educational Resources (OERs) could be effectively implemented and assessed in an engineering college environment. The study examined the advantages and challenges of employing OERs in a flipped classroom approach, assessed the perceptions of students and faculty towards this model, and evaluated its impact on student learning outcomes. Data was collected from both primary and secondary sources. Primary sources included direct beneficiaries such as students, teachers, Instructional Design and Technology (IDE) experts, and Information Technology (IT) experts. Semi-structured questionnaires, Key Informant Interviews (KII), and Focus Group Discussions (FGD) were employed to collect data from primary sources. The information obtained from primary sources was categorized into qualitative and quantitative data. The quantitative data was analyzed using the Statistical Package for the Social Sciences (SPSS) in this study. Qualitative data from the structured questionnaires, KII, and FGD was analyzed using content analysis techniques.

Secondary data analysis is a crucial component in demonstrating the robustness and validity of research. There is no research that has not employed secondary data analysis. Similarly, the present study has extensively utilized secondary data from various literature sources available online. A significant aspect of this effort was to search for empirical articles by scouring essential electronic databases in engineering education, including Springer, Science Direct (Elsevier), IEEExplore, International Journal of Engineering & Technology, International Conference on Interactive Collaborative Learning (ICL), British Journal of Educational Technology, IEEE Global Engineering Education Conference (EDUCON), Journal of Research in Innovative Teaching, International Journal of STEM Education, Proceedings of Frontiers in Education Conference, among others.

This research data aims to evaluate the efficiency of the flipped classroom approach when utilizing open educational resources (OERs) in engineering colleges, and present practical suggestions for institutions that plan to implement this method of teaching. The report's discoveries are expected to provide valuable guidance on student learning outcomes, engagement, and satisfaction, as well as the challenges and advantages of using OERs. Ultimately, these insights could help engineering colleges enhance their teaching approaches.

1.6 Pre-Test

Before collecting data from participants using semi-structured questionnaires, structured questionnaires, Key Informant Interviews (KII), and Focus Group Discussions (FGD), a pre-testing sampling plan was implemented to assess the hypothetical acceptance of the sample questions. The pre-test sampling was conducted in four stages, namely, by an English Language Expert, teachers, students, and KII. The procedure included one English Language Expert, one teacher, five students, and one IDE. The sampling plan's data summary is presented in Table 1.4, and individual data outputs will be discussed in the subsequent sections.

Table 1.3: Pre-Test Sampling Plan

Pre-Test		Institute	Sampling type	Total Sample
Pre-Test#01	Pre-test by English Language Expert	SEC	Purposive sampling	01
Pre-Test#02	Pre-test by Teachers	SEC		01
Pre-Test#03	Pre-test by Students	SEC		05
Pre-Test#04	Pre-test by KII	SEC		01

1.6.1 Outcomes of Pre-Test # 01

An English Language Expert reviewed and provided minor suggestions for improvement to Pre-Test #01, and confirmed the appropriateness of the sampling process. To ensure that the questionnaire was free from errors, the suggested grammatical changes and expert recommendations were incorporated to hypothetically validate the questionnaire.

1.6.2 Outcomes of Pre-Test # 02

A structured questionnaire was developed for the purpose of pretesting to assess its hypothetical validity. One teacher from the institution was involved in this process, and the data collected from the questionnaire was analyzed qualitatively. The results showed that the process followed the initial hypothesis.

1.6.3 Outcomes of Pre-Test # 03

To evaluate the hypothetical theory, quantitative data was gathered from 05 students for pre-testing purposes. The data was analyzed using SPSS software, and it was found that the collected data aligned perfectly with the planned hypothesis. Prior to processing the final outputs of the data, statistical analysis was conducted. Ultimately, the statistics obtained from the collected data provided robust support for the hypothesis.

1.6.4 Outcomes of Pre-Test # 04

In order to analyze the pretest samples, one Key Informant Interview (KII) was conducted with the principal of SEC. The response was evaluated qualitatively and met the hypothetical criteria.

Finally, the data collected during the pre-testing phase, including semi-structured questionnaires, structured questionnaires, KII, and input from the English language expert, indicated that the results were viable for implementing the strategy, and the hypothesis was supported by the analyzed data, affirming its realistic nature.

1.7 Ethical Considerations

Data collection is an integral part of many research activities in various fields, including social sciences, healthcare, marketing, and more. However, the process of collecting data can raise several ethical concerns, including:

1.7.1 Some Ethical Issues in Data Collection

To collect data, it is important to obtain consent from participants beforehand. Participants must be fully informed about the study's purpose, the data that will be gathered, its intended use, and any potential risks or benefits. Participants should also have the right to decline or withdraw from the study at any

time. For this study, all participants were thoroughly briefed on its purpose. Additionally, data collection must be unbiased and free from discrimination. Researchers should take care to avoid any form of prejudice towards individuals or groups based on their race, gender, religion, sexual orientation, or other characteristics. To minimize bias, the authors used odd roll numbers to select students for the FC group and the rest for the traditional group. Lastly, researchers must ensure that the data collected is reliable, accurate, and error-free. They should use validated measurement tools and follow appropriate data collection procedures to ensure the data's high quality. The researchers of this study made efforts to ensure the accuracy of the collected data.

1.7.2 Some Ethical Issues in Data Reporting

The researchers of this study made an effort to ensure that the data collected remained confidential and was not disclosed to unauthorized persons. To further protect the participants' identities, the data was anonymized, and their consent was obtained for data sharing. Additionally, the researcher provided a transparent report of the study's methods, results, and any biases or limitations that may have been present.

1.8 Outline of the Report

The remainder of this thesis is structured in the following manner:

- **Chapter 1: *Introduction*:** This chapter discusses the study's basic introduction. It starts with a detailed discussion of various research questions. Meanwhile, it includes the logic of the research that underpins his work.
- **Chapter 2: *Design a model learning module using OER to implement FC pedagogy:*** The study's results include the development of a model learning module that was created by examining learning module issues and Open Educational Resources (OERs). The data for this study was collected through Key Informant Interviews (KII), with instructional design experts (IDE) and teachers serving as the primary sources of information.
- **Chapter 3: *Designing a customized online platform to implement:*** The study's results include the development of a newly designed, customized and FC approach-based learning management tool, named FCLM, by examining the planning, development and testing indicators.
- **Chapter 4: *Evaluation of Efficacies of FCP as well as OER:*** The aim of this chapter is to provide a detailed discussion of the evaluation measures used to assess the implementation of the flipped classroom (FC) approach and the newly developed Flipped Classroom Learning Module (FCLM) tool. The evaluation process is divided into three categories: students' reflections, teachers' reflections, and perception surveys.
- **Chapter 5: *Conclusion, Implication of Practice, Limitations and Future Work:*** The objective of this chapter is to provide a concise summary of the key findings from the previous chapters and draw a conclusion based on the results of the study. Additionally, this chapter discusses the practical implications of the research, limitations of the study, and future work required to enhance the understanding of the flipped classroom (FC) approach and guide educators interested in implementing it in their courses.

Chapter 2

Design a model learning module using OER to implement FC pedagogy

In recent years, the use of open educational resources (OER) has gained traction in the field of education, as it provides a cost-effective and flexible way to design and deliver learning materials. Additionally, flipped classroom (FC) pedagogy has emerged as a popular instructional approach, which involves flipping the traditional lecture-based classroom model to a student-centered, active learning environment. The combination of OER and FC pedagogy offers numerous benefits to both instructors and students, including improved engagement, retention, and achievement. This chapter aims to guide educators in designing a model learning module using OER to implement FC pedagogy.

2. Outcomes

In general, there are various factors/issues to support the development of a learning module using open educational resources (OER) in order to implement the FC approach, as demonstrated in Fig. 2.1. For each of these factors, multiple indicators have been identified, and data has been collected through key informant interviews (KII) with teachers and instructional design experts (IDE). As the data from the KII is qualitative in nature, content analysis was conducted to synthesize the findings. The following section of this chapter provides a summary of the outcomes associated with each indicator, along with supporting evidence from primary and secondary data sources.

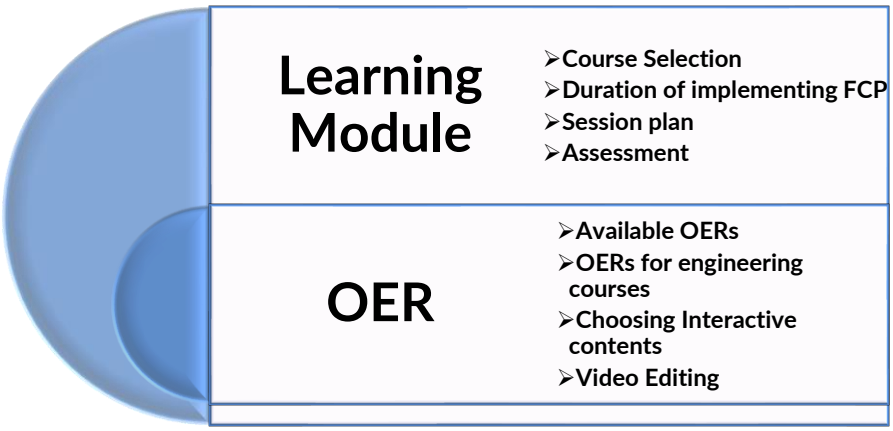


Figure 2.1: Issues and Indicators for RQ # 1

2.1 Learning Module

A learning module is a structured educational tool designed to help learners acquire knowledge and skills in a particular subject area. It typically consists of a series of lessons, activities, and assessments that are designed to help learners achieve specific learning objectives. Learning modules are often used in online learning environments, but they can also be used in traditional classroom settings. They should also be interactive, allowing learners to actively engage with the material and apply what they have learned. Overall, learning modules can be an effective way to provide structured and engaging learning experiences that help learners achieve their goals and improve their skills and knowledge. Based on these arguments, an attempt has been made to develop an exemplary learning module according to certain criteria, which are elaborated upon below.

2.1.1 Course Selection

According to the information provided by the indicator, it seems that *"The Basic Electronic Course worth 3 credits is a suitable option to begin the implementation of the FC approach in EC"*. Also, IDE suggests that utilizing the flipped classroom method for teaching Basic Electronics could be beneficial in improving students' comprehension and proficiency in practical skills.

From the secondary literature review, Lo et al. (2021), applied flipped classroom teaching for electronics courses in vocational high school, and experimentally explored the influences of flipped teaching on learning strategies. Also, Yelamarthi (2015), has been applied FC approach for flipped first-year digital circuits course for engineering and technology students. Similarly, Karayaka et al. (2015), a hybrid flipped classroom approach to teaching Power Electronics course to Electrical Engineering Students has been proposed in Western Carolina University.

Most engineering programs typically mandate students to take at least one electronic engineering (EE) course. Nonetheless, some students who are not majoring in EE may only comprehend the importance of EE to their chosen field when they are confronted with a real-world issue, which often happens after they graduate and start working. At this point, it may be too late for them to learn practical real-world skills or concepts in a course-based environment. This presents a significant challenge for engineering educators in engaging all engineering and technology (ET) students in meaningful EE activities that would motivate them to pursue a career in ET. To address these challenges and opportunities, a flipped basic electronic course for all ET majors is being proposed. The course aims to teach basic electronics fundamentals, and the advanced skills and tools used in the profession.

2.1.2 Duration of Implementation of FC approach

Teachers and the IDE have stated that "*The course spanned over a period of 5 weeks, comprising of one class per week, each of which lasted for at least 90 minutes*". However, IDE has also mentioned that the duration of the classes may differ depending on the material covered in the course and the objectives of learning.

Furthermore, Thinh et al. (2021) utilized the FC method in an academic English course at a state university in Hanoi, Vietnam for a period of 15 weeks, with each class lasting for 3 hours. Similarly, Lo et al. (2021) employed the FC approach for a duration of 30 weeks. However, it has been observed from the literature that the duration of the FC approach is considerably shorter compared to other experimental studies. This can be attributed to the time constraints imposed by the authorities, which necessitated the completion of the study within a fixed timeframe. Nonetheless, as a pilot project, the short duration of the FC approach has been deemed feasible based on the primary data, depending on the course material and learning objectives.

2.1.3 Session Plan

According to the Thinh et al. (2021), the teacher and students' role can be played as shown in Table 2.1. IDE states that a module for implementing the flipped classroom pedagogy typically includes various components such as learning objectives, pre-class resources, in-class activities, post-class resources, and assessments. The given session plan for the model seems to be suitably designed for the flipped classroom pedagogy as it comprises of activities that are conducted before, during, and after the class, and each activity has a specific time frame assigned to it. IDE also suggests that using an LMS for pre- and post-class materials and assessments can improve student engagement and their interaction with the course content. In conclusion, it can be stated that the session plan that has been created (refer

to appendix A) has been designed precisely with all its characteristics to involve students in the flipped classroom approach.

Table 2.1 Teacher and Students' Roles in

	Students	Teacher
Pre-class	Access and study the provided materials Take notes of main ideas and questions(if any) Discuss with their peers about questionsand assignment	Prepares and uploads materials Keeps track of students' study process through instant feedback (Facebook comment)
Class time	Answer teacher's review questions ofthe previous weeks (brief review) Attend mini-lectures (if any) and ask prepared questions (Q&A) Practice performing skills which they have learned	Helps students to review learned knowledge/skills Answer students' questions Guides the process with feedback and mini-lectures (if necessary)
After class	Continues to apply their knowledge/skills after clarification andfeedback Seek teacher's help when they need it Reflection via after-class feedback forms(6)	Posts any additional explanations and resources as necessary Continues to provide feedback or grade students' work Continues to guide students towards deeper understanding

2.1.4 Assessment

The assessment strategies employed by Bhat et al. (2020), Yelamarthi et al. (2015), Lo et al. (2021), Karayaka et al. (2015), and Thinh et al. (2021) varied based on factors such as course content, learning objectives, and student type. From IDE and teachers, to ensure effective assessment in a flipped classroom, it is essential for instructors and instructional designers to align assessment criteria with course learning objectives and to provide clear instructions and expectations for students. Providing feedback to students on their performance and using assessments as a tool to enhance teaching and learning are also crucial. In light of the above arguments, the following steps have been taken for assessment:

Pre-Class Assessment: Prior to each class session, an online test is administered using the recently developed FCLM tool. The specific marks allocated to each test are determined by the respective instructors. Following the conclusion of the 5-week FC approach, the pre-test scores are converted into a score out of 5 for final marking purposes.

In-Class Assessment: During each class session, a group task is assigned to foster collaboration among students, and the completed task is submitted through the newly created FCLM tool. The specific marks allocated to each group task are determined by the respective instructors. Following the conclusion of the 5-week FC approach, the marks obtained for the group tasks are factored in and the pre-test scores are converted into a score out of 5 for final grading purposes.

Post-Class Assessment: After each class session, an assignment is given to promote student engagement, and it is submitted using the newly developed FCLM tool. The specific marks assigned to each assignment are determined by the respective instructors. Following the conclusion of the 5-week FC approach, the marks obtained for the assignments are factored in and the pre-test scores are converted into a score out of 5 for final grading purposes.

Final Assessment: To assess the effectiveness of the FC approach, a class test worth 15 full marks is administered to both FC and Traditional Group students after the completion of the 5-week FC program.

2.2 Open Educational Resources (OER)

OERs are teaching and learning materials that are available in the public domain or released under a license that permits their free use, sharing, and modification. These resources can include textbooks, videos, online courses, lesson plans, and more. OERs provide educators and learners with access to high-quality educational content that can be used and adapted to meet their specific needs. The following sections briefly discuss about OERs for the current research.

2.2.1 Available OERs

Iqbal et al. (2022) reported that there is an abundance of open educational resources available, and a vast majority (95%) of students have confirmed the availability of various resources on the internet, such as videos, simulations, eBooks, and soft copies of lecture notes. Similarly, Husniyah (2018) asserted that numerous open educational resources are accessible on the internet. Li (2017) conducted a project on implementing an Open Educational Resources (OER)-based Flipped Classroom approach, where the authors utilized OERs such as Coursera, Sakai-based, and Massive open online courses (MOOCs). In Nistal's (2017) study, the development process and utilization of educational materials were explained in detail, and the resources were developed using different operating systems (e.g., Windows, Android, and iOS) and applications (both free and commercial).

The present research suggests that selecting appropriate Open Educational Resources (OERs) for a flipped classroom approach requires careful consideration of various factors such as relevance, quality, licensing, diversity, interactivity, and alignment. Based on these considerations, the following OERs were utilized in the current study: YouTube, Khan Academy, Phet Simulation, Coursera, MIT Open Course, IIT Learning Center, OpenStax, DataCamp, MERLOT, CK-12, and TinkerCAD.

2.2.2 OERs for Engineering Courses

According to the literature, there is a lack of research specifically focusing on Open Educational Resources (OERs) for engineering courses. Hence, the current study attempted to identify students' preferred OERs for such courses. While various OERs offering engineering courses can be found online, **Khan Academy** and **Coursera** are the most popular ones in Bangladesh.

2.2.3 Choosing Interactive contents

Iqbal (2022) stated that there are various interactive resources accessible, and a significant percentage (80%) of students confirmed their availability on the internet. In addition, Husniyah (2018) argued that engaging content can enhance the interest and effectiveness of studying. Within the current study, the IDE identified several online platforms that can be utilized to create interactive content for flipped classroom pedagogy, including Quizz, Edpuzzle, PlayPosit, H5P, Nearpod, Kahoot!, Genially, ThingLink, Quizlet, Mentimeter, and Canva.

2.3 Summary

In conclusion, the development of a model learning module using Open Educational Resources (OER) for implementing Flipped Classroom (FC) pedagogy has been presented in this chapter. The reason for selecting the Basic Electronic course for this pilot project is its significant value. Additionally, the chapter highlights that the FC class spanned over five weeks, with one class scheduled each week, lasting 90 minutes per session. Although previous literature suggests that the duration of FC approach to evaluate its effectiveness should be much longer, the current study still produced significant results with the use of a shorter FC approach.

Furthermore, the model module was designed based on careful consideration of various factors such as relevance, quality, licensing, diversity, interactivity, and alignment. The use of OERs such as Khan Academy, Coursera, Phet Simulation, and others were found to be effective in promoting student engagement and enhancing the learning experience. The integration of interactive content using online platforms such as Quizz, Edpuzzle, and H5P further enhanced the effectiveness of the FC pedagogy. The implementation of this model learning module in engineering courses could provide a viable approach to optimize the learning experience for students. Future studies could investigate the effectiveness of this model in diverse educational settings to promote the adoption of OERs and FC pedagogy in education.

Chapter 3

Designing a customized online platform to implement FC pedagogy through E-training app-based web EtvetBD

The education sector has been experiencing a significant transformation in recent years, with a growing emphasis on technology-enabled learning. This has been particularly evident in the field of engineering education, where the use of digital tools and platforms has become increasingly important in delivering effective learning experiences. One approach to engineering education that has gained popularity is FC pedagogy, which emphasizes the development of practical skills and knowledge that are relevant to the needs of the job market. In this chapter, we will explore the design of a customized online platform that utilizes FC pedagogy through an E-training app-based web platform called EtvetBD. We will discuss the key features and functionalities of the platform, its potential benefits for learners and educators, and the challenges that may arise during implementation. In essence, the objective of this chapter is to furnish a thorough comprehension of how to create and execute an online learning platform grounded in FC pedagogy. The platform is intended to aid engineering colleges in their digital-age initiatives.

3. Outcomes

Based on the present research findings, one could argue that, *"Learning Management Systems (LMS) play a crucial role in implementing the flipped classroom pedagogy effectively"*. These provide a centralized platform for teachers to organize and distribute content, including videos, readings, and interactive activities, to students before class. LMS also offer a variety of tools that support active learning, such as discussion forums, group collaboration features, and assessment and grading functions. These tools enable teachers to track student progress, facilitate peer-to-peer learning, and provide feedback to students.

Moreover, LMS can help to address some of the challenges associated with implementing a flipped classroom approach, such as the need for consistent communication with students and the management of large amounts of digital content. With an LMS, teachers can communicate with students through announcements, emails, and messaging features, and organize content in a way that is easy to navigate. There are many learning management systems (LMS) available that can support the flipped classroom pedagogy. Here are some examples: Canvas, Moodle, Blackboard, Schoology and Google Classroom

Iqbal et al. (2022) suggests that having a shared learning management system can be highly beneficial for technical education. A significant number of students (85%) agree that a common LM system is essential for the implementation of the FC approach, and they acknowledge the crucial role of LM systems in supporting their technical learning. Additionally, IDE notes that in Australia and the United States, educators use EDMODO and Blackboard as LM systems to enhance their teaching and facilitate learning.

Khan et al. (2021) conducted research titled "Flipped classroom: How higher education institutions (HEIs) of Bangladesh could move forward during COVID-19 pandemic". The research aimed to introduce open-source technologies that can be used as an alternative to paid LMS systems in developing countries during the COVID-19 pandemic. The authors suggested using three open-source tools - Gmail Group, Google Drive, and a closed Facebook group - for organizing modified flipped

classroom activities. Additionally, free online classes could be conducted using the Zoom platform. However, while these tools are free, they may not fully comply with the FC approach, and a customized tool based on FC approach would need to be designed for effective implementation. Unfortunately, no online LM tool currently specifies the three sections (pre-class, in-class, and post-class) individually. Therefore, the research aims to design a customized online-based LM tool based on the FC approach.

In general, there are a variety of factors and issues that support the need for a customized online tool to implement the FC approach, as shown in Figure 3.1. To gather data on each of these factors, key informant interviews were conducted with teachers, instructional design experts, and IT experts, and a focus group discussion was held with students during the testing phase of the new online platform based on the FC approach. As the data collected from these sources is qualitative in nature, the findings were analyzed using content analysis. The next section of this chapter summarizes the results associated with each indicator, supported by evidence from primary and secondary data sources.

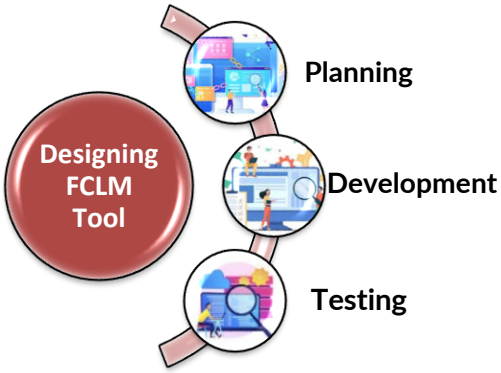


Figure 3.1: Issues and Indicators for RQ # 2

3.1 Planning

Careful planning is essential for the success of the FC pedagogy implementation through the e-training app-based web EtvetBD, which requires a customized online platform. To optimize the FCLM tool, data has been collected from various sources. To ensure a better understanding of the planning concept, a rough diagram (see Appendix B) has been provided to all data sources, which demonstrates the overall skeleton of the learning management system to be developed for implementing the flipped classroom pedagogy, according to IDE. The following points should be considered during the planning process: Privacy and security of personal data, Accessibility and User-friendliness, Multimedia Integration, Feedback Mechanism, Analytics and Reporting, Collaboration and Communication. Additionally, learning activities can be divided into three categories on a weekly basis, including Pre-class, In-class, and Post-class, and these sections should be available every week in separate tabs within the course module of the learning management system. Furthermore, a robust feedback mechanism should be integrated into the learning management system to allow for continuous feedback to both students and educators, which can be achieved by incorporating features such as peer review, self-assessment, rubrics, and automated grading.

Teachers have stated that the developed FCLM tool should be easily accessible to all students and compatible with a variety of devices. It should also have strong security features to protect the data of both students and teachers. Additionally, an IT expert has recommended that in order to create the specialized FCLM tool:

- The frontend should be designed to be clean and user-friendly and
- The choice of backend framework should be carefully considered to ensure efficiency and scalability.

3.2 Development

The development phase of designing a customized online platform to implement FC (Functional Contextualization) pedagogy through an E-training app-based web platform like EtvetBD is a crucial stage in the overall process. This phase involves the creation and implementation of the software and technology that will be used to deliver the training program to learners. The first step in the development phase is to define the goals and objectives of the online platform. This will involve identifying the target audience and the learning outcomes that are expected. The next step is to design the user interface and user experience, taking into consideration the needs and preferences of the learners. Throughout the development phase, it is important to test the online platform and make necessary adjustments based on feedback from users. This will ensure that the platform is user-friendly and meets the needs of the learners.

During the FCLM tool design phase, an IT expert was consulted as the main source of information. Various questions were posed to them, including those relating to the backend and frontend tools, programming languages used in implementation, API key, hosting & domain and security. The aim was to develop a customized, optimized, and user-friendly LM tool based on the expert's advice. As the data collected were qualitative, the findings were subject to content analysis, and the summary of the results is presented below.

Frontend Tools:

- *HTML5*
- *CSS3*
- *Javascript*

Backend Tools:

- *Python (Language)*
- *Django (Library)*

Database:

- *MySQL*

Domain & Hosting:

- *Namecheap*

API Key:

- *REST api*

IT expert has stated that, JavaScript and Python are commonly utilized as the primary languages for both frontend and backend development. However, the expert also acknowledged that managing large amounts of data in databases can present challenges. To ensure security, it is important to create an admin panel and strictly control authorization.

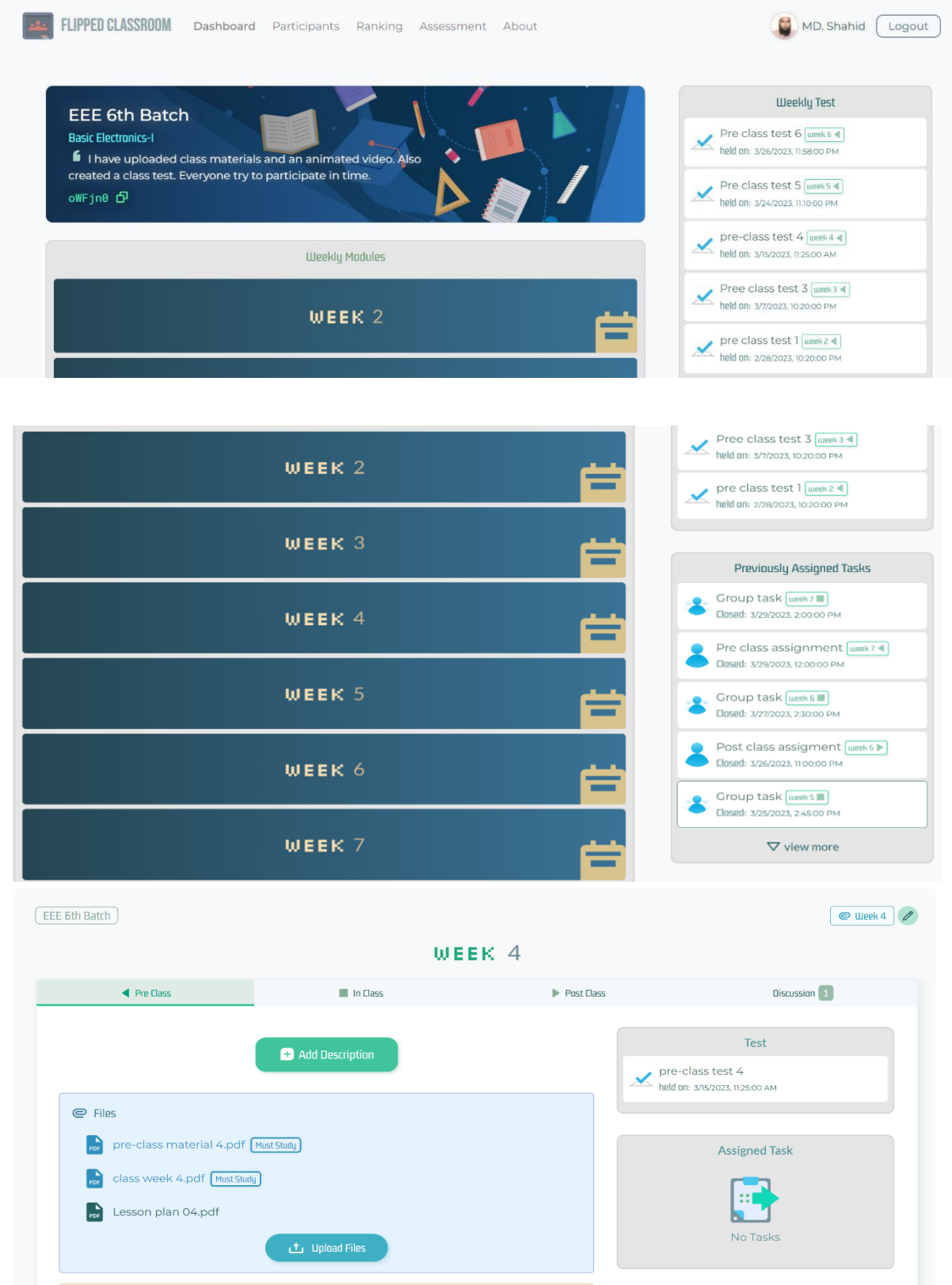
3.3 Testing

Designing a customized online platform to implement FC pedagogy through E-training app-based web EtvetBD involves thorough testing to ensure the platform FCLM, shown in Fig. 3.2, is fully functional and meets the desired specifications. Testing will be conducted at different stages of the platform development process, including unit testing, integration testing, and system testing.

It's great to hear that unit testing, integration testing, and system testing have been done on the platform, and that feedback has been received from teachers and IT experts. The feedback regarding the discussion forum is also valuable and can be used to improve the platform's user interface and functionality.

To address the feedback, the development team could consider making changes to the design of the discussion forum to make it more easily accessible to students. For example, they could add a prominent link to the forum on the platform's homepage or create a separate tab for the forum in the platform's navigation menu. They could also make sure that the forum is easy to use and navigate, with clear instructions and prompts for students to ask questions and engage in discussions.

The IT expert has stated that the frontend of the FCLM tool is lightweight and has a quick loading time. On the other hand, the backend has been designed using Python and the hosting provider used for the tool has a well-known reputation for its global service. Overall, the FCLM tool is deemed to be in a satisfactory state and is capable of fulfilling the requirements necessary for implementing FC pedagogy.

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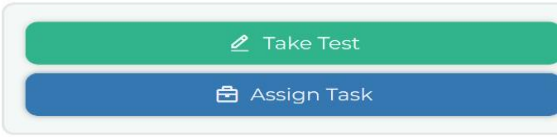
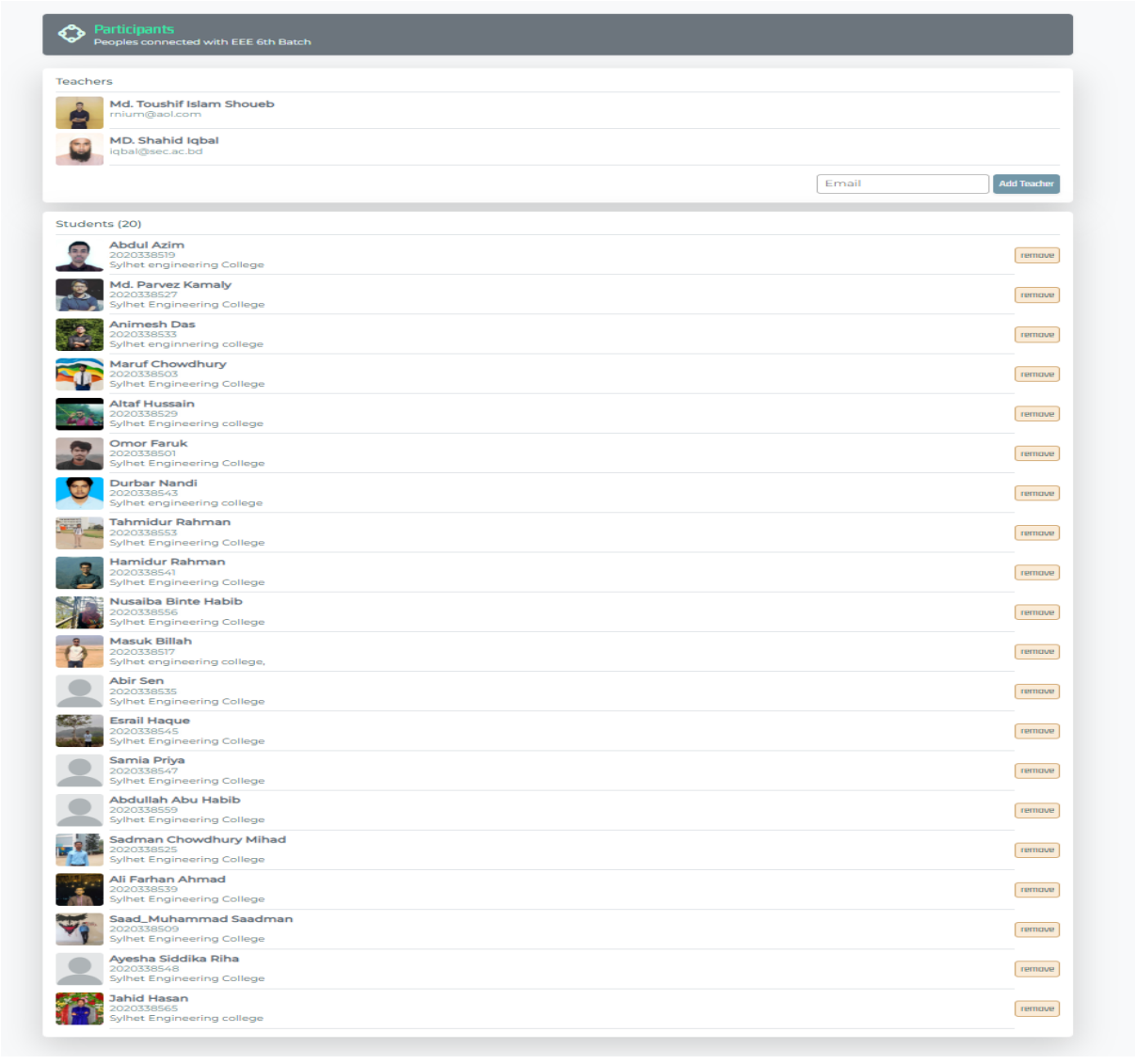

Take Test
Assign Task


Participants
Peoples connected with EEE 6th Batch
Teachers
Md. Toushif Islam Shoueb
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MD. Shahid Iqbal
iqbal@sec.ac.bd
Email
Add Teacher
Students (20)
Abdul Azim
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Sylhet engineering College
Md. Parvez Kamaly
2020338527
Sylhet Engineering College
Animesh Das
2020338533
Sylhet enginnering college
Maruf Chowdhury
2020338503
Sylhet Engineering College
Altaf Hussain
2020338529
Sylhet Engineering college
Omor Faruk
2020338501
Sylhet Engineering College
Durbar Nandi
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Sylhet engineering college
Tahmidur Rahman
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Sylhet Engineering College
Hamidur Rahman
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Sylhet Engineering College
Nusaiba Binte Habib
2020338556
Sylhet Engineering College
Masuk Billah
2020338517
Sylhet engineering college,
Abir Sen
2020338535
Sylhet Engineering College
Esrail Haque
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Sylhet Engineering College
Samia Priya
2020338547
Sylhet Engineering College
Abdullah Abu Habib
2020338559
Sylhet Engineering College
Sadman Chowdhury Mihad
2020338525
Sylhet Engineering College
Ali Farhan Ahmad
2020338539
Sylhet Engineering College
Saad_Muhammad Saadman
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Ayesha Siddika Riha
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Sylhet Engineering College
Jahid Hasan
2020338565
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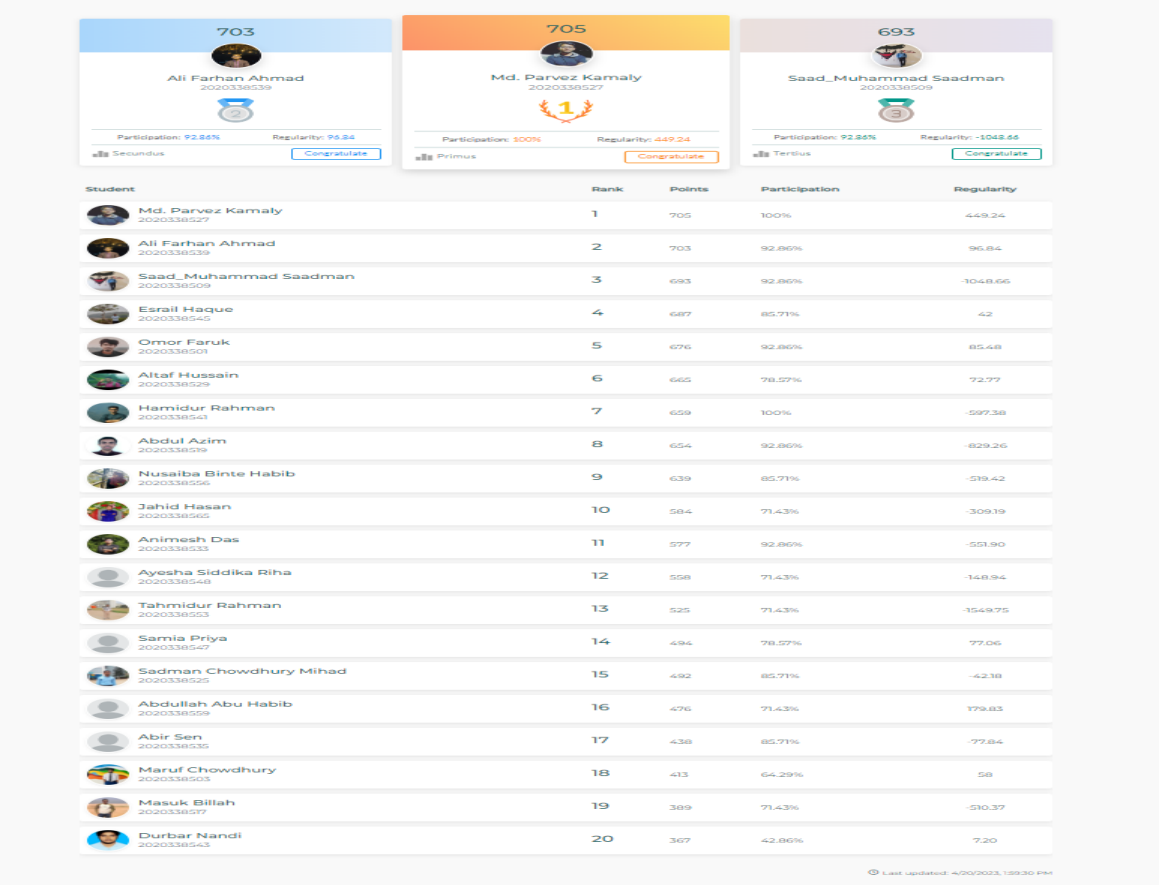

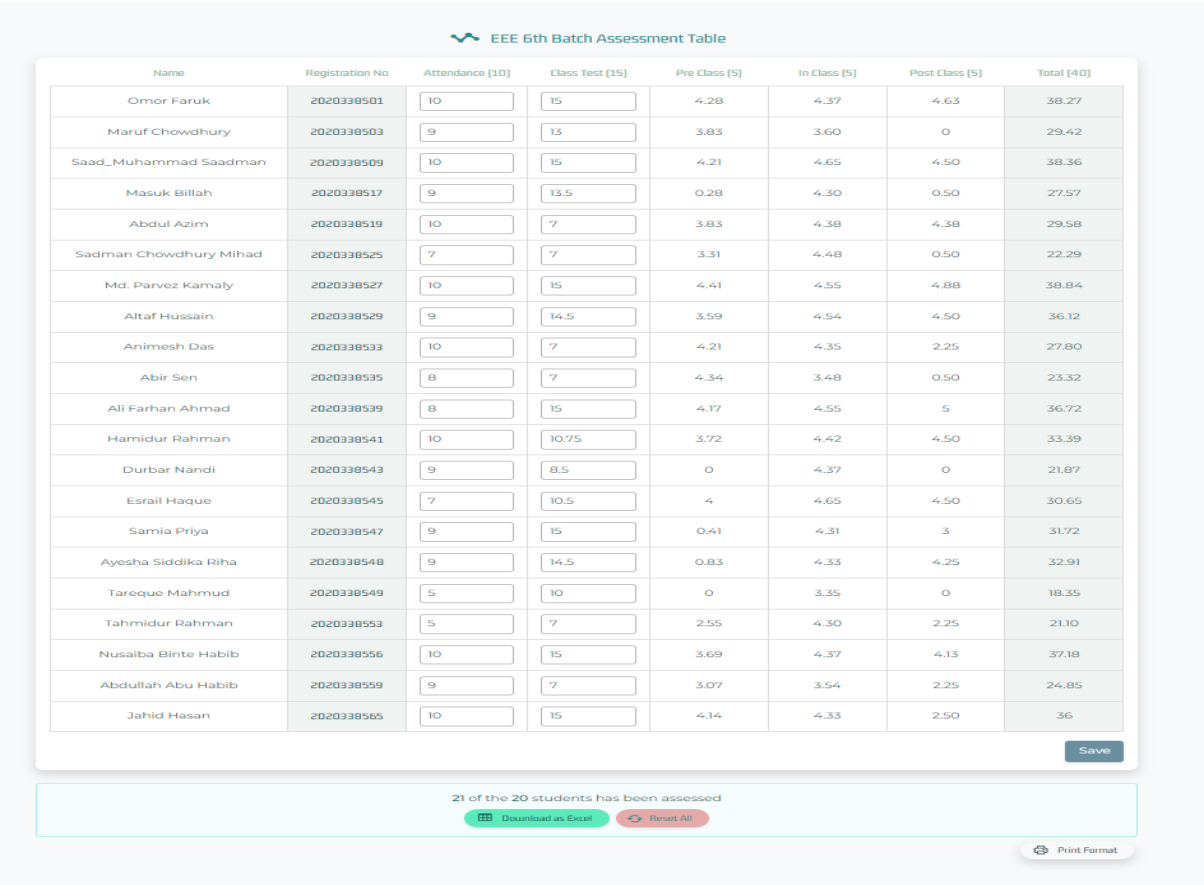

Figure 3.2: An Image of Newly Developed FCLM

Moreover, it is crucial to perform user acceptance testing (UAT) to ensure that the platform satisfies the requirements of its intended users. This entails testing the platform with real users in order to receive feedback and detect any problems that need to be resolved. As a part of this process, a focus group discussion (FGD) was conducted with first-year to fourth-year students to obtain appropriate feedback. One noteworthy observation that was gathered pertains to notifications. To enhance the FCLM tool, it was suggested that a notification be sent to each student every time a task is assigned to them. As a result of this feedback, the FCLM tool incorporated a notification feature for optimization purposes.
It's important to continue gathering feedback and making improvements to the platform based on user input to ensure that it meets the needs of both teachers and students. Furthermore, by conducting rigorous testing, the customized online platform can provide a seamless and effective e-training experience for learners and educators alike.

3.4 Summary

In general, developing a specialized website for flipped classroom pedagogy can be a useful tool for educators to effectively implement this teaching approach. The website should be designed to support the unique needs of the flipped classroom method, such as the ability to deliver and access digital content and facilitate online discussions and collaboration among students.

In terms of further development, the website should be regularly updated with new features and functionalities based on feedback from educators and students. It should also be user-friendly and accessible to all users, regardless of their technical expertise. Additionally, the website could benefit from integration with other educational tools and platforms to enhance the learning experience for students. Moreover, regular training on the new features of the website for educators as well as for students can be very useful for smooth functionality to achieve objectives of flipped classroom pedagogy. Overall, a well-designed and regularly updated website can be an effective tool for educators to implement the flipped classroom pedagogy and improve student engagement and learning outcomes.

Chapter 4

Evaluation of Efficacies of FCP as well as OER

The use of technology in education has significantly changed the way we learn and teach. As a result, the evaluation of the effectiveness of technology-based educational tools has become an essential part of educational research (Chowdhury et al. 2019). In this chapter, we will explore the evaluation of the efficacies of two widely used technology-based tools in education: Flipped Classroom Pedagogy (FCP) and Open Educational Resources (OER). We will review the existing literature on the evaluation of FCP and OER, highlight the benefits of using these tools, and discuss the challenges associated with their implementation. Furthermore, we will provide insights into the best practices for evaluating the effectiveness of FCP and OER in education.

4. Outcomes

To assess the effectiveness of both FCP and OER, this study used both quantitative and qualitative data in order to present an impartial and well-rounded perspective. The research questions were carefully chosen, and appropriate instruments were chosen to address them. To gain a deeper understanding of the FC approach using OER and the newly designed FCLM tool, data collection was conducted in two phases. The first phase involved obtaining feedback/reflection from students and teachers to assess the FC approach, while the second phase consisted of a final survey to gather the perceptions of teachers, students, and IDEs on different aspects of the findings. In line with this, it can be said that the study's third research question was divided into three issues, each with multiple indicators, as shown in Figure 4.1. The following sections briefly describe the data collection, data analysis, and findings for each of the individual issues and indicators.

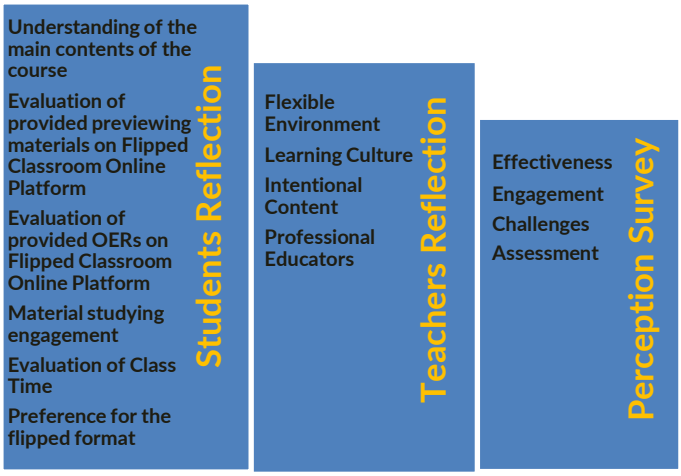

Figure 4. 1: Issues and Indicators for RQ # 1

4.1 Students Reflection

To demonstrate the effectiveness of the current research on the flipped classroom (FC) approach using Open Educational Resources (OER) and a newly designed Flipped Classroom Learning Management (FCLM) tool, intermediate data was collected from students after 2- and 4-week completion. A semi-structured questionnaire was designed, combining both quantitative and qualitative data, based on Thinh, T. N. (2021) survey constructs with some modifications, shown in Table 4.1. The reflection

survey questionnaire set was used for the intermediate surveys, which were administered after 2- and 4-week classes to show the consistency of students' reflections. The data was analyzed quantitatively using a 5-point Likert scale (1 means strongly disagree, 5 means strongly agree) and SPSS for descriptive statistics, including mean and standard deviation for each construct, and frequency data. Qualitative data was analyzed using content analysis. The final survey of the reflection questionnaire can be found in Appendix C.

Table 4. 1: Descriptive Statistics for each Reflection of students

Reflections	***Code***		***M***		***SD***	
Understanding of the main contents of the course	UMC W2	UMC W5	4.7000	4.4500	.57124	.60481
Evaluation of provided previewing materials on Flipped Classroom Online Platform	EMW 2	EMW 5	4.6167	4.4667	.27091	.48846
Evaluation of provided OERs and FCLM tool on Flipped Classroom Online Platform	EOE RW2	EOER W5	4.4000	4.3500	.43225	.46169
Material studyingengagement	MSE W2	MSE W5	4.3700	4.2600	.42190	.33779
Evaluation of class time	ECT W2	ECT W5	4.5300	4.4900	.48243	.43758
Preference for the flipped format	PW2	PW5	4.5750	4.3250	.73045	.69348

Table 4.1 indicates that the higher mean value for each reflection suggests that the students' understanding of the main course material, pre-class materials, provided OERs, and FCLM tool, study engagement, class time, and preference of flipped format are superior to that of the traditional format. The subsequent sections provide a concise summary of the mean and frequency of reflection for each questionnaire item.

4.1.1 Understanding of the main contents of the course

The survey results, which consisted of quantitative data, were analyzed to assess *how well the students understood the key concepts* taught in the course. Table 4.2 shows the mean and standard deviation of responses to all questionnaire items in each category for both week 2 and 4. Additionally, a frequency curve was created and displayed in Fig. 4.2 to compare students' reflections throughout the FC approach. Furthermore, the researchers used supplementary qualitative data to gain a more detailed understanding of the students' reflections in relation to the current indicator.

Table 4. 2: Descriptive Statistics for Each Question Item (Reflection 1) in one Reflection

Reflection 1	***Understanding of the main contents of the course***	***QM***		***QSD***		***RM***		***RSD***	
		UMC W2	UMC W5	UMC W2	UMC W5	UMC W2	UMC W5	UMC W2	UMC W5
Item 1	*I am confident in my learning of the course contents better with flipped classroom learning approach compare to traditional lecture.*	4.70	4.45	.571	.605	4.7	4.45	.571	.604

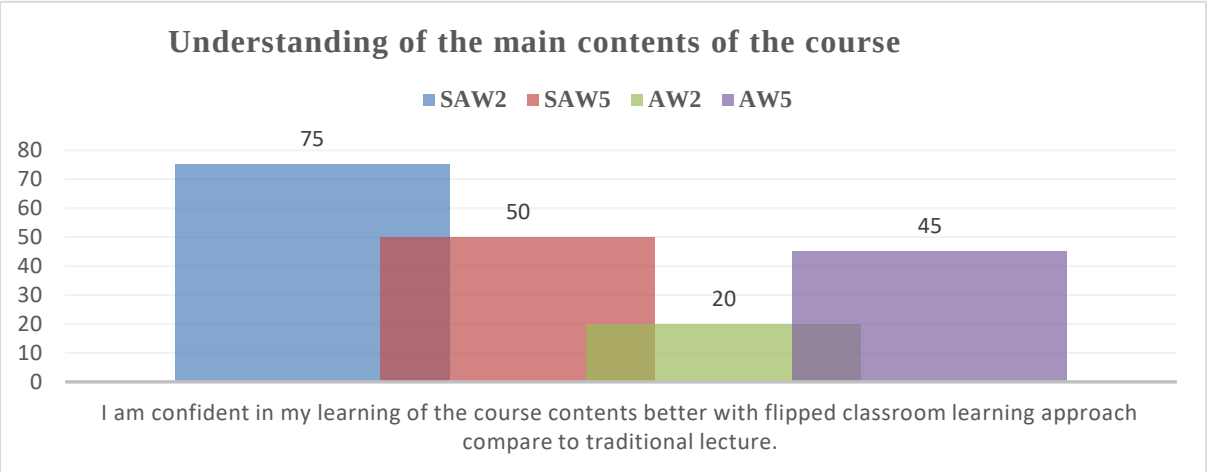

Figure 4. 2: Frequency Statistics for Each Question Item (Reflection 1) in one Reflection.

It has been revealed that the use of FCP has resulted in "*95% of students gaining confidence and a better understanding of the primary course material"*. Fig. 4.2 shows that the agreement level remained high and constant for both week 2 and week 4 regarding the understanding of the main contents. Higher mean of reflection (RM) values of 4.70 and 4.45 for week 2 and week 5 respectively suggest that students felt they had a better understanding. Supplementary qualitative data analysis also showed that most students felt that the provided materials helped them to understand the course better.

According to Thinh, T. N. (2021), in their research, the author claimed that the mean value for understanding the main contents of the course was 3.9905. Johnson (2013) found that 72% of students agreed or strongly agreed that mastery learning improved their math learning, while Jaster (2017) claimed that the mean value of preparedness for the course was 3.150. In conclusion, the results of the current study provide evidence that the FC approach is valid for helping students understand the main contents of the course.

4.1.2 Evaluation of provided previewing materials on FCLM

The quantitative data gathered from the survey was examined to assess the materials given before class through FCLM. Table 4.3 presents the average and deviation of the responses to the questionnaire items in every category for both week 2 and 4. Fig. 4.3 displays a frequency curve that compares the students' reflections during the FC approach regarding pre class materials.

Table 4. 3: Descriptive Statistics for Each Question Item (Reflection 2) in one Reflection.

Reflection 2	***Evaluation of provided previewing materials on Flipped Classroom Online Platform***	***QM***		***QSD***		***RM***		***RSD***	
		EM W2	EM W5	EM W2	EM W5	EM W2	EM W5	EM W2	EM W5
Item 2	*I think that the resources provided through FCLM class is sufficient to meet each lesson's objectives.*	4.30	4.30	.470	.470	4.616	4.466	.2709	.4884
Item 4	*There is a variation of different types of learning resources (videos, slides, handouts)*	4.70	4.70	.470	.657				
Item 5	*Studying the provided materials before class helps me feel more prepared and confident in class.*	4.85	4.40	.366	.681				

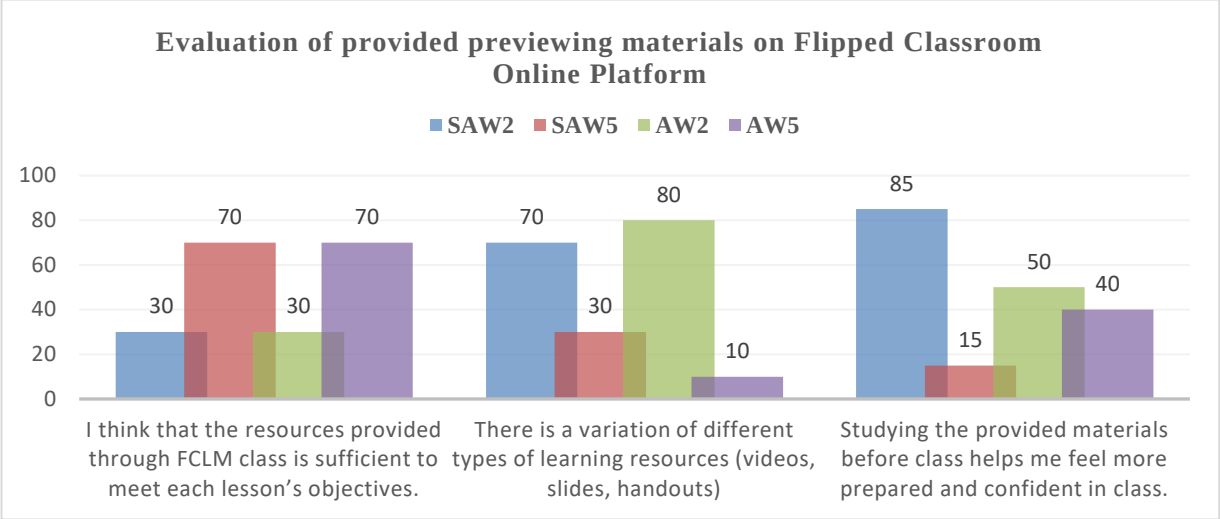

Figure 4. 3: Frequency Statistics for Each Question Item (Reflection 2) in one Reflection.

The implementation of FCP has led to a *"100% satisfaction rate among the students, and they have gained confidence in the provided materials"*. Fig. 4.3 indicates that the level of agreement remained consistently high in both week 2 and week 4 in terms of comprehending the primary concepts. The mean reflection (RM) values for week 2 and week 5 were 4.616 and 4.466 respectively, which suggests a positive attitude towards the previewing materials due to their various types (EM 4.70).

Thinh, T. N. (2021) stated in their research that the average rating for the assessment of the materials provided on Google Drive was 4.3452. Yelamarthi (2015) reported that at the end of the semester, all students agreed that pre-class videos helped them to understand the course content. Jaster (2017) stated that the average score for video viewing engagement was 4.800. To sum up, the findings of the present study offer proof that the pre-class materials provided through the FCLM tool for the FC approach are adequate, given the variety of types and high level of student preparedness.

4.1.3 Evaluation of provided OERs and newly designed FCLM

This indicator involves the analysis of two significant paradigms: open educational resources (OER) and a recently developed customized FCLM tool. The survey collected quantitative data, which was evaluated to determine the effectiveness of the OERs and FCLM tool. The findings are presented in Table 4.4, which shows the average and deviation of responses to the questionnaire items for each category in weeks 2 and 4. Additionally, Fig. 4.4 depicts a frequency curve that compares the students' reflections on OERs and FCLM tool.

On average, 95% of the students agreed that having a variety of OERs (especially videos from Khan Academy and Course Era) helped them understand their course content better and increased their confidence. Similarly, 95% of the respondents expressed high satisfaction with the newly designed customized FCLM tool. Fig. 4.4 shows that the level of agreement remained consistently high in both week 2 and week 4 in terms of understanding the primary concepts. The mean reflection values for week 2 and week 5 were 4.400 and 4.350, respectively, indicating a positive attitude towards the OERs (4.65) and FCLM tool (4.50). While the feasibility of the FCLM tool was previously tested through FGD with students, the current indicator aimed to verify its consistency, which yielded good results.

Table 4. 4: Descriptive Statistics for Each Question Item (Reflection 3) in one Reflection.

Reflection 3	*Evaluation of provided OERs and FCLM tool on Flipped Classroom Online Platform*	*QM*		*QSD*		*RM*		*RSD*	
		EOER W2	EOER W5	EOER W2	EOER W5	EOER W2	EOER W5	EOER W2	EOER W5
Item 6	*I think that the number of provided OERs before class is sufficient to meet each lesson's objectives*	4.10	3.95	.553	.826	4.400	4.350	.4322	.4616
Item 7	*The provided OERs are of various types (videos, slides, animation)*	4.35	4.45	.671	.510				
Item 8	*Provided OERs before class helps me feel more prepared and confident*	4.65	4.50	.489	.607				
Item 21	*I find specially designed FCLM tool effective*	4.50	4.50	.761	.607				

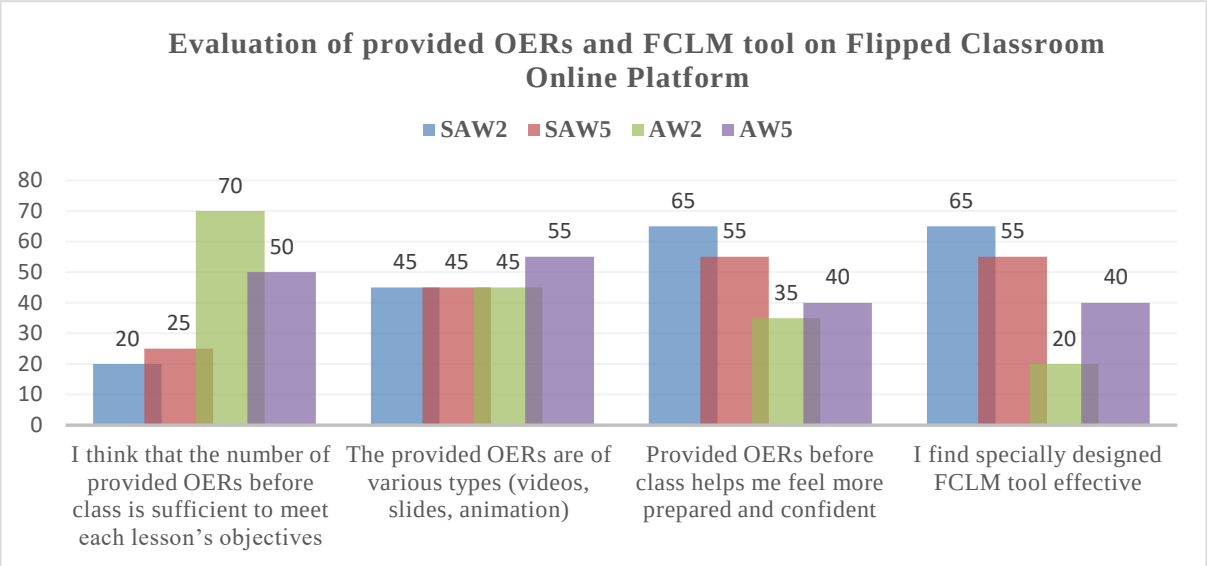

Figure 4. 4: Frequency Statistics for Each Question Item (Reflection 3) in one Reflection

Thinh et al. (2021) reported a mean value of 4.3452 for the materials provided on Google Drive without differentiating between OERs and customized tools. Li et al. (2017) conducted a study on OER-Based Flipped Classroom Practice in an Undergraduate Course and found a high mean value of 5.47 for the statement "I was very satisfied with the course." Bhat et al. (2020) used NPTEL videos and CANVAS as an LM tool for the flipped classroom model and found positive indications of students liking towards it. Yelamarthi et al. (2015) reported that 90.9% of students strongly agreed with the positive feedback regarding TED videos by the end of the semester, and all students agreed that pre-class videos helped them understand the course content. In Johnson's et al. (2013) mathematics course, only YouTube was used to upload different videos. Additionally, Lo et al. (2021) have used Delta MOOCX which is a learning platform developed by Delta Electronics Foundation and Ministry of Education, Taipei, Japan. In conclusion, the results of the present study provide evidence that the provided OERs and newly designed customized FCLM tool for the FC approach are adequate and highly satisfactory to students.

4.1.4 Material Studying Engagement

According to the current study, it was found that 95% of students have a positive attitude towards material studying engagement. The Material studying engagement reflection was created to measure how often students engaged in self-study of previewing materials, including both Must-study and Optional folders. This fourth reflection had a mean higher than the midpoint of 4 and a standard deviation of .3377, as indicated in Table 4.5. The survey data suggests that while some students are more engaged in studying the materials than others, most students chose to study the Must-study folder only, with nearly 75% shown in Fig. 4.5. Additionally, 95% and 90% of students in week 2 and 5 respectively, found that FC provides opportunities for collaborative learning with their peers during class time. Finally, the higher and relatively consistent mean values of Reflection 4, RM 4.370 and 4.260 for week 2 and 5 respectively, also promote greater engagement of students in learning.

Table 4. 5: Descriptive Statistics for Each Question Item (Reflection 4) in one Reflection.

Reflection 4	***Material studying engagement***	***QM***		***QSD***		***RM***		***RSD***	
		MSE W2	MSE W5	MSE W2	MSE W5	MSE W2	MSE W5	MSE W2	MSE W5
Item 9	*I only study Must-study folder all the time*	3.70	3.85	1.129	.745	4.370	4.260	.4219	.3377
Item 10	*I study both Must-study and Optional folder all the time*	4.30	4.15	.733	.745				
Item 11	*I feel that the Optional folder is necessary for my learning.*	4.30	4.35	1.031	.745				
Item 12	*Flipped classroom offers me more opportunities to collaborate with my teammate(s) during class time*	4.80	4.50	.523	.688				
Item 13	*Provided materials makes me feel more engaged in study.*	4.75	4.45	.550	.605				

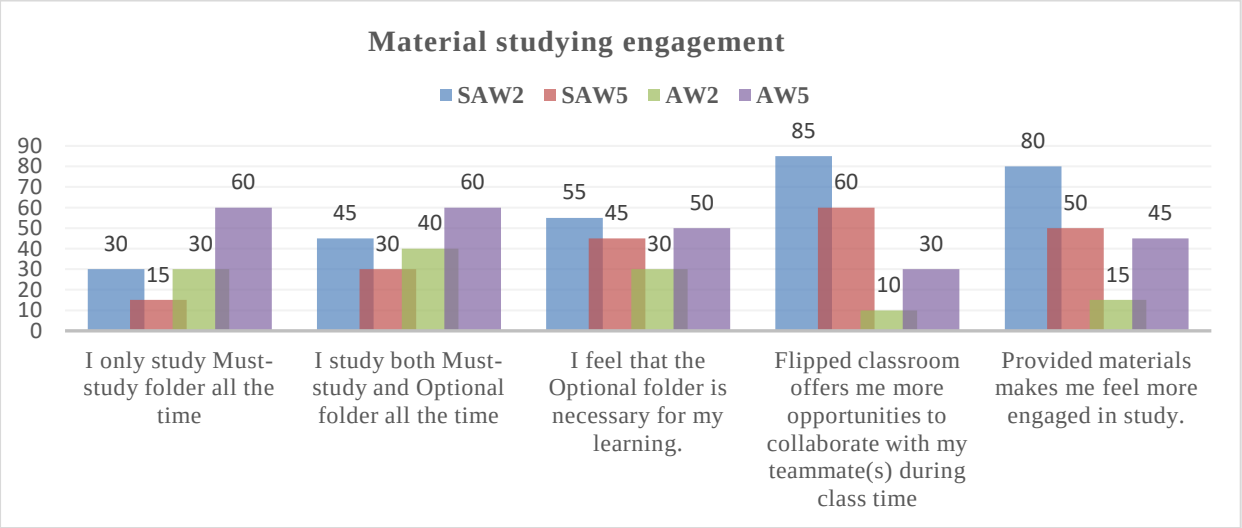

Figure 4. 5: Frequency Statistics for Each Question Item (Reflection 4) in one Reflection.

Secondary data suggests that, based on Cho's et al. (2021) research, 56 out of 99 students had a positive reflection on covering the theory. Johnson et al. (2013) stated that 85% of students either strongly agreed or agreed that "The Flipped Classroom gives me greater opportunities to communicate with other students." Jaster et al. (2017) reported a mean value of 4.800 for video viewing engagement, while Thinh et al. (2021) found a mean value slightly above 3 for material studying engagement. In addition, Yelamarthi et al. (2015) reported that 100% of students strongly agreed with the in-class handout materials and also have believed that collaborative work helped them to develop interpersonal skills". Ultimately, the study's results regarding the potential for material studying engagement to foster collaboration with peers are supported by the findings.

4.1.5 Evaluation of Class Time

According to the current research, a large majority of students (85% for week 2 and 80% for week 5 as shown in Fig. 4.6) agreed that class time in FC is more effective than traditional classroom settings. This could be attributed to the consistently high mean value of 4.70 for item 14 shown in Table 4.6, which indicates that students appreciate being able to communicate with their instructor during class and receive personalized help with their assignments. Additionally, the constant mean value of 4.50 for item 18 indicates that students find the course materials to be academic, reliable, and relevant to the lesson objectives, suggesting that the class time is being used effectively in the FC approach. Furthermore, 95% students for week 2 & 5 have agreed that they got useful feedback than traditional one.

Thinh et al. (2021) found that the average score for assessing class time was 4.1667. Additionally, Johnson et al. (2013) demonstrated that 91% of students agreed that the FC approach effectively utilizes class time. Kim et al. (2014) also reported that 87% of students preferred solving problems in the classroom. Moreover, according to Yelamarthi et al. (2015), all the students surveyed confirmed that the interactive discussion format facilitated their comprehension of the course material. The high average score of 4.530 and 4.490 for week 2 and 4, respectively, in the evaluation of class time reflects positive feedback from students. This is further supported by previous indicators data.

Table 4. 6: Descriptive Statistics for Each Question Item (Reflection 5) in one Reflection.

Reflection 5	***Evaluation of class time***	***QM***		***QSD***		***RM***		***RSD***	
		ECT W2	ECT W5	ECT W2	ECT W5	ECT W2	ECT W5	ECT W2	ECT W5
Item 14	*I like being able to speak with my instructor during class and receive individual help when working on the assignment.*	4.70	4.70	.571	.470	4.530	4.490	.4824	.4375
Item 15	*I can get more useful feedback from the teacher in flipped classroom than traditional one*	4.55	4.50	.510	.513				
Item 16	*I have more time to practice in class in flipped model.*	4.50	4.45	.688	.686				
Item 17	*The class time in flipped classroom is more effective than traditional one.*	4.50	4.30	.889	.923				
Item 18	*I find all the materials academic, reliable and relevant to each lesson's objectives*	4.40	4.50	.598	.607				

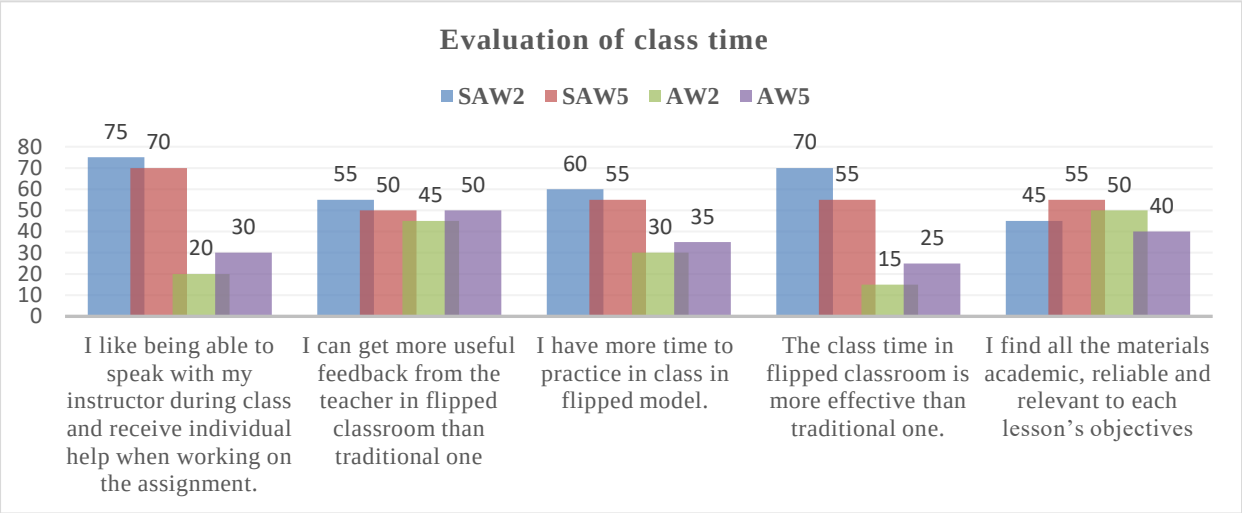

Figure 4. 6: Frequency Statistics for Each Question Item (Reflection 5) in one Reflection.

4.1.6 Preference for the flipped format

Figure 4.7 presents a significant and potent finding, revealing that 95% of students in both weeks 2 and 5 expressed a preference for the flipped format over the traditional lecture format and desired to participate in another flipped class in the future. Additionally, Table 4.7 shows that the mean values of item 19 and 20 in the reflection, namely 4.575 and 4.325 for week 2 and 4, respectively, are higher than 4, and the deviations are low at 0.7305 and 0.6934, respectively. One possible explanation for this strong inclination towards the flipped model is the provision of more valuable feedback and extra practice time, rather than solely listening to hour-long lectures, as discussed in the previous indicators.

Table 4. 7: Descriptive Statistics for Each Question Item (Reflection 6) in one Reflection.

Reflection 6	***Preference for the flipped format***	***QM***		***QSD***		***RM***		***RSD***	
		P W2	P W5	P W2	P W5	P W2	P W5	P W2	P W5
Item 19	*I would like to have another Flipped Classroom in the future.*	4.60	4.30	.754	.733	4.575	4.325	.7304	.6934
Item 20	*I prefer the flipped classroom format to the traditional lecture format.*	4.55	4.35	.826	.813				

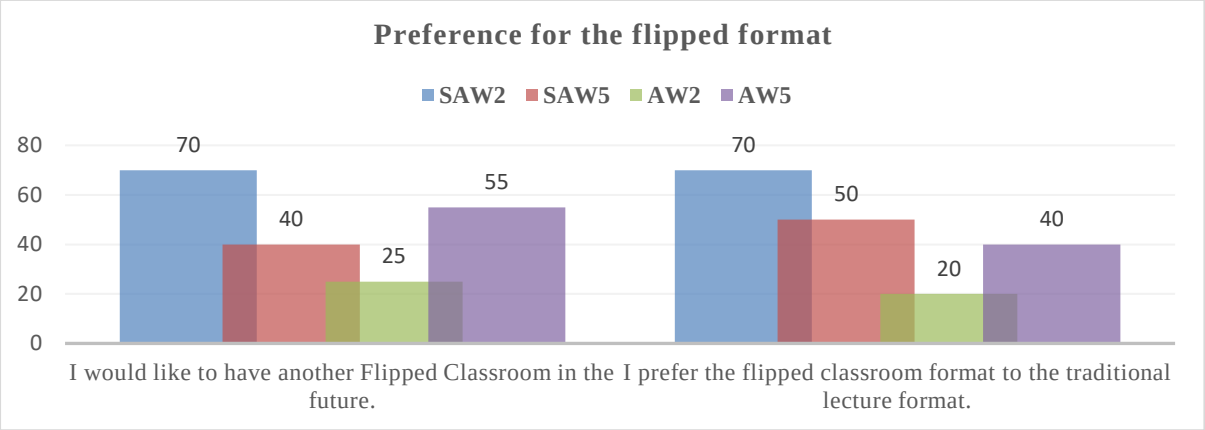

Figure 4. 7: Frequency Statistics for Each Question Item (Reflection 6) in one Reflection.

In order to substantiate the aforementioned potential findings, this study has presented some secondary data from the literature. Thinh et al. (2021) found that the average score for assessing the flipped format was 4.1667. Additionally, Johnson et al. (2013) demonstrated that 83% of students did not disagree with the statement that they would recommend the flipped classroom to a friend. Although Jaster et al. (2017) reported a low mean score of 2.3 regarding the preference for the flipped format, this finding is not in contradiction with the current study or others in the literature, as other indicators have shown a positive attitude towards the flipped approach. It is possible that Jaster et al. (2017) had some misleading information in the questionnaire used. Kim et al. (2014) also reported that 85% of students preferred the flipped classroom. Furthermore, according to Li et al. (2017), they showed a mean score of 4.80 regarding the statement "I will take as many courses via the Internet as I can". Finally, all primary and secondary data revealed that students who attend at least one flipped class prefer the flipped format over the traditional one for future courses.

Despite the fact that these findings were based solely on feedback from the second and fourth weeks of the FC approach, they suggest that the FC approach is effective in promoting understanding of main content, evaluating provided previewing materials, evaluating provided OERs and FCLM, engaging with material during study, evaluating class time, and preferring the flipped format. As a result, the positive attitudes of students towards the FC approach are reflected in various aspects.

4.2 Teachers Reflection

FLN 2014 proposes the Four Pillars as a framework for educators who wish to implement the FC approach in their classes. These pillars include a flexible environment, learning culture, intentional content, and professional educators. To gather insight data on the development of the FC approach, a feedback or reflection questionnaire has been designed based on these four themes. The results of this feedback help to ensure accurate and effective implementation of the FC approach.

Table 4. 8: Descriptive Frequency Statistics for Reflection Pillars with Each Items

Reflection Pillars	***Items***	***Code***	***Agreement Level***	
			YES	**NO**
Flexible environment	*I establish spaces and time frames that permit students to interact and reflect on theirlearning as needed.*	F	100%	X
	I continually observe and monitor students to make adjustments as appropriate.			
	I provide students with different ways to learn content and demonstrate mastery.			
Learning culture	*I give students opportunities to engage in meaningful activities without the teacher being central.*	L	100%	X
	I scaffold these activities and make them accessible to all students through differentiation and feedback.			
Intentional content	*I prioritize concepts used in direct instruction for learners to access on their own.*	I	100%	X
	I create and/or curate relevant content (typically videos) for my students.		X	100%
	I differentiate to make content accessible and relevant to all students.		100%	X
Professional educators	*I make myself available to all students for individual, small group, and class feedback in real time as needed.*	P	100%	X
	I conduct ongoing formative assessments during class time.			
	I collaborate and reflect with other educators and take responsibility for transforming my practice.			

Table 4.8 shows that all four pillars have been incorporated into the FC approach, aided by the customized FCLM tool that provides students with a flexible learning environment and improves their engagement with learning. Teachers can also provide useful feedback to encourage student engagement. With slight modifications, the subsequent parts will offer a concise explanation of each of the four pillars, as stated by Thinh et al. (2021).

4.2.1 Flexible Environment

To ensure students had enough time to study materials and seek help if needed, the instructor uploaded learning materials at least one day before each class meeting. Students appreciated the flexibility of being able to study at their own pace and in their preferred location. The teacher was able to save class time by focusing on guiding student practice rather than delivering theories. Two folders of materials were provided, with most students studying the Must-study folder and a minority studying the Optional folder. During class time, students were given time to work on assignments and ask for support. The course offered a range of written and audio/visual materials to cater to different learning styles, but the assignment only allowed for written submissions. Table 4.8 showcases positive findings obtained through the utilization of three diverse questionnaires to ensure a flexible environment.

4.2.2 Learning Culture

The teacher allocated a significant amount of class time for students to work in pairs and practice their skills or apply the knowledge they had learned in completing assignments. As an example, during the third week, they received instruction on constructing a rectifier diode circuit, and subsequently, they utilized diode circuits in various applications in the succeeding weeks. During this process, the teacher provided instant feedback and demonstrations to help students carry out the tasks on their own, allowing them to engage in meaningful activities without the teacher taking the central role.

Regarding differentiation, the researcher acknowledges that every student has different learning styles and preferences. However, it is challenging to differentiate instruction for a large class within a limited time frame. Flipped classrooms provide more opportunities for one-to-one interaction between the teacher and students, making differentiation more feasible. Although not much differentiation was observed in the course, the teacher provided different pairs with different amounts of time and feedback based on their needs. Struggling students received more attention and help from the teacher, while fast-finishers received constructive feedback to improve their work. This approach allowed struggling students to get the necessary support and attention they needed to improve their learning outcomes. Table 4.8 showcases positive findings obtained through the utilization of two different questionnaires to promote a culture of learning.

4.2.3 Intentional Content

To introduce new concepts such as PN junction, Rectifier Diode VI characteristics, AC-DC conversion and Zener diode, a considerable amount of lecture time would be needed in a non-flipped classroom. However, in a flipped model, the teacher can send materials that explain these concepts thoroughly beforehand and use class time to review, answer questions, and visually demonstrate them. This saves more time for meaningful practice activities and allows for better understanding of the concepts than traditional lectures.

Each lesson in the course was planned to include brief review Q&A, mini-lecture, student practice with teacher's feedback and support. However, not all sections were delivered and it depended on the students' understanding and mastery of the contents. Mini-lectures were only given when students needed further instructions and explanations, and the rest of the time was spent on student practice and

teacher feedback. Table 4.8 indicates that teachers have attempted to develop intentional content in order to enhance students' comprehension.

4.2.4 Professional Educators

Do students in a flipped classroom have to learn everything on their own, making instructors obsolete? Not at all. In fact, instructors now take on the role of learning facilitators, which involves providing more personalized consultations to students and helping them achieve a deeper understanding of the subject matter. This shift means that instructors are no longer the "sage on the stage" but instead serve as a "guide on the side." During class, while students work on assignments, the instructor circulates to offer support and answer questions. Furthermore, the present study aims to create a tailored tool solely for the flipped format known as the FCLM tool, which acts as a means of communication between students and teachers whenever needed. This tool can be particularly beneficial for students who feel hesitant to ask questions in a public setting during in-class activities, as it provides a professional platform for them to engage with their instructors. According to Table 4.8, the FC approach can contribute to the development of professional educators.

4.3 Perceptions

After completing the 05-week Flipped Classroom (FC) approach using Open Educational Resources (OER) and a newly designed Flipped Classroom Learning Management (FCLM) tool, a final demonstration was conducted to evaluate the effectiveness of the current research on implanting FC approach. To measure the effectiveness, three survey questions were formulated to investigate three different paradigms: effectiveness, engagement, and challenges. The primary data was collected from students, teachers, and an instructional design expert (IDE), while a literature review was conducted for secondary data. Feedback from students and teachers was also collected and utilized to inform the perceptions of all parties involved. The data collected was mixed-mode, including quantitative and qualitative data. Quantitative data was analyzed using a 5-point Likert scale and SPSS for descriptive statistics, while qualitative data was analyzed using content analysis. The final survey questionnaire is available in Appendix D. Additionally, Table 4.9 displays descriptive statistics in terms of mean (M) and standard deviation (SD) for all the paradigms, indicating the overall rating of FC approach based on student perceptions. The results show that the mean value for all paradigms is greater than 4, which indicates a high level of agreement among students regarding the FC approach.

Table 4. 9: Descriptive Statistics for Students Perceptions of FC approach

Perceptions	***Items***	***M***	***SD***
Effectiveness	*Item 4*	4.316	.4520
	Item 7		
	Item 8		
Engagement	*Item 1*	4.333	.4955
	Item 2		
	Item 6		
Challenges	*Item 9*	4.300	.7327

4.3.1 Effectiveness

According to the study, feedback from students is crucial and can be summarized as follows: a high percentage (85%, 90%, and 95%) of students agree that the FC approach is effective in improving their understanding of course materials, compared to other teaching methods, and in achieving learning objectives, respectively. One student suggested that regular study is necessary to keep up with the FC approach. The frequency of students' perceptions is clearly shown in Figure 4.8. In addition, Table 4.10 provides descriptive data on the mean and standard deviation to further support the effectiveness of the FC approach. The results in Table 4.10 are particularly noteworthy as the total mean perception score for items 4, 7, and 18 is 4.316, indicating that students strongly agree with these statements.

After analyzing the survey data, which aimed to determine the effectiveness of the FC approach from the perspective of teachers, it was found that one teacher reported the following:

- FC approach students were more engaged and focused than those in the traditional approach. Furthermore, FC students asked more questions, and overall, teaching through the FC approach was found to be more engaging and effective.

Based on the quantitative analysis of IDE survey data presented in Table 4.11, it can be concluded that the currently implemented FC approach is considered extremely effective, fully aligned, moderately easy, and regularly evaluated by participants. IDE also suggests that

- Various technology tools, including learning management systems (LMS), open educational resources (OER), video hosting platforms, and online collaboration tools, can be used to support the FC method. These tools can enhance content delivery and management, facilitate communication and collaboration among students, as well as between students and instructors.

Table 4. 10: Descriptive Statistics for Students Perception 1 with Each Question Item

Perception 1	***Effectiveness***	***QM***	***QSD***	***PM***	***PSD***
Item 4	*On a scale of 1-5, how effective was the flipped classroom method in improving your understanding of the course material? (1=least effective; 2= Somewhat effective; 3= Moderately Effective; 4= Very effective; 5=Extremely effective)*	4.25	.716	4.316	.4520
Item 7	*On a scale of 1-5, how does the flipped classroom method compare to other teaching methods you have experienced? (1=least effective; 2= Somewhat effective; 3= Moderately Effective; 4= Very effective; 5=Extremely effective)*	4.35	.671		
Item 8	*On a scale of 1-5, how effective was the flipped classroom method in helping you learn and achieve the course objectives? (1=least effective; 2= Somewhat effective; 3= Moderately Effective; 4= Very effective; 5=Extremely effective)*	4.35	.587		

Table 4. 11: Descriptive Statistics for Perception 1 for IDE with Each Question Item

Perception 1	***Effectiveness***	***Agreement Level***
Item 1	*On a scale of 1 to 5, how effectively do you think the flipped classroom method supports active learning? (1=least effective; 2= Somewhat effective; 3= Moderately Effective; 4= Very effective; 5=Extremely effective)*	Extremely Effective
Item 2	*On a scale of 1 to 5, how confident are you in the ability of the flipped classroom method to enhance student learning outcomes? (1=Not confident at all, 2= Somewhat confident; 3= Confident; 4= Very confident; 5= Extremely confident).*	Extremely Confident
Item 3	*On a scale of 1 to 5, how well do you think the flipped classroom method aligns with the course objectives? (1=Not aligned at all, 2= Somewhat aligned; 3= Aligned; 4= Fully aligned; 5=Extremely aligned).*	Fully Aligned
Item 4	*On a scale of 1 to 5, how easy is it to implement the flipped classroom method? (1=Not easy at all, 2= Somewhat easy; 3= Easy; 4= Very easy; 5=Extremely easy).*	Moderately Easy
Item 6	*On a scale of 1 to 5, how often do you evaluate the effectiveness of the flipped classroom method? (1=Not evaluated at all, 2= Slightly evaluated; 3= Evaluated; 4= Perfectly evaluated; 5=Extremely evaluated).*	Regularly Evaluated

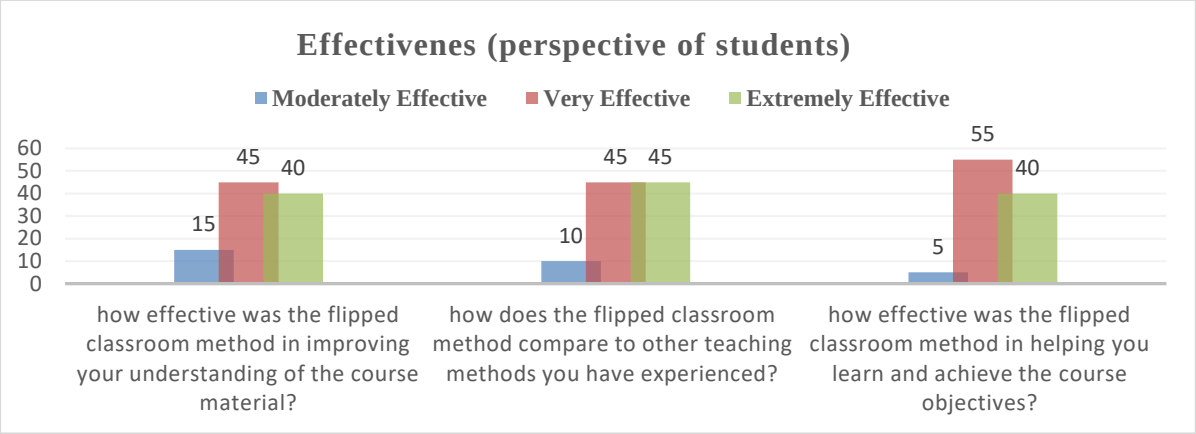

Figure 4. 8: Frequency Statistics for Students Perception 1 with Each Question Item

To further support the presented data, additional sources were consulted and their findings are summarized below. Johnson et al. (2013) reported that 70% of students agreed that they were motivated to learn math in a flipped format. Lo et al. (2021) interviewed 42 students in the second semester, and of those, 40 had positive views on flipped teaching in the course of electronics. Kim et al. (2014) found that in Spring 2013, 83% of students received a "C" grade or better and 140 students successfully completed the course, including 25 who had dropped or failed in Fall 2012. Cho et al. (2021) discovered that "covering new or challenging theory" was the most significant benefit of the online pre-lecture for 56 students. Karr et al. (2015) conducted a survey on flipped classroom in engineering education and cited Pang et al. (2014), who found that 85.8% of students in a software engineering course found this way of learning to be interesting. Karabulut-Ilgu et al. (2018) summarizes the findings from Chao et al. (2015), Ossman et al. (2014), and Yelamarthi et al. (2015), which suggest that flipped classroom is more effective than traditional teaching.

However, Karabulut-Ilgu et al. (2018) also reports negative findings from Hagen and Fratta et al. (2014) and McClelland et al. (2013), which are associated with technical issues and video content. To overcome these limitations, current research offers high-quality open educational resources (OERs) and a customized online platform that facilitates collaboration between students and teachers, as well as among students. In conclusion, the FCP is an effective approach for both teachers and students.

4.3.2 Engagement

The study highlights the importance of gathering feedback from students, which can be summarized as follows: 90% of students always watched pre-recorded materials, 95% of students agreed that they were always engaged in collaborative work during class, and 85% of students reported that the flipped classroom (FC) approach was very effective in improving their engagement with the course material.

Frequency statistics of students' perception about engagement with learning are presented in Fig. 4.9, and Table 4.12 displays the average mean value for perception 2 regarding engagement, further supporting the students' positive feedback on the FC approach. Notably, item no. 6 had a mean of 4.35, indicating that students were highly engaged in collaborative work with their peers throughout the FC approach. This finding is significant in justifying the research's other findings.

Table 4. 12: Descriptive Statistics for Perception 2 of students with Each Question Item

Perception 2	***Engagement***	***QM***	***QSD***	***PM***	***PSD***
Item 1	*On a scale of 1-5, how often did you watch the pre-recorded lectures before attending in-class activities? (1=Never, 2=Rarely; 3=Sometimes; 4=Usually; 5=Always)*	4.45	.686	4.333	.4955
Item 2	*On a scale of 1-5, how effective was the flipped classroom method in improving your engagement in the course material? (1=least effective; 2= Somewhat effective; 3= Moderately Effective; 4= Very effective; 5=Extremely effective)*	4.20	.951		
Item 6	*On a scale of 1-5, how often did you engage in collaborative activities with your peers during in-class activities? (1=Never, 2=Rarely; 3=Sometimes; 4=Usually; 5=Always)*	4.35	.733		

Table 4. 13: Descriptive Statistics for Perception 2 of IDE with Each Question Item

Perception 2	***Engagement***	***Agreement Level***
Item 5	*On a scale of 1 to 5, how often do you modify the flipped classroom method to address the needs of different students or courses? (1=Not modified at all, 2= Slightly modified; 3= Modified; 4= Perfectly Modified; 5=Extremely modified).*	Modified

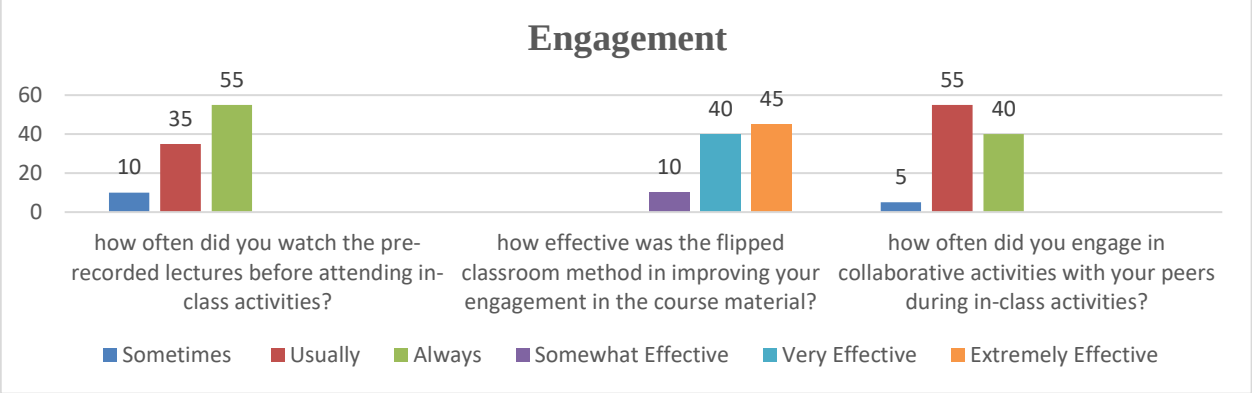

Figure 4. 9: Frequency Statistics for Perception 2 of students with Each Question Item

The qualitative analysis of survey data from teachers aimed to determine the level of student engagement with learning. One teacher stated that “they found the FC approach to be a continuous learning method, as it involved pre-class, in-class, and post-class modules, which ensured that students remained in touch with their teachers throughout the learning process”.

Table 4.13 presents quantitative analysis of IDE survey data, indicating that the currently implemented FC approach has been modified to address the diverse learning needs of students and increase engagement. IDE suggests that to further enhance the FC approach, multiple resources should be provided, content should be adapted for different learning styles, collaboration should be encouraged, formative assessments should be incorporated, personalized feedback should be offered, and a safe and inclusive learning environment should be created.

Similar to other indicators, we conducted some secondary data analysis. Johnson's et al. (2013) research found that 72% of students believed that they could succeed in the course. Kim et al. (2014) stated that 70% of students preferred group work. Lo et al. (2021) claimed that many students believed that class discussions could increase interaction and foster friendships among classmates while also allowing them to express themselves confidently. In Yelamarthi's et al. (2015) study, the use of flipped learning in a first-year Digital Circuits class resulted in an increase in course content covered, higher mean student grades, and a significant reduction in the distribution range between the minimum and maximum grades. Student-centered instructional approaches, like flipped learning, not only facilitate content acquisition but also provide opportunities for developing professional skills that are increasingly demanded in today's competitive global market (Kumar & Hsiao, 2007, p. 18).

Karabulut-Ilgu's et al. (2018) study reported that several authors have argued that flipped learning can enhance students' professional skills such as life-long learning (Luster-Teasley et al., 2014), learner autonomy (Kim et al., 2014; Mok et al., 2014), critical thinking (Chetcuti et al., 2014), and interpersonal skills (Yelamarthi, 2015). Another benefit of flipped learning is improved student engagement (Lavelle et al., 2013), with several studies showing that students come to class better prepared (Chetcuti et al., 2014; Jungic et al., 2015; Mok et al., 2014; Papadopoulos et al., 2010) and devote more time to forming better study habits compared to traditional classroom approaches (Papadopoulos et al., 2010).

After examining the preceding discussion, it can be concluded that the research results hold merit. It is also possible to assert that the favorable outcomes are a result of implementing OERs and a newly tailored FCLM tool.

4.3.3 Challenges

In this study, the FC approach was implemented in a flexible environment using OERs and a customized FCLM tool. The high effectiveness and engagement of students with the FC approach were discussed in previous sections. However, the study also aimed to identify any challenges in terms of supportiveness. The results showed that 85% of students agreed that the FC approach was extremely supportive in achieving the learning objectives. Although qualitative analysis revealed some challenges, these factors did not affect the overall evaluation of the FC approach. Some challenges mentioned by students were the pressure on the course teacher to make the FC approach effective and time management difficulties. Table 4.14 also supported the study's findings of the supportive nature of the FC approach, as evidenced by the high mean value of 4.30.

Through analyzing survey data from teachers, it was found that one of the challenges for implementing the FC approach was the unfamiliarity of students with this approach. One teacher mentioned that they

provided continuous support and guidance to the students as they were not used to the FC approach. Additionally, the teacher had to invest more time in preparing class materials for the FC approach compared to the traditional approach. Another teacher recommended that both students and teachers should be trained in the FC method before implementing it. These challenges were common and temporary for the first implementation of the FC approach. However, a strong motivation was required to break through the traditional system and replace it with a new approach.

To better understand the challenges of implementing the FC approach, a survey question was designed for IDE in a mixed manner to collect both qualitative and quantitative data. One of the major challenges identified was the reliance on students' feedback to measure the effectiveness of the FC approach. However, from quantitative data analysis presented in Table 4.15, it was revealed that IDE believed that "Students' feedback to improve FC approach is reliable." This positive result may be due to the consistency in the intermediary feedback for week 2 and 5, as discussed in the students' reflection section. If there were any ambiguities in the feedback between week 2 and 5, then the reliability of the students' survey would be low.

Furthermore, IDE mentioned several potential challenges that may arise when implementing the FC approach, including dependence on technology, increased preparation time, accountability, limited lecture time, and potential for unequal learning outcomes. While the FC approach has the potential to be effective, it requires careful planning and consideration of the needs of both students and instructors to overcome these challenges.

In addition to the challenges, IDE also highlighted the advantages of the FC approach, such as promoting the development of digital literacy skills among students by requiring them to use digital resources, tools, and platforms for their learning activities. Furthermore, the FC approach allows instructors to utilize various technological tools and platforms to deliver content and engage with students, such as online discussions, video conferencing, and collaborative learning activities.

Table 4. 14: Descriptive Statistics for Perception 3 of students with Each Question Item

Perception 3	***Challenges***	***QM***	***QSD***	***PM***	***PSD***
Item 9	*On a scale of 1-5, did you feel adequately supported in the flipped classroom method? (1=least supportive 2= Somewhat supportive; 3= Moderately Supportive; 4= Very supportive; 5=Extremely supportive)*	4.30	.733	4.300	.7327

Table 4. 15: Descriptive Statistics for Perception 3 of IDE with Each Question Item

Perception 3	***Challenges***	***Agreement Level***
Item 7	*On a scale of 1 to 5, how much do you rely on student feedback to improve the flipped classroom method? (1=Not reliable at all, 2= Slightly reliable; 3= Reliable; 4=Very reliable; 5=Extremely reliable).*	Reliable

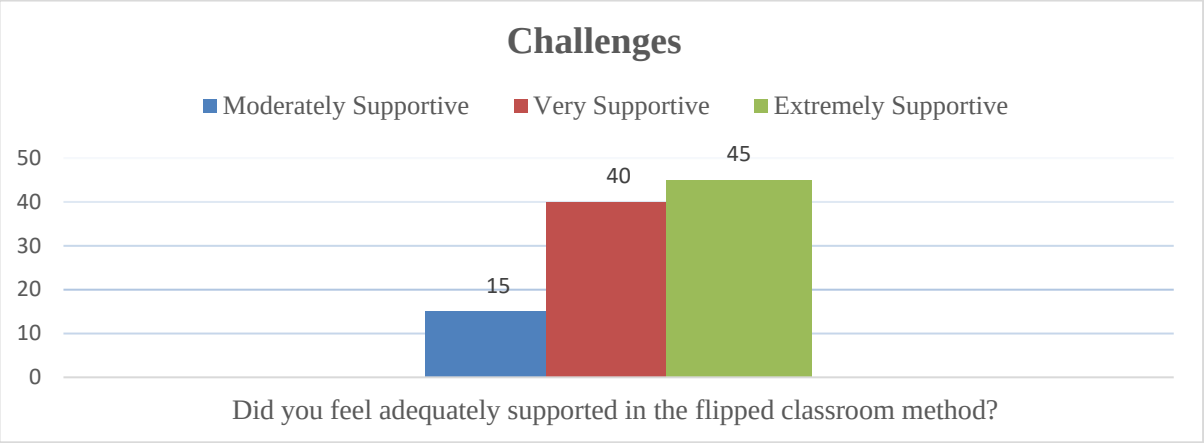

Figure 4. 10: Frequency Statistics for Perception 3 of students with Each Question Item

The secondary sources contain a substantial amount of information on the challenges associated with flipped classrooms. Jaster (2017) identified several challenges as reported by teachers, including some students being unable or unwilling to complete assignments, lacking confidence, and being hesitant to ask questions in class. Grading can also be time-consuming. Johnson (2013) found that some students were dissatisfied with having to wait to ask questions and may give up if the video does not explain a concept well enough. Karabulut-Ilgu (2018) listed challenges such as heavy workload and technical issues but suggested that these could be effectively addressed. Kerr (2015) reported that students initially found the flipped format frustrating and required self-discipline and adjustment to study habits, but by week four, most had adapted. Yelamarthi (2015) noted that providing extra assistance during learning activities can be a challenge, especially with a large class size of 40 students.

Current research has successfully overcome certain obstacles by adopting specific processes or methodologies. For example, a customized FCLM tool has been developed to address the problem of students feeling hesitant to ask questions in class. This tool allows students to ask questions during class or outside of class, and grading is done automatically, relieving teachers of additional pressure. With advancements in technology, the FCLM tool now comes equipped with sophisticated backend and frontend tools, making technical issues less of a concern. Despite initial difficulties in familiarizing students with the FC approach, the use of OERs and customized FCLM tools has ultimately proven to be effective and engaging for student learning. This is supported by Kerr's (2015) research, which found that students required several weeks to become comfortable with the FC approach.

4.3.4 Assessment

Various studies have demonstrated the impact of the FC approach on students' academic performance by evaluating their exam results at different stages, including pre-class, in-class, post-class, and final assessments. For instance, in a flipped Circuits 1 course (Kim et al., 2014), 83% of students received a grade of "C" or higher, compared to the previous semester's passing rate of 56%. The standard deviation was reduced, and student retention was significantly improved. In an Introduction to Circuit Analysis course that blended content from MOOC with team-based learning and hands-on instruction (Ghadiri et al., 2014), the student pass rate increased from 59% to 91% compared to the previous year's face-to-face class. Similarly, in a first-year Digital Circuits course (Yelamarthi et al., 2015), there was an increase in course content coverage and mean student grade. In a senior-level signal processing class, 90% of students in the flipped class scored above 70/100 on the final exam, whereas only 55% of the

previous face-to-face class achieved this score (Veen et al., 2013). In a third-year Technical Communications course for electronics and electrical engineering students, the students' subjective sense of achievement was enhanced (Hanaswa et al., 2014). Additionally, from Bhat et al. (2019), The flipped classroom approach received a higher rating from the students compared to the traditional classroom. The feedback given by the students at the end of the semester also suggested that they preferred the flipped model.

Table 4. 16: A comparison Table between the FC and Traditional approach based on Formative Assessment

Formative Assessment	M	SD
FC	11.76	3.42
Traditional	6.76	4.83

The current study assessed the performance of students through a final examination, which was conducted after five weeks of completion of the course. To do this, the students in a single section were divided into odd and even registration numbers, as previously discussed in the study. The traditional group students and the flipped students took the same final exam in different rooms simultaneously. Table 4.16 shows that the flipped students achieved significantly higher mean (M) final results with a score of 11.76, compared to the traditional group students' mean score of only 6.76. This indicates that the flipped group students had a better understanding of the course content and met the learning objectives successfully. These results are consistent with the data presented earlier in the study. The use of OERs and the newly developed customized FCLM tool have played a vital role in achieving these promising results.

4.3.5 Validity of Research

4.3.5.1 FGD with Traditional Group Students (a supplementary study)

To ensure the validity of the research findings, a focus group discussion (FGD) was conducted with 20 students from the traditional group. The purpose of this FGD was to get feedback from traditional group students about the flipped approach, as they were in the same batch as the flipped students. The feedback collected from traditional group students can be summarized as follows:

- The FC approach is highly interactive.
- Pre-class materials are highly effective in promoting engagement during class.
- The FC group has a better opportunity to make progress.
- There is no chance of achieving good results by cheating.

Overall, the FC group receives more benefits in achieving their learning goals.

4.3.6 Summary

To assess the effectiveness of using the OER and FCLM tool for the FC approach, researchers obtained consistent feedback or reflection from weeks 2 and 5 of the implementation, which provided strong support for conducting the final survey of perceptions. To ensure the reliability of student data, two additional resources, teachers and one IDE, were consulted. Questionnaires were designed to collect both quantitative and qualitative data, and mixed data was analyzed to gain more insight into the research. SPSS was used to present both frequency statistics and descriptive statistics results, helping to better understand the central tendency of student perceptions. Teachers' reflections were collected in

the middle of the FC approach, based on four pillars: flexible environment, learning culture, intentional content, and professional educators. Teachers strived to meet all these paradigms.

Following the feedback session, a survey was conducted to collect perceptions from students, teachers, and IDEs, based on four different paradigms: effectiveness, engagement, challenges, and assessment. Secondary literature was used to support the findings at every stage. In cases where secondary data showed negative results in relation to the research findings, a positive explanation was provided to support the research. However, some challenges in the literature were also applicable to the current research, such as the adaptability of students to the FC approach requiring some time. Additionally, supporting data from FGD of traditional group students was presented.

Overall, the evaluation of the FC approach based on effectiveness, engagement, challenges, and assessment revealed positive outcomes, which further supports teachers, students, and administration who want to implement the FC approach in their field.

Chapter 5

Conclusion

The aim of this chapter is to provide a brief summary of the research findings discussed in the previous chapter. The previous chapter focused on analyzing three research questions in order to identify three distinct paradigms. The first question aimed to design a model learning module, while the second question listed important suggestions and tools required for developing a customized online tool based on the flipped classroom approach. The third question sought to measure the effectiveness of the implemented flipped classroom approach for engineering students in a Basic Electronics course at Sylhet Engineering College, as well as Open Educational Resources (OERs) and the newly developed customized Flipped Classroom Learning Module (FCLM) tool through a survey.

The subsequent sections of this chapter provide a brief review of these three research questions and their outcomes, which have already been discussed in previous chapters. The implications of the proposed FC approach as a piloting project, its limitations during implementation, and future directions for further development of flipped classroom pedagogy, particularly in Bangladesh, are also discussed.

5.1 Conclusion

The flipped classroom model is a teaching approach where the traditional lecture and homework components of a course are reversed. In this model, students receive direct instruction through online videos or other computer-based resources outside of class, while classroom time is spent on interactive group learning activities, discussion of difficult concepts, and problem-solving. This model has gained popularity in higher education, but there has been limited research on its use in engineering education (Kerr et al. 2015). Empirical studies that have investigated the impact of the flipped classroom model in undergraduate engineering education and suggested that the flipped classroom is particularly well-suited to engineering education because it combines active, problem-based learning activities with instructional lectures.

Engineering teachers face two major challenges: covering course content and creating an active classroom where students can interact with each other and apply what they have learned (Bhat et al. 2020). However, these challenges are often at odds with each other, leaving students to learn on their own during lecture time. The solution is to have students access learning resources virtually so that teachers can use classroom time for discussion and application of the learning. The study shows that students prefer the flipped classroom model because it allows them to acquire new technical skills on their own time while still having the opportunity to interact with peers and teachers during class. The flipped classroom also gives teachers the flexibility to design in-class activities that best suit their course objectives.

A survey by the Center for Digital Education and Sonic Foundry found that 29% of higher education faculty in the US are currently using flipped learning, and 27% are planning to implement it soon (Bart et al. 2013). The adoption of flipped pedagogy has improved in the US, and there has been extensive research on its effectiveness in K12 and higher education. However, in Bangladesh, while the Education Sector Plan aims to provide equitable, accessible, and quality education (Education Sector Plan (ESP) for Bangladesh fiscal years 2020/21 – 2024/25, published in 10 December 2020), there have been no

distinct steps taken to implement flipped pedagogy except for a few research studies (Chowdhury et al., 2019; Raihan et al., 2012; Hossain, 2013; Fatema et al., 2020; Jannat et al., 2021; Khan et al., 2021; Iqbal et al., 2022) only to study the feasibility of the FC approach in different paradigms such as effectiveness, opportunities and challenges. Furthermore, no research has been conducted on the efficacy of flipped learning for engineering students in Bangladesh. This study aims to bridge this gap by evaluating the effectiveness of the flipped classroom approach in Basic Electronic Course for 2nd year EEE students at Sylhet Engineering College. The study utilizes open educational resources (OERs) and a customized flipped classroom learning management (FCLM) tool to enhance the effectiveness of the flipped classroom approach for engineering students and has added a new dimension to the approach.

In this study, the first research question was about developing a model learning module that utilizes Open Educational Resources (OER) to implement the Flipped Classroom (FC) pedagogy. The focus of the study was on the Basic Electronic course, which was used as a pilot project. The FC class ran for five weeks, with 90-minute sessions once a week. Although previous research (Thinh et al., 2021; Lo etal., 2021) had suggested longer durations for FC approaches, this study still achieved significant results with the shorter FC approach. Before each session, students were provided with a session plan (see Appendix A) that clearly described the objectives and strategies for the session. Each session was designed with three sections: pre-class, in-class, and post-class, each with an assigned task and minimum mark. According to Thinh's et al. (2021) study, the absence of pre-class tests and a marking system led to low engagement. The pre-class activity involved completing a must-study folder and a pretest assigned by the instructor. The pretest was given on the night before the session and lasted for only 10 minutes to prevent cheating. However, based on student feedback, it was noted that the duration of the pretest was too short, and some students suggested that it be increased. The researcher is considering the feasibility of increasing the duration of the pretest. The in-class activity included a lecture period of 15-20 minutes followed by group problem-solving tasks, which were submitted to the instructors through an online tool. Collaborative work was encouraged among teachers, students, and peers during the group work. The post-class activity included an assignment that was assigned either individually or in a group, depending on the teacher's strategy. The students were rewarded for completing each section, which increased their motivation to engage with the course.

The model module was designed with various factors in mind, such as relevance, quality, licensing, diversity, interactivity, and alignment. Iqbal et al. (2022) reported that there is an abundance of open educational resources available, and a vast majority (95%) of students have confirmed the availability of various resources on the internet, such as videos, simulations, eBooks, and soft copies of lecture notes. The use of OERs such as Khan Academy, Coursera, and Phet Simulation effectively increased student engagement and improved the learning experience especially for engineering students. Incorporating interactive content through online platforms like Quizz, Edpuzzle, and H5P further enhanced the FC pedagogy's effectiveness. Implementing this model in engineering courses could optimize the learning experience for students, and future studies could examine its effectiveness in diverse educational settings to encourage the adoption of OERs and FC pedagogy in education.

Before discussing the second research question about the development of the FCLM online tool based on the flipped classroom pedagogy, the author wants to provide some background information. As previously mentioned and consistent with the previous discussions, secondary sources have a wealth of information on the challenges associated with flipped classrooms. According to Jaster et al. (2017), teachers have reported various challenges, such as some students being unable or unwilling to complete assignments, lacking confidence, and being hesitant to ask questions in class. Grading can also be time-

consuming. Johnson et al. (2013) found that some students may become dissatisfied with having to wait to ask questions and may give up if the video does not explain a concept well enough. While Karabulut-Ilgu et al. (2018) listed challenges such as heavy workload and technical issues, they also suggested that these challenges could be effectively addressed. Kerr et al. (2015) reported that students initially found the flipped format frustrating and required self-discipline and adjustments to study habits, but by the fourth week, most had adapted. Lastly, Yelamarthi et al. (2015) noted that providing extra assistance during learning activities can be challenging, especially with a large class size of 40 students.

The current study has successfully addressed various challenges by implementing specific procedures and techniques. To illustrate, a customized FCLM tool has been developed to tackle the issue of students feeling reluctant to ask questions during class. This tool enables students to ask questions both inside and outside of class, and it is equipped with an automatic grading feature, which alleviates teachers' workload. With advancements in technology, the FCLM tool is now equipped with advanced backend and frontend tools, reducing concerns about technical issues. Despite the initial challenges in introducing students to the FC approach, the use of OERs and customized FCLM tools has ultimately been effective and engaging for student learning. This finding is consistent with Kerr's et al. (2015) research, which found that students required a few weeks to adjust to the FC approach.

The newly designed FCLM tool has unique features that can be summarized as follows: The learning activities are divided into three categories- pre-class, in-class, and post-class, on a weekly basis. Each of these categories is available as a separate tab within the course module on the learning management system. The tool allows instructors to assign tasks for each category, such as quizzes or written Q&A forms as pretest, and group tasks or individual tasks as in-class activity. The FCLM tool automatically creates groups and offers the option to create groups as required by the instructor. For post-class activities, instructors can assign assignments and students can submit them through the FCLM tool, which automatically calculates individual marks. Students can receive updates throughout the week and can use the discussion tab to ask questions at any time, whether in or outside of class. For more information, please visit the FCLM website.

The primary focus of this research is on assessing the effectiveness of the FC approach, as well as the OERs and FCLM tool. The evaluation was conducted in three stages, including feedback from students and teachers in weeks 2 and 5, followed by a final survey for students, teachers, and an Instructional Design Expert (IDE). The feedback from students and teachers played a crucial role in demonstrating the strength of the FC approach, OERs, and FCLM tool. The survey results showed that the students had a positive perception of the flipped classroom, including the provided materials, OERs, FCLM tool, and the use of class time. These findings are consistent with previous research, according to Thinh et al. (2021), indicating that the FC approach improves engagement (Johnson et al., 2013; Basal et al., 2015; Yang et al.,2018), enables more meaningful use of class time (Yang et al., 2018), and enhances understanding of course content (Choe et al., 2016).

One plausible reason for this success is that flipping the course with the customized FCLM tool provided more time for students to practice and seek direct support and instant feedback from the teacher. This led to better satisfaction with class time and improved the quality of their assignments. Additionally, the flipped model encouraged students to ask more questions (it can be done through FCLM tool) and raise issues more freely, resulting in better performance compared to traditional lecture-based classrooms. Furthermore, the use of the FCLM tool facilitated students' connection with both their peers and teachers, thereby enhancing their engagement with the learning process. In contrast, students in traditional classrooms struggled with basic principles and practical problem-solving, lacking the same level of support and guidance from the instructor that the FC approach provides.

In terms of final survey of students, teachers and IDEs perceptions about the implemented FC approach using OERs and FCLM tool, shows a positive attitude regarding the effectiveness, engagement and challenges. Both frequency and descriptive statistics revealed the high agreement level. Due to the reasons for this positive attitude, also from the instructor, is that in the FC approach, there was no need to spend an excessive amount of time talking and explaining, as was often the case in the traditional approach where lessons could not be completed on time. In the Basic Electronics course, circuit designing and problem-solving content can be lengthy and difficult to master in a single sitting. However, the flipped activities before class provided ample learning opportunities using interactive OERs for acquiring these main contents. Pre-class assessments allowed both students and teachers to gauge their level of knowledge, and with brief reviews, mini-lectures, Q&A sections, and group work in class, students could develop a solid understanding of the content by the end of each class meeting.

Moreover, students were exposed to more materials than usual when studying the course book, snapshots of the main contents and selective videos from different online OERs in advance outside class in their spare time. The instructor's self-reflection revealed that the flipped classroom provided more time for practice, feedback, and one-on-one interactions. Despite the extra workload involved in preparation and feedback, which can lead to occasional pressure, the instructor also shared the students' positive view of this teaching approach. In addition, as noted by Jaster et al. (2017), grading can often be a time-consuming task. However, through the use of the FCLM tool, grading and ranking of students were performed automatically, streamlining the process.

Regarding the evaluation of students, there was a significant improvement in their quality, as demonstrated by similar results found in previous studies (Kim et al., 2014; Yelamarthi et al., 2015; Bhat et al., 2019) that implemented the FC approach in various engineering courses. However, this new finding highlights the development of circuit-solving skills, which are considered advanced and challenging to master all at once. The students would benefit from further guidance, demonstration, and practical experience with circuit solving over time.

Numerous studies have been conducted in the field of engineering education, each with their unique set of challenges. The current study focuses on the effective utilization of open educational resources (OERs) and a newly designed flipped classroom learning management (FCLM) tool. The well-designed pre-class materials and customized online tool are crucial factors in increasing the effectiveness of this approach and reducing implementation challenges for both students and teachers.

The findings of this study shed new light on the effectiveness of the flipped classroom, OERs, and FCLM tool in the Basic Electronics course, particularly in circuit solving with rectifier diodes. Most of the surveyed students expressed a positive attitude towards the flipped format and indicated a preference for it in future courses, as confirmed by feedback forms and final surveys.

Teachers and instructional designers also evaluated the current FC approach as a new dimension in the field of flipped classroom approach, particularly in the utilization of OERs and a newly designed customized FCLM tool. The study has shown that students have a better understanding of course content, increased engagement in learning, and a significant improvement in performance quality. This research has shifted the paradigm in the flipped approach for engineering students, marking a new era in flipped classroom education.

5.2 Implications of Practice

The implication of practice refers to the practical consequences or outcomes that result from a particular action or behavior. It involves understanding the real-world effects of a practice or activity and assessing how it can be applied in various situations. The implication of practice is important in many fields, including education, healthcare, and business, as it allows for informed decision-making and the development of effective strategies to improve outcomes. By considering the implications of practice, individuals and organizations can identify areas for improvement, make adjustments to their approach, and ultimately achieve their desired goals.

In Bangladesh, no research has been conducted on the implementation of the FC approach in engineering courses. Hence, the potential implications of the study findings are significant. The study highlights important findings, such as the use of OERs and FCLM tool in creating a model learning module that produced positive outcomes regarding the effectiveness of the FC approach in engineering courses. These findings may serve as a guide and inspiration for engineering teachers who wish to implement the flipped format in their courses, and it may also encourage students to opt for the FC approach in other courses. Furthermore, the results of this study can provide decision-makers and administrators with a valuable tool to implement this approach in their institutions. Finally, since the FC approach has already demonstrated its effectiveness around the world, this study adds further evidence to support its efficacy.

5.3 Limitations

The implementation of the flipped classroom approach in this study has some limitations. Firstly, due to the lack of preparation time, the course did not utilize any self-made videos with voice-over narration. Instead, videos were curated from the Internet, which may have made students feel less connected to the video instructors than their own teacher. Secondly, the small sample size limits the generalizability of the findings, and this study can be considered a pilot study with exploratory purposes that can pave the way for further research on a larger scale. Additionally, students were not given sufficient training on how to effectively use the pre-class materials, such as note-taking, critical thinking, and asking questions, as well as how to make the most of in-class time with their peers and teacher.

5.4 Future Works

The study provides some suggestions to improve the implementation of flipped classroom approach for future research. Firstly, instructors should prepare recorded lecture videos and self-assessment quizzes in advance to ensure sufficient quantity and high-quality materials for students. Secondly, the implementation of the FC approach should be extended to other engineering courses to evaluate its effectiveness. Thirdly, according to Thinh (2021), future research should be based on reliable theoretical frameworks such as Piaget (1950) or Vygotsky's (1978, 2005) socio-cultural theory. Fourthly, providing the contents of all weeks beforehand allows students to work ahead of the course schedule at their own pace. Lastly, there is potential to increase the facilities integrated with the newly designed FCLM tool to enhance student engagement and provide a better assessment platform for teachers.

In conclusion, the FC approach is a promising teaching method for Electronics, but more empirical research is necessary to solidify its effectiveness. Educators who implement this approach should take into account the limitations found in this study and consider the suggestions provided to maximize its potential for student learning.

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Appendix A

(Session Plan)

LESSON PLAN : 02	
COURSE TITLE	Electronics-1
COURSE CODE	EEE 301
COURSE TEACHER	Md. Toushif Islam Shoueb
LESSON TITLE	Semiconductor diodes
DURATION	90 Minutes

SL NO	TASK/ ACTIVITIES	METHODE	LEARNING RESOURCES	TIME	EXTRA NOTE
01	PRE CLASS ACTIVITIES	Flipped classroom	Pre-class materials, animated video from youtube		Online quiz
02	CLASS ACTIVITIES	Introduction to the course	Course syllabus and internet	25mins	Face to face
		Lecture on the topic	Electronic devices and circuit theory ,a book by R.L. boylestad	35mins	
		Group discussion	Prompt question	30mins	
03	POST CLASS ACTIVITIES	Flipped classroom	Assignment		feedback
			Q & A		

LEARNING OBJECTIVES:

After completing the lesson, students will be able to-

1. Differentiate between the concept of electronics and electrics.
2. Understand why semiconductor is use in electronic devices.
3. Explain doping and its role.
4. Understand the basics of diode and its biasing conditions.

LESSON PLAN : 03	
COURSE TITLE	Electronics-1
COURSE CODE	EEE 301
COURSE TEACHER	Md. Toushif Islam Shoueb
LESSON TITLE	Semiconductor diodes
DURATION	90 Minutes

SL NO	TASK/ ACTIVITIES	METHODE	LEARNING RESOURCES	TIME	EXTRA NOTE
01	PRE CLASS ACTIVITIES	Flipped classroom	Pre-class materials, animated video from youtube		Online quiz
02	CLASS ACTIVITIES	Lecture on the topic	Electronic devices and circuit theory ,a book by R.L. boylestad	30mins	Face to face
		Problem solving	Electronic devices and circuit theory ,a book by R.L. boylestad	30mins	
		Group discussion	Prompt question	30mins	
03	POST CLASS ACTIVITIES	Flipped classroom	Assignment		feedback
			Q & A		

LEARNING OBJECTIVES:

After completing the lesson, students will be able to-

1. Illustrate the characteristics curve of diode and effect of temp. on it.
2. Differentiate between Ideal and Actual diode.
3. Understand the resistance level of diode.
4. Understand what is zener diode and its usage.

LESSON PLAN : 04	
COURSE TITLE	Electronics-1
COURSE CODE	EEE 301
COURSE TEACHER	Md. Toushif Islam Shoueb
LESSON TITLE	Applications of diodes
DURATION	90 Minutes

SL NO	TASK/ ACTIVITIES	METHODE	LEARNING RESOURCES	TIME	EXTRA NOTE
01	PRE CLASS ACTIVITIES	Flipped classroom	Pre-class materials, animated video from youtube		Online quiz
02	CLASS ACTIVITIES	Lecture on the topic	Electronic devices and circuit theory ,a book by R.L. boylestad	35mins	Face to face
		Class test & Problem solving	Electronic devices and circuit theory ,a book by R.L. boylestad	35mins	
		Group task	Prompt question	30mins	
03	POST CLASS ACTIVITIES	Flipped classroom	Assignment		feedback
			Q & A		

LEARNING OBJECTIVES:

After completing the lesson, students will be able to-

1. Differentiate between the concept of electronics and electrics.
2. Understand why semiconductor is use in electronic devices.
3. Explain doping and its role.
4. Understand the basics of diode and its biasing conditions.

LESSON PLAN : 05	
COURSE TITLE	Electronics-1
COURSE CODE	EEE 301
COURSE TEACHER	Md. Toushif Islam Shoueb
LESSON TITLE	Applications of diodes (CLIPPER CIRCUIT)
DURATION	90 Minutes

SL NO	TASK/ ACTIVITIES	METHODE	LEARNING RESOURCES	TIME	EXTRA NOTE
01	PRE CLASS ACTIVITIES	Flipped classroom	Pre-class materials, animated video from youtube		Online quiz
02	CLASS ACTIVITIES	Lecture on the topic	Electronic devices and circuit theory ,a book by R.L. boylestad	35mins	Face to face
		Class test & Problem solving	Electronic devices and circuit theory ,a book by R.L. boylestad	35mins	
		Group task	Prompt question	30mins	
03	POST CLASS ACTIVITIES	Flipped classroom	Assignment		feedback
			Q & A		

LEARNING OBJECTIVES:

After completing the lesson, students will be able to-

1. Understand what clipper circuit is.
2. Evaluate the importance of clipper circuit.
3. Solve and find out the output wave form of any clipper circuit.

LESSON PLAN : 06	
COURSE TITLE	Electronics-1
COURSE CODE	EEE 301
COURSE TEACHER	Md. Toushif Islam Shoueb
LESSON TITLE	Applications of diodes (CLAMPER CIRCUIT)
DURATION	90 Minutes

SL NO	TASK/ ACTIVITIES	METHODE	LEARNING RESOURCES	TIME	EXTRA NOTE
01	PRE CLASS ACTIVITIES	Flipped classroom	Pre-class materials, animated video from youtube		Online quiz
02	CLASS ACTIVITIES	Lecture on the topic	Electronic devices and circuit theory ,a book by R.L. boylestad	35mins	Face to face
		Class test & Problem solving	Electronic devices and circuit theory ,a book by R.L. boylestad	35mins	
		Group task	Prompt question	30mins	
03	POST CLASS ACTIVITIES	Flipped classroom	Assignment		feedback
			Q & A		

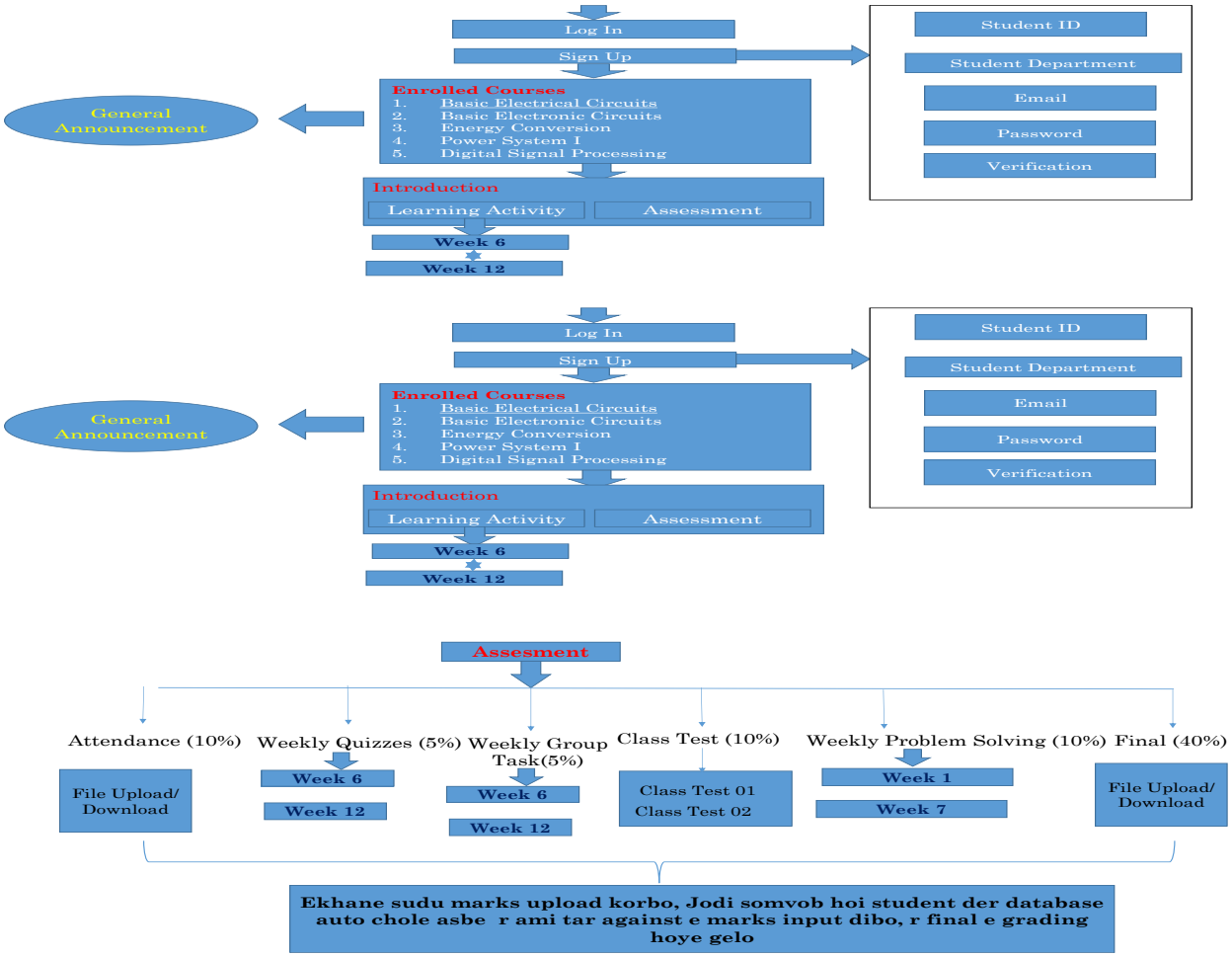
LEARNING OBJECTIVES:

After completing the lesson, students will be able to-

1. Understand what clamper circuit is.
2. Evaluate the importance of clamper circuit.
3. Solve and find out the output wave form of any clamper circuit

Appendix B

(FCLM Planning Flowchart)



Appendix C

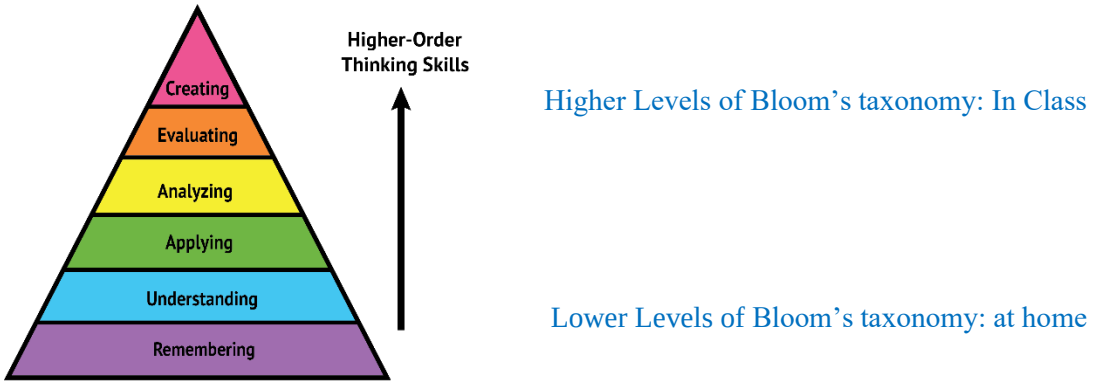


Figure 1. 1 : Hierarchy of Bloom's taxonomy 1

Appendix D

(Research Questionnaires)

RQs for Learning Module

How familiar are you with the flipped classroom method?
What factors should be taken into account when designing and implementing a flipped classroom approach?
Give your opinion about the model Learning Module to implement flipped classroom pedagogy.
Give your opinion about the assessment criteria of students' performance in flipped classroom pedagogy.
Also give your opinion that how the assessment criteria of students' performance can be used to evaluate the efficacy of flipped classroom pedagogy.
Please evaluate the given Model Session Plan and give your opinions regarding the following points:

- Is the session plan designed appropriately?
- Do you think that the Basic Electronics Course is better to implement FC pedagogy?
- What do you think about FC pedagogy's approach to class length?
- As an implementation stage of FC pedagogy how many weeks is required in order to evaluate the efficacy of FC pedagogy?

Please finally give your overall opinion and suggestions for any further development required to implement FC pedagogy?

RQs for OERs

How familiar are you with the OERs?
What factors should be taken into account when choosing OERs for flipped classroom approach?
Could you suggest names of available OERs?
Could you mention the names of OERs for engineering courses?

Could you please suggest some online platforms which is helpful to create interactive contents for FC pedagogy?
Could you please suggest some online platforms related to video editing or to create interactive videos for FC pedagogy?
Do you think that YouTube is also can be used as OERs?
Please finally give your overall opinion and suggestions for any further development required to implement FC pedagogy?

RQs for FCLM tool

Have you ever visited an education based specialized website? If, please share some information?
How familiar are you with the learning management tool?
Do you ever know about the learning management tool specified for flipped classroom pedagogy? If you know this, then please mention the names of this tools.
What do you think about the importance of LM tool for implementing flipped classroom pedagogy effectively?
What factors should be taken into account when designing and implementing of LM tool for flipped classroom?
Please provide your feedback by evaluating the following planning strategy of developing specialized FC based LM online platform. If there is any suggestion please mention.
Please finally give your overall opinion and suggestions for any further development required to implement this specialized website for FC pedagogy?

RQs for Feedback (Students)

Sl. No.	**Survey Questionnaire**	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
1	I am confident in my learning of the course contents better with flipped classroom learning approach compare to traditional lecture.					
2	I think that the resources provided through FCLM class is sufficient to meet each lesson's objectives.					
3	What do you think that provided resources can be added to support your learning last week?					
4	There is a variation of different types of learning resources (videos, slides,handouts)					
5	Studying the provided materials before class helps me feel more prepared and confident in class.					
6	I think that the number of provided OERs before class is sufficient to meet each lesson's objectives					
7	The provided OERs are of various types (videos, slides, animation)					
8	Provided OERs before class helps me feel more prepared and confident					
9	I only study Must-study folder all the time					
10	I study both Must-study and Optional folder all the time					

11	I feel that the Optional folder is necessary for my learning.					
12	Flipped classroom offers me more opportunities to collaborate with my teammate(s) during class time					
13	Provided materials makes me feel more engaged in study.					
14	I like being able to speak with my instructor during class and receive individual help when working on the assignment.					
15	I can get more useful feedback from the teacher in flippedclassroom than traditional one					
16	I have more time to practice in class in flipped model.					
17	The class time in flipped classroom is more effective than traditional one.					
18	I find all the materials academic, reliable and relevant to each lesson's objectives					
19	I would like to have another Flipped Classroom in the future.					
20	I prefer the flipped classroom format to the traditional lecture format.					
21	I find specially designed FCLM tool effective					

RQs for Survey (Students)

On a scale of 1-5, how often did you watch the pre-recorded lectures before attending in-class activities? (1=Never, 2=Rarely; 3=Sometimes; 4=Usually; 5=Always)
On a scale of 1-5, how effective was the flipped classroom method in improving your engagement in the course material? (1=Not effective at all; 2= Somewhat effective; 3= Effective; 4= Very effective ; 5=Extremely effective)
What did you find most effective about the flipped classroom method?
On a scale of 1-5, how effective was the flipped classroom method in improving your understanding of the course material? (1=Not effective at all; 2= Somewhat effective; 3= Effective; 4= Very effective ; 5=Extremely effective)
What did you find most challenging about the flipped classroom method?
On a scale of 1-5, how often did you engage in collaborative activities with your peers during in-class activities? (1=Never, 2=Rarely; 3=Sometimes; 4=Usually; 5=Always)
On a scale of 1-5, how does the flipped classroom method compare to other teaching methods you have experienced? (1=Not effective; 2=less effective; 3= Somewhat effective; 4= Effective; 5=More effective)
On a scale of 1-5, how effective was the flipped classroom method in helping you learn and achieve the course objectives? (1=Not effective at all, 2= Somewhat effective; 3= Effective; 4= Very effective ; 5=Extremely effective)
On a scale of 1-5, did you feel adequately supported in the flipped classroom method? (1=Not at all supportive 2= Somewhat supportive; 3= Supportive; 4= Very supportive;5=Extremely supportive)

RQs for Survey (Teachers)

How long have you been using the flipped classroom method?
What motivated you to adopt the flipped classroom method in your teaching?
What resources and tools did you use to create pre-recorded lectures and materials for the flipped classroom method?
How did you assess student engagement and participation in the flipped classroom method?
What strategies did you use to encourage student collaboration and discussion during in-class activities?
How did you support students who may have struggled with self-directed learning in the flipped classroom method?
How did you provide feedback and assess student understanding of the course material in the flipped classroom method?
Have you noticed any changes in student engagement or performance since adopting the flipped classroom method?
How would you rate the overall effectiveness of the flipped classroom method in achieving the learning objectives of the course?
What challenges did you face in implementing the flipped classroom method, and how did you address them?
What advice would you give to other teachers who are considering adopting the flipped classroom method?
How did you modify your flipped classroom approach to meet the diverse learning needs of your students?
What kind of feedback did you receive from your students regarding the flipped classroom method?
What changes did you make to your flipped classroom approach over time to improve its effectiveness?
Please mention a comparison analysis between the traditional and flipped classroom approach based on your own experience.

RQs for Survey (Instructional Design Expert)

On a scale of 1 to 5, how effectively do you think the flipped classroom method supports active learning?
(1=Not supportable at all, 2= Somewhat supportable; 3=Supportable; 4=Very supportable; 5 = Extremely supportable).
On a scale of 1 to 5, how confident are you in the ability of the flipped classroom method to enhance student learning outcomes? (1=Not confident at all, 2= Somewhat confident; 3= Confident; 4= Very confident; 5= Extremely confident).
On a scale of 1 to 5, how well do you think the flipped classroom method aligns with the course objectives? (1=Not aligned at all, 2= Somewhat aligned; 3= Aligned; 4= Fully aligned; 5=Extremely aligned).
On a scale of 1 to 5, how easy is it to implement the flipped classroom method? (1=Not easy at all, 2= Somewhat easy; 3= Easy; 4= Very easy; 5=Extremely easy).
On a scale of 1 to 5, how often do you modify the flipped classroom method to address the needs of different students or courses? (1=Not modified at all, 2= Slightly modified; 3= Modified; 4= Perfectly Modified; 5=Extremely modified).
On a scale of 1 to 5, how often do you evaluate the effectiveness of the flipped classroom method? (1=Not evaluated at all, 2= Slightly evaluated; 3= Evaluated; 4= Perfectly evaluated; 5=Extremely evaluated).

On a scale of 1 to 5, how much do you rely on student feedback to improve the flipped classroom method? (1=Not reliable at all, 2= Slightly reliable; 3= Reliable; 4=Very reliable; 5=Extremely reliable).

How well does the flipped classroom method integrate with other teaching methods and tools?

How well do you think the flipped classroom method addresses the challenges of teaching and learning in the digital age?

What do you believe are the key benefits and challenges of using the flipped classroom method?

What factors should be taken into account when designing and implementing a flipped classroom approach?

How would you rate the effectiveness of the flipped classroom method in achieving the learning objectives of the course?

How can the flipped classroom method be improved or modified to better meet the diverse learning needs of students?

What additional research do you believe is needed to further investigate the effectiveness of the flipped classroom method in higher education settings?

What advice would you give to teachers and institutions considering adopting the flipped classroom method?

CONTRIBUTORS

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