IJELHE
e-ISSN: 3030-6663

Available online at
https://journalined.uitm.edu.my/

International Journal on e-Learning and Higher Education 21 (2) 2026, 138-159

Synchronised Online Flipped Classroom: A 3-60 Approach Implemented in Geotechnical Engineering Course

Noraida Mohd Saim[1], Nur Asmaliza Mohd Noor[2], Rohaya Alias[3]*

[1]Faculty of Civil Engineering, Universiti Teknologi MARA (UiTM), Shah Alam, Selangor, Malaysia
[2,3]Faculty of Civil Engineering, Universiti Teknologi MARA (UiTM), Bandar Tun Abdul Razak Jengka, Pahang, Malaysia

ARTICLE INFO

Article history:
Received 22 September 2025
Revised 15 June 2026
Accepted 23 June 2026
Online first
Published 30 June 2026

Keywords:
Engineering education
Flipped classroom
Online classroom
Self-learning
Synchronised learning

DOI:
10.24191/ijelhe.v21n2.21213

ABSTRACT

The flipped classroom approach has emerged as a highly effective teaching and learning strategy, particularly in facilitating active engagement in online and blended learning environments. This paper describes the concept of improved learning in a synchronised online flipped classroom, implemented through a 3-60 approach for the Geotechnical Engineering course. The three-hour lecture sessions for this course, spanning 14 weeks, were conducted entirely in online distance learning mode. The session was divided into three sections: the first 60 minutes were allocated to self-learning, and the second 60 minutes were for a live meeting to discuss the overall content and any issues students needed to understand. The final 60 minutes were allocated to problem-solving activities and exercises. During the 3-hour session, the lecturer served as a facilitator. The qualitative assessment of students' perceptions revealed that 93.3% of students were satisfied or very satisfied with the effectiveness and relevance of this method for online learning. Students' performance in achieving course outcomes (COs) and programme outcomes (POs) has also improved. Overall, it can be concluded that a synchronised online flipped classroom effectively improves students' conceptual understanding, encourages self-learning and creates a better online learning environment.

[1*]Corresponding author. E-mail address: aidams2000@uitm.edu.my

1. INTRODUCTION

The flipped classroom learning method has become increasingly popular and widely used nowadays (Saterbak & Wettergreen, 2016; Jia et al., 2023; Zhang et al., 2023). Flipped classrooms have been highlighted in many research studies (Bergmann & Sams, 2012; Mavromihales & Holmes, 2016; Milman, 2022; Merret, 2023). This method has gained widespread use in recent years and is also referred to as flipped learning, flipped instruction, or flipped teaching (Hung, 2022). According to Demirel (2016), the flipped classroom method consists of three stages: pre-class, in-class, and post-class activities. In the pre-class stage, students prepare by engaging with instructional materials, such as reading materials, watching videos or listening to podcasts, and completing assignments provided on a learning platform.

The in-class stage focuses on applying, analysing, synthesising, and evaluating problems, with instructors facilitating discussions, addressing misconceptions, and promoting collaboration. Activities at this stage often include group problem-solving and presentations. Finally, the post-class stage involves assessments to evaluate students' understanding of pre-class and in-class materials, typically completed at home. This method shifts the focus from teacher-centred lectures to student-centred learning, encouraging active participation and problem-solving. The flipped classroom is one of the methods used to promote self-learning and student engagement. The concept of the flipped classroom involves a facilitator providing instructional resources for students to use outside the classroom, thereby making class time less traditional and teacher-centred (Bergmann & Sams, 2012). This method redefines the roles of facilitators and students. November and Mull (2012) suggested that a flipped classroom is an approach that prompts students to prepare themselves for the lesson by watching videos, listening to podcasts, and reading articles. The facilitator is an instructor who helps students by identifying and resolving misconceptions, developing problem-solving skills, and facilitating collaboration among them. Facilitators are essential in attracting students' interest in a lesson (Lee, 2020).

The success of using this method can be determined by how responsible and independent students are in doing their learning (Bergmann & Sams, 2012). Moreover, this method can increase interaction between students and facilitators, with responsibility for learning transferred to students, allowing them to revise the material as often as required and to prepare for class at times that suit them (Milman, 2022). The flipped classroom method can enhance learning experience and increase collaboration between students and facilitators (Persky & McLaughlin, 2017). According to Schmidt and Ralph (2016), the flipped classroom has transformed traditional teaching into a digital format, promoting active learning. Class activities were found to be more effective because students are more active and independent (Haghi, 2020). Fulton (2012) stated that the flipped classroom approach creates a more creative and effective learning process with technology today.

Additionally, the online flipped classroom model has emerged as a transformative pedagogical approach that leverages digital platforms to enhance learning. This model allows students to access materials and participate in activities from anywhere. The online flipped classroom has significantly transformed traditional teaching paradigms into a digital mode, promoting active learning, fostering student autonomy, and enhancing collaborative interactions (Hung, 2022). Smith and Boscaks (2021) examined standard online flipped classroom pedagogy. The students were provided with pre-class videos and online lectures on the learning topics. The researchers then evaluated students' satisfaction with the learning activities. The findings indicated that the students were satisfied with the more flexible approach, which helped them develop their confidence and skills more effectively. With the advancement of digital learning, researchers have increasingly examined the effectiveness of online flipped classrooms. Many students find the approach beneficial and engaging. However, notable challenges, such as poor video selection, can affect the quality of instruction. Additionally, technical limitations, such as internet connectivity, device availability, and technological infrastructure, can hinder effective implementation. Moreover, online flipped classrooms require competent instructors and self-disciplined students prepared to learn independently. Without early exposure to new content, students may experience stress and struggle with active learning sessions (Ab Latif et al., 2021).

The conventional online flipped classroom method requires further improvement to enhance student engagement. This study introduces an innovative online flipped classroom approach, known as the Synchronised 3-60 Approach for Teaching and Learning in Geotechnical Engineering, which divides each three-hour lecture into three segments: 60 minutes for self-learning, 60 minutes for live online discussions, and 60 minutes for problem-solving activities. This structured approach encourages self-directed learning and active engagement while addressing limitations such as internet usage, meeting duration, and students' ability to maintain focus. The study aims to evaluate the effectiveness of this method and to gather student feedback on their experiences and performance with the 3-60 Approach.

1.1 Flipped Classroom Approach in Engineering Education

The flipped classroom learning method has been fully practised in engineering education. Rechenmacher (2020) used the flipped classroom method in the Geotechnical Engineering course. Students were asked to watch short lecture videos outside of class, solve group problems in class, give presentations, and interact with the instructor. The students demonstrated a higher level of knowledge mastery and are more interactive and interested in this course. Li and Daher (2016) evaluated the effectiveness of flipped teaching applied in the Water Resources Engineering course. The study found that students were willing to participate in learning using this approach. It can also enhance students' understanding of concepts and improve their problem-solving skills. Zhang et al. (2023) proposed a flipped-classroom-based learning approach for teaching an engineering course, Hydrology. Through this learning method, the average final exam score in this course improved, and the failure rate decreased. Positive feedback from student questionnaires confirmed that flipped classroom-based learning was effective and can motivate students. This finding contradicts a study conducted by Hagen and Fratta (2014), which analysed the effect of flipped classroom learning on student performance in a Geological Engineering course by comparing the flipped classroom method with the traditional lecture method in parallel in the same academic year. They found that the students in the flipped classroom did not perform as well as their counterparts learning in a traditional environment. Flipped-class students perceived the course negatively because they were stressed and unprepared for the exam, as they had to manage their own learning. This finding aligns with McClelland's (2013) assessment of the effectiveness of the flipped classroom in the Fluid Mechanics course. Studies have found that flipped classroom learning does not result in higher exam scores than traditional teaching approaches. The study found that the average final examination score for the traditional teaching format was 83.75%, compared with 80.1% for the flipped classroom format.

However, based on students' perceptions, most stated they were satisfied with and enjoyed the flipped classroom format and agreed it was appropriate. Chiang and Wang (2015) evaluated the effectiveness of the flipped classroom in a Database Engineering course within a master's programme. The results showed that students in the flipped classroom performed better than those in the traditional classroom. Moreover, this method has increased students' interest in collaborative learning.

1.2 Flipped Classroom Implementation in Malaysia

In Malaysia, studies on the flipped classroom approach began in 2015 with Danker (2015), involving students in the Performing Arts at Sunway University. Before class, the students were assigned a video to watch as homework, and during class, the lecturer facilitated their learning. The results indicated that the large class was successfully transformed into an active learning environment, enabling students to receive personalised feedback during class. Another study on flipped classes by Zainuddin and Attaran (2016) at Universiti Malaya reported significant findings. It had a positive impact, especially for shy, quiet, and lower-proficiency level English language students. The application of flipped classrooms to Technical and Vocational Education and Training (TVET) students has been examined by Singh et al. (2017), and the results indicated that flipped classrooms had a positive impact on second-language learners, providing valuable enrichment with well-planned instruction. Meanwhile, another positive finding was reported by Abdullah and Azizan (2017) in their study on improving students' grades with the flipped classroom, which refined students' comprehension and overall performance.

The flipped classroom has been implemented in engineering for Structural Steel Design as part of a Bachelor of Science in Architectural Engineering programme. The students were divided into two groups: 95 were in the traditional classroom, while another 97 went through a flipped classroom (Alkhatib, 2018). The findings indicated that students' skills and performance were reflected positively in the examination and course assessments, with higher exam scores associated with more frequent use of the online lecture material than among lower-grade students. Another study using flipped classrooms in engineering subjects was conducted at Universiti Teknologi Petronas, focusing on Transport Phenomena for 54 Year 3 Chemical Engineering Degree students. The students stated that implementing flipped classrooms allowed them to learn effectively, and the performance results aligned with the students' statement, as the number of A students in examinations increased significantly (Abdullah & Azizan, 2017).

Due to the high demand for online distance learning, more researchers have evaluated the effectiveness of online flipped classrooms in maintaining high-quality education in these environments. Therefore, student feedback regarding the issues related to online flipped classrooms motivates this study. Three main issues that require attention while conducting the online flipped classroom are presented. The existing online flipped classroom method requires improvement to maintain full engagement between students and facilitators. Thus, the implementation details of an improved online flipped classroom are explained in the Methodology section.

2. METHODOLOGY

The research methodology adopted in this study is divided into three sections. The first section identifies the issues and challenges associated with online learning in engineering education, based on a student survey. The second section describes the implementation of the Synchronised Online Flipped Classroom using the proposed 3-60 Approach in the Geotechnical Engineering course. The third section presents the data collection and analysis procedures used to evaluate the effectiveness of the implemented approach.

To assess the effectiveness of the proposed approach, a mixed-method research design was adopted, incorporating both quantitative and qualitative data. Quantitative data were obtained from students' Course Outcome (CO) and Programme Outcome (PO) attainment records and compared with the performance of the previous cohort. Qualitative data were collected through a student perception survey administered at the end of the semester. The survey aimed to evaluate students' satisfaction, engagement, and perceived effectiveness of the learning approach.

2.1 Getting Feedback on Issues Related to Online Learning

A closed online survey was distributed to students to gather feedback on online learning issues. The questionnaire was constructed based on the research objectives, with reference to previous studies, and adapted to the scope and environment of this study. Four (4) questions were asked about common challenges in online learning, including limited interaction, passive participation, difficulty maintaining concentration during lengthy online sessions and internet accessibility constraints. Students were required to indicate their responses to each statement as Strongly Agree, Agree, Disagree, or Strongly Disagree. The findings supported the need for this study to improve the online learning environment in the Geotechnical Engineering subject.

The participants consisted of all students enrolled in the Geotechnical Engineering course during the implementation semester, March – August 2022. A total of 60 students from four different classes, each with 15 students who registered for this course, participated in the study. Due to the online environment, class sizes were reduced to ensure that learning sessions were controlled and effective. A census sampling approach was adopted as all registered students were invited to participate. Participation in the survey was voluntary and anonymous. Students were informed that their responses would be used solely for research purposes and would not affect their course grades. The feedback is presented in Section 3: Results and Discussion.

2.2 Implementation of Synchoronised Online Flipped Classroom: A 3-60 Approach

The instructional design was based on flipped-classroom principles, in which knowledge acquisition occurs prior to instructor-led interaction, allowing synchronous sessions to focus on clarification, discussion, and higher-order problem-solving activities.

The Synchronised Online Flipped Classroom: A 3-60 Approach was implemented in the Geotechnical Engineering course in the March-August 2022 session. This was an elective course with 3 credit hours for final-year students pursuing a Bachelor of Civil Engineering degree. During the session, 60 students enrolled in the course for that semester. There were four main topics: Two-dimensional Flow in Soils, Slope Risk Engineering, Analysis and Design of Retaining Structures, and Ground Improvement Techniques. Table 1 illustrates the mapping of course outcomes to programme outcomes and the allocation of hours based on the content for each topic.

Table 1
The Course Outcomes of the topic in Geotechnical Engineering are mapped with Programme Outcomes and allocated contact hours

Programme Outcomes (POs)	Course outcomes (COs)	Topic	Hours
PO2: Identify, formulate, research literature, and analyse complex civil engineering problems, reaching substantiated conclusions using the first principles of mathematics, natural sciences, and engineering science. Two-dimensional Flow in Soils.	CO1: Analyse seepage in 2D flow problems associated with the construction of the dam.	Two-dimensional Flow in Soils	12
	CO2: Conduct slope risk assessment analysis and propose slope protection and rehabilitation works.	Slope risk engineering	9
PO3: Design solutions for complex civil engineering problems and design systems, components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal and environmental considerations.	CO3: Analyse and design retaining structures and reinforced earth structures.	Analysis and Design of a retaining structure	12
	CO4: Propose methods of ground improvement techniques for different soil conditions.	Ground Improvement Techniques	9

The flow of the Synchronised Online Flipped Classroom implementation is shown in Fig. 1. In the Geotechnical Engineering course, three contact hours (180 minutes) were allocated in the schedule. These durations were divided into three synchronised sessions, with each session allocated 60 minutes.

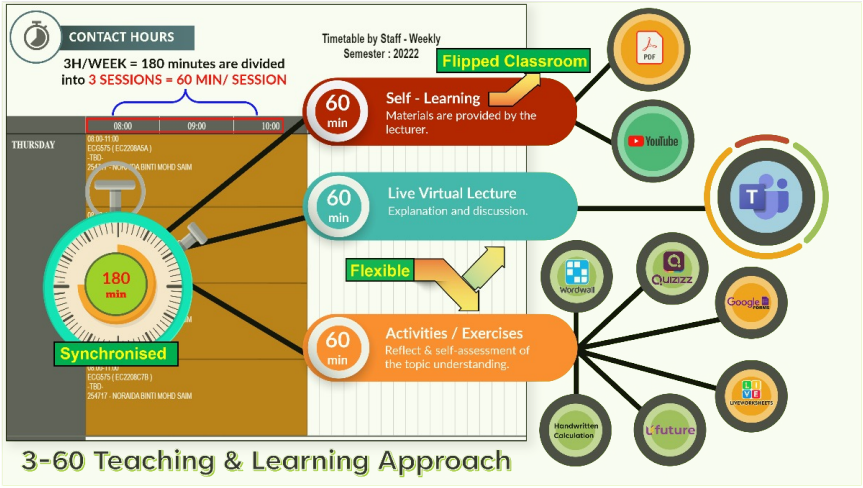

Fig. 1 *Implementation of the 3-60 Synchronised Online Flipped Classroom*

The first session, which lasts for 60 minutes, is designated for the self-review of the learning material to be discussed in the next 60-minute session. The instructor provided the learning material in an easily accessible format for students. This includes instructor-self-produced YouTube videos and notes in PDF format. WhatsApp groups and Microsoft Teams were used to share materials with students. Microsoft Teams provided facilities for forming a learning team, as illustrated in Fig. 2. This approach helps ensure that students are adequately prepared for class sessions and can actively participate in the learning process.

The second 60-minute session is a virtual lecture, as shown in Fig. 3, in which the instructor discusses and answers students' questions about topics they did not fully comprehend during their self-review in the first session. This session is more interactive since students have a basic understanding of the topic from the previous session. Additionally, problem-solving examples are demonstrated and discussed with the students. Allocating one hour to the virtual lecture allowed for a thorough discussion of various topics.

This method is more effective than asking students to prepare outside of class time, as they often report having limited time. The virtual lecture was conducted on the Microsoft Teams platform, which provides the convenience of creating a learning group to upload and share course content in various formats. The online meeting feature also allows recording of lectures for future reference, in case students need to review the material. The Channel feature further facilitated course content organisation, including the weekly lecture recordings arranged by week and topic. Hence, it provides students with easy access to the material for later reference.

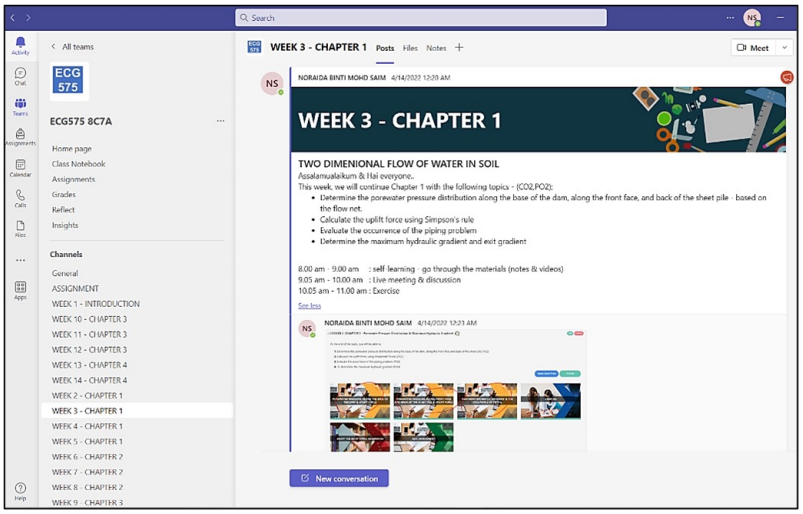

Fig. 2 *Channel in Microsoft Teams features for sharing structured material with students*

In the final 60-minute session, students had time to work through exercises related to the material covered. The exercises were provided in various formats depending on the topic discussed. For instance, written computation exercises were assigned for design- and analysis-related topics. On the other hand, for theoretical and conceptual issues, various platforms, such as Wordwall, Liveworksheet, and Google Forms, were used for interactive exercises. Fig. 4 shows an example of exercises submitted through the Microsoft Teams channel.

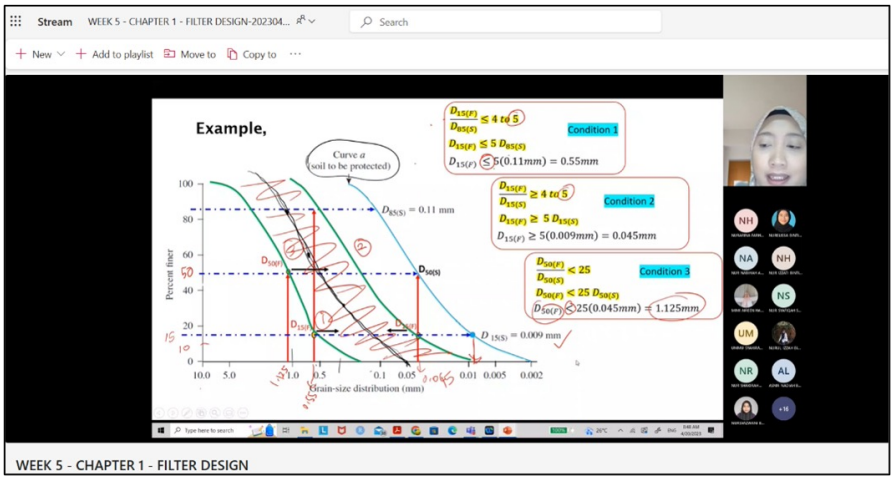

Fig. 3 *The virtual lecture was conducted during the 60-minute second session*

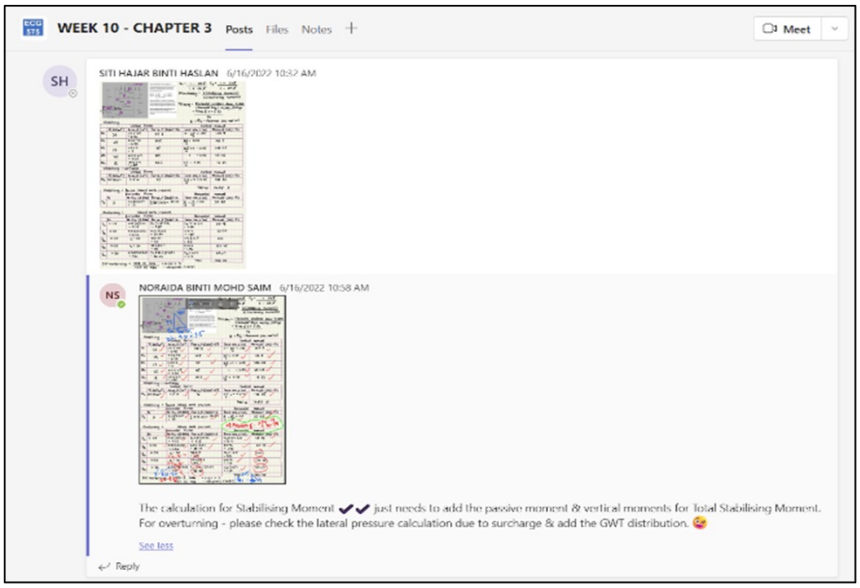

Fig. 4 *Exercise completed within 60 minutes in the third session*

In this session, students can choose whether to remain online for the meeting on Microsoft Teams while completing the exercises or to work offline. However, the instructor remains online and is also available through the WhatsApp group to assist students if they encounter any difficulties while completing the exercises. This choice provides students with greater comfort and satisfaction, as they no longer have to worry about using their internet data to stream the lecture. Furthermore, the exercises provided were carefully designed so students can complete them within one hour. This is necessary to ensure that students can comprehend the material, as they need to submit the completed exercises at the end of the three hour lecture. The instructor can then evaluate whether the students have achieved the learning outcomes. The 3-60 method provides ample time for students to prepare and engage with the learning material, thus facilitating a more effective learning process.

2.3 Effectiveness Analysis of Implementation of the Synchronised Online Flipped Classroom: A 3-60 Approach

The effectiveness of the implemented approach was assessed based on the students' satisfaction level and academic performance. Students' perceptions were gathered through a questionnaire survey administered at the end of the semester to assess their satisfaction, engagement and perceived effectiveness of the learning approach. Meanwhile, academic performance was evaluated by assessing attainment of Course Outcomes (COs) and Programme Outcomes (POs), and these were compared with those of the previous session.

An online closed questionnaire was distributed to the students to gather their feedback. The respondents were the same population mentioned in Section 2.1. The questionnaire was constructed based on the research objectives, with reference to previous studies, and adapted to the scope and context of this study. The questionnaire presented concise, easy-to-understand questions and comprised four sections. Section A contained four questions about student satisfaction when contact hours are divided into three sessions. Section B concerned student satisfaction with the use of internet data when this method is implemented. Subsequently, Section C contained five questions related to student satisfaction with the course content, the learning materials provided and the course assessment. A 5-point Likert scale was used, requiring respondents to indicate their agreement with a statement. Table 2 presents the details of the Likert scale used in the questionnaire.

Table 2
A Likert scale was used in the questionnaire

Likert scale	Likert scale description
1	Very dissatisfied (VD)
2	Dissatisfied (D)
3	Neutral (N)
4	Satisfied (S)
5	Very satisfied (VS)

Meanwhile, the students' performance was compared to that of the previous semester (March-August 2021), which did not employ a method similar to the one used in the March-August 2022 semester. A comparative analysis of CO and PO attainment was conducted to examine trends in students' academic achievement following the implementation of the 3-60 Approach.

The data collected from the questionnaire and students' attainment were analysed using the Analysis ToolPak in Microsoft Excel. Descriptive analysis, including mean scores, standard deviation, and percentages, was conducted. The combined analysis of perception and performance data provided a comprehensive evaluation of the effectiveness of the proposed learning strategy.

3. RESULTS AND DISCUSSION

The results present the issues and challenges associated with online learning, as identified through the student survey, together with students' satisfaction with the implementation of the Synchronised Online Flipped Classroom using the 3-60 Approach in the Geotechnical Engineering course. Moreover, the effectiveness of the approach was also evaluated based on students' academic performance, as reflected in the attainment of Course Outcomes (COs) and Programme Outcomes (POs), and these outcomes were analysed and discussed.

3.1 Feedback on Issues Related to Online Learning

The online flipped classroom is typically conducted asynchronously, with students reviewing course materials before class. However, for the Geotechnical Engineering course, the online flipped classroom has been adapted to be conducted synchronously during class hours, with each contact session lasting three hours. This was conducted in response to feedback from students who had to attend online classes continuously from morning until the final afternoon session. Several issues were identified as the driving force for improving the online flipped classroom.

Fig. 5 illustrates the students' responses regarding online learning. Students expressed three main concerns. Firstly, there is difficulty maintaining focus during online classes lasting 2-3 hours. Approximately 86.7% of the students lost focus after the first hour, resulting in a passive online learning environment in which the instructor talks without receiving any student responses. This observation is consistent with Mukhtar et al. (2020), who noted that students navigate learning demands alongside other home-based activities. Besides, the prolonged online learning sessions often make students feel isolated and burnt out due to the lack of social interaction (Meena et al., 2023)

Secondly, more than 90% of students expected the instructors to provide more interactive and engaging online activities to prevent boredom and maintain focus during online learning. Studies conducted by Mukhtar et al. (2020) and Meena et al. (2023) showed that shorter, more interactive sessions can help maintain student attention and enhance learning outcomes.

Thirdly, the high internet data consumption is associated with attending multiple online lectures throughout the semester. The internet data usage for extended online streaming (almost 8 hours per day across four courses, with at least 2 hours per session) was a concern for 70% of the students because of the cost of internet subscriptions. Substantial internet data usage results in additional financial commitments for data subscriptions. This aligns with findings from various studies in which students reported that expensive data subscriptions significantly limited their ability to engage in online learning (Salifu & Owusu-Boateng, 2022). This issue highlights the importance of designing online learning activities that are not only pedagogically effective but also mindful of students' technological and financial constraints.

The findings suggest that prolonged lecture sessions, limited interaction, and concerns about internet accessibility were among the major challenges faced by students during online learning. These issues justify the need for alternative instructional strategies, such as the Synchronised Online Flipped Classroom and the proposed 3-60 Approach, which aim to promote active engagement, improve learning effectiveness, and optimise the use of online learning time.

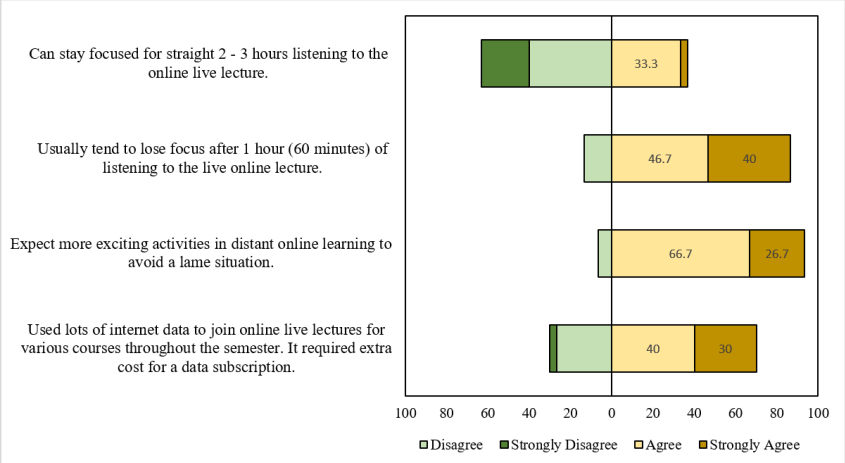

Fig. 5 *Issues related to online learning*

3.2 Satisfaction Towards the Implementation of the Synchronised Online Flipped Classroom: A 3-60 Approach

Table 3 presents the results of the questionnaire analysis regarding satisfaction with the implemented approach. The mean score for the effectiveness of session division was 4.23, indicating a positive reception of the implemented approach. The distribution of satisfaction levels further elucidated these findings, with 63.3% of students being satisfied with the implemented teaching and learning methods and 30% being very satisfied. This indicates that almost all students (93.3%) perceived the implemented approach as effective and relevant for online learning.

Table 3
Satisfaction with the implementation of 3-60 Synchronised Online Flipped Classrooms

Statement	Mean	SD	VD (%)	D (%)	N (%)	S (%)	VS (%)
The approach implemented by dividing the lecture hours into THREE (3) sessions is more effective and relevant.	4.23	0.57	0.0	0.0	6.7	63.3	30.0
Self-learning within the first 60 minutes provides students with an overview of the topic.	4.47	0.68	0.0	3.3	0.0	43.3	53.3
A 60-minute virtual lecture session for explanation and discussion is sufficient, as I have reviewed the material earlier. Additionally, I can stay focused during the lecture because the duration is reasonable and I already have an idea of the topic, which makes it more engaging to listen to and ask questions.	4.17	0.87	3.3	3.3	0.0	60.0	33.3
An additional 60 minutes is allocated for activities designed to enhance students' understanding. The lecturer stays online to facilitate the students. This session helped to improve my knowledge of the topic. I can complete the exercise without being online; instead, I can do it offline and then submit it to the platform later.	4.27	0.78	0.0	6.7	0.0	40.0	53.3

Note: SD = Standard Deviation, VD = Very Dissatisfied, D = Dissatisfied, N = Neutral, S = Satisfied, VS = Very Satisfied

Additionally, the allocated 60-minute time slot for each session was observed to have significantly facilitated the teaching and learning process. When students were given time to review the content before discussions and subsequently test their understanding through provided exercises, the entire three-hour duration was utilised effectively.

The first 60 minutes were highly significant for the students, with 96.6% expressing satisfaction and high satisfaction with the first session. Besides, the mean score of 4.47 also indicates positive feedback. Students had adequate and appropriate time to pre-read the material and mark down points they do not understand, which can be discussed in the subsequent online lecture session. By incorporating self-learning sessions within class time, instructors can create a more dynamic and responsive learning environment that encourages students to engage in peer-to-peer learning and discussion. At the same time, this approach addresses the issue that online teaching often struggles to sustain student interest and participation, resulting in passive learning experiences (Ortigosa & Planells, 2020).

Moreover, 93.3% of students reported being satisfied and very satisfied, indicating that the second session greatly benefited them and helped maintain their focus. With some preparations made by the students during the initial 60 minutes, the effectiveness of the online lecture session is enhanced when two-way communication is facilitated, allowing them to follow the material in class during the virtual session. The students actively ask questions when topics require clarification. Additionally, the allocated time was sufficient as the students continue to inquire about the challenging aspects.

Furthermore, in the third session, the students favoured allocating 60 minutes to complete the exercise to evaluate and enhance their understanding of the topics covered. The mean score of 4.27 indicates that students expressed satisfaction with this session. With well-structured exercises, students completed the tasks within the allocated time. Students also felt more comfortable having the option to stay in the online session or complete the exercises offline. This indirectly helps minimise students' internet data usage. Meanwhile, the lecturer was always ready to assist with any questions about the exercises provided.

3.3 Satisfaction due to Internet Utilisation.

Fig. 6 shows the satisfaction level towards internet utilisation upon implementing a 3-60 synchronised online flipped classroom setting for a Geotechnical Engineering course. A significant majority (70%) of students were satisfied that internet data usage was reasonable and acceptable. A further 23% of students reported being very satisfied, demonstrating overall satisfaction with internet data usage in the course. This response was attributed to the option allowing students to fully participate live during either the second or third 60-minute sessions, or only during the second session, which is a virtual online meeting. Consequently, internet data usage could be reduced.

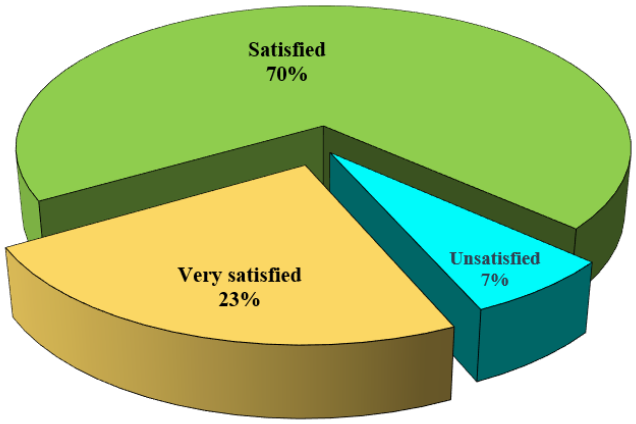

Fig. 6 *Satisfaction with Internet data usage in implementing Synchronised Online Flipped Classrooms: 3-60 Approach*

Moreover, the 3-60 approach directly addresses inequality related to the financial burden of accessing the internet. The high cost of data usage disproportionately affects students from lower socioeconomic backgrounds, who often struggle to afford reliable and affordable internet access for their online courses (Salifu & Owusu-Boateng, 2022). By offering the option to participate in shorter 60-minute virtual online lectures instead of the typical 180-minute continuous sessions, the 3-60 approach significantly reduces the amount of data needed. This makes online learning more financially accessible and fair for all students. Besides addressing the cost of data usage, this approach also helps to keep students engaged by breaking the learning process into more manageable segments. This is especially helpful when dealing with attention-span limitations, which can be exacerbated during long online sessions. Therefore, the 3-60 approach eases financial pressure and creates a more inclusive and effective learning environment.

3.4 Satisfaction Regarding the Course Content, Materials and Lesson Activities.

Table 4 presents findings on student satisfaction with the course content, learning materials, and lesson activities. The data indicate high overall satisfaction across all three aspects, with mean scores ranging from 4.33 to 4.37 and standard deviations from 0.48 to 0.49, suggesting low variability in student responses.

A substantial majority (66.7%) reported satisfaction with the alignment of materials to course outcomes, while 63.3% of students expressed satisfaction with the clarity and comprehensibility of the learning materials.

Table 3
Satisfaction with the implementation of 3-60 Synchronised Online Flipped Classrooms

Question statement	Mean	*SD*	*VD (%)*	*D (%)*	*N (%)*	*S (%)*	*VS (%)*
I found the materials relevant to the course outcomes.	4.33	0.48	0.0	0.0	0.0	66.7	33.3
I found the course materials easy to understand and follow.	4.37	0.49	0.0	0.0	0.0	63.3	36.7
I found the lesson activities are structured.	4.37	0.49	0.0	0.0	0.0	63.3	36.7

Note: *SD* = Standard Deviation

Similarly, the structured nature of the lesson activities was well received, with 63.3% of students reporting satisfaction and 36.7% expressing high satisfaction, highlighting the effectiveness of the lesson structure. Overall, these findings demonstrate that the course design effectively supported students' learning outcomes.

Research shows that well-organised course design and comprehensive material enhance the overall learning experience in online education. Chen (2022) reveals that thoughtfully planned delivery methods in lesson activities can significantly increase student engagement and provide a more coherent learning path. Similarly, Kim et al. (2021) found that a well-structured flipped learning environment led to higher student satisfaction than traditional lecture formats, highlighting the value of strategic course design. In addition, the quality of materials provided also significantly influences student satisfaction, as reported by Kanagaraj et al. (2022). This emphasises that access to various learning resources, such as interactive tools and digital content, can foster collaborative learning. Additionally, students are more likely to achieve course objectives and have a positive experience. Furthermore, Ghaderizefreh and Hoover (2018) found that clear course objectives and expectations directly impact student satisfaction. Therefore, the regular exercises in the third session help students gauge their understanding of the material, fostering a sense of accomplishment and increased engagement in achieving the course outcomes.

3.5 Effectiveness Based on The Student's Performance.

The effectiveness of the 3-60 Synchronised Online Flipped Classroom method was also measured by students' performance. The focus is on analysing the attainment of the Course Outcomes (COs) and Programme Outcomes (POs). Student achievement for the semester in which this method was implemented (March-August 2022) is compared with student achievement for the semester in which this method was not implemented (March–August 2021). While improvements were observed in CO and PO attainment, the comparison between the 2021 and 2022 cohorts should be interpreted cautiously. Differences in student characteristics, learning environments and assessment conditions may have contributed to the observed variations.

Fig. 7 compares the mean CO attainment scores between the March to August 2021 and March to August 2022 semesters. The chart reveals a noticeable improvement in student performance during the 2022 semester. Across all four course outcomes (CO1, CO2, CO3, and CO4), the mean scores for 2022 consistently exceed those of 2021. This indicates that students in the March to August 2022 cohort attained higher levels of achievement in each course outcome. This improved attainment suggests that the improved online flipped classroom may have positively impacted student learning and performance.

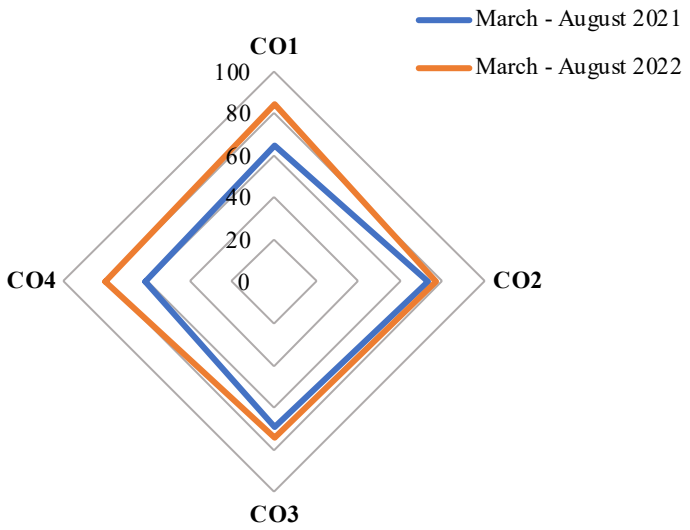

Fig. 7 *Comparison of the mean score for CO attainments*

Furthermore, Fig. 8(a) – (d) illustrates a comparative analysis of CO attainment between the March-August 2021 and March-August 2022 semesters. The results show trends in student performance across CO1, CO2, CO3, and CO4, indicating improvements and areas that may need further attention.

During the March-August 2022 semester, a noticeable improvement in student performance was observed across multiple course outcomes (COs). For CO1, more students achieved higher marks in the 80-89 and 90-100 ranges than in 2021, when most students scored between 60-64 and 75-79. This reflects an apparent improvement in understanding and application.

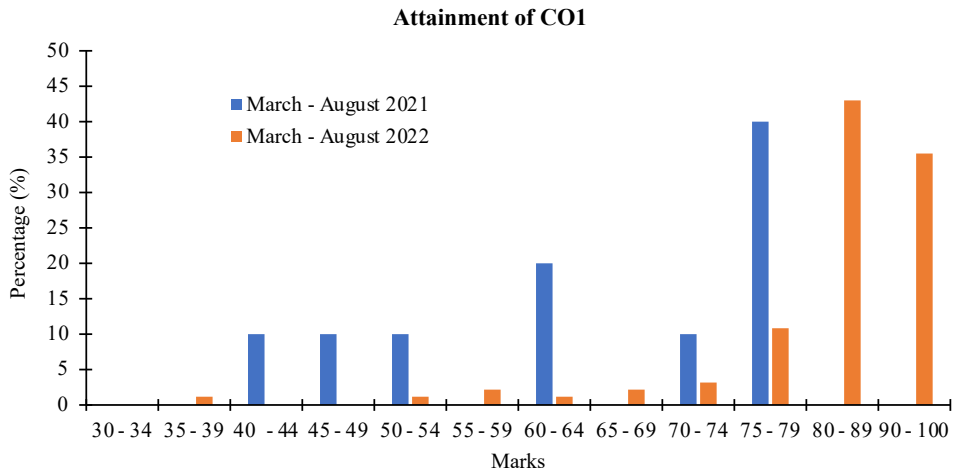

Fig. 8(a) *Comparison of the CO1 Attainments*

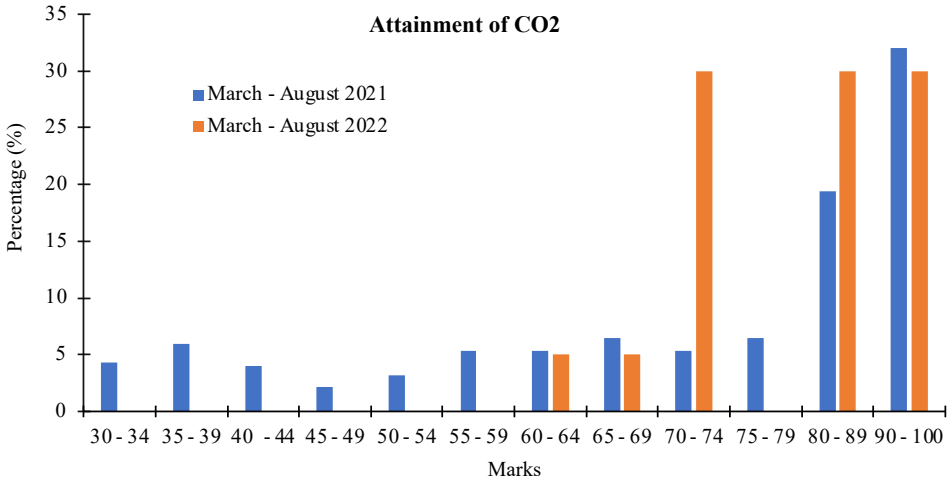

Fig. 8(b) *Comparison of the CO2 Attainments*

Similarly, CO2 saw substantial progress, with all students scoring above 50 marks in 2022 and a majority within the 70-74 and 80-100 ranges, indicating a significant improvement in meeting and exceeding minimum competency levels.

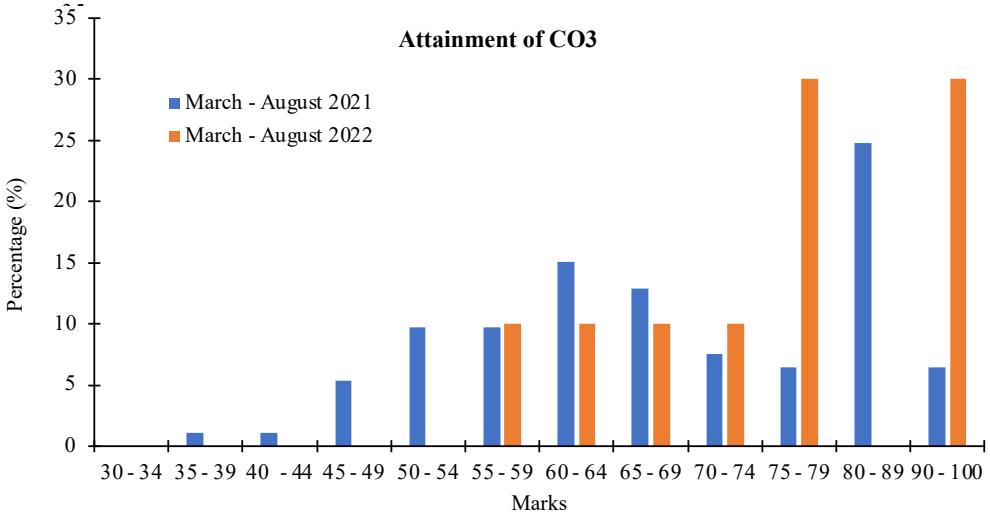

Fig. 8(c) *Comparison of the CO3 Attainments*

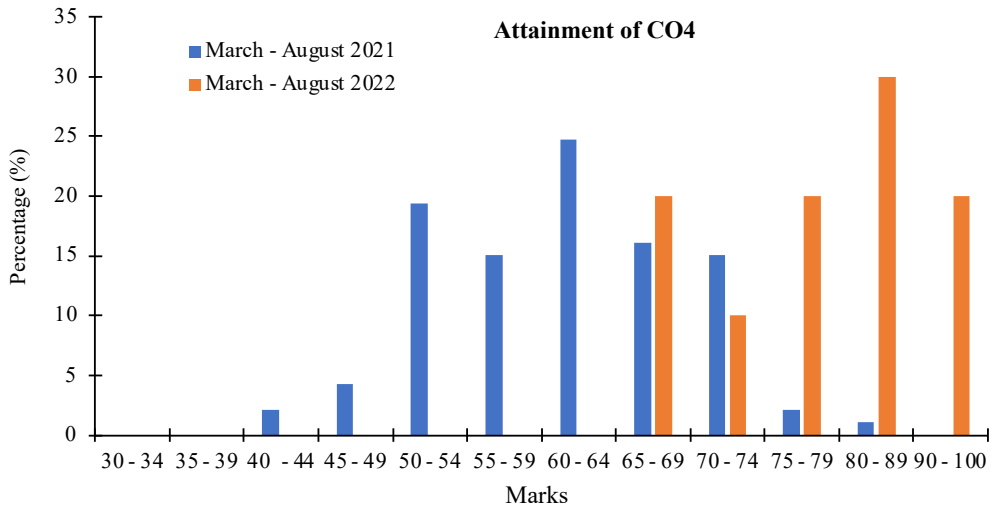

Fig. 8(d) *Comparison of the CO4 Attainments*

For CO3, while the 2021 cohort was mainly concentrated in the 55-69 and 80-89 ranges, the 2022 cohort showed an increase in students scoring in the 75-79 and 90-100 ranges, with no students scoring below 50 marks. This suggests a marked enhancement in student attainment. In CO4, most students in 2022 scored above 65 marks, with a significant concentration in the 80-89 range, compared to a broader distribution in 2021.

Overall, the data indicate that the March-August 2022 semester outperformed the previous year across all the course outcomes. Therefore, the results suggest that the teaching and learning interventions implemented by the Synchronised Online Flipped Classroom: 3-60 Approach successfully improved student performance and the ability to achieve course outcomes.

In addition, Fig. 9(a) – (b) shows a clear improvement in Programme Outcome (PO) attainment for PO2 and PO3 between the March-August 2021 and March-August 2022 semesters. For PO2, the 2022 cohort had a higher percentage of students achieving marks in the 60-64, 70-74, and 80-89 ranges compared to the 2021 cohort. A similar positive trend was observed for PO3, with a significant increase in the 80-89 and 90-100 ranges in 2022, while 2021 scores were more widely distributed below these levels. This improvement may be attributed to have resulted from allocating a 60-minute session to complete exercises in the third session, which included guided problem-solving. This structure provided students with direct support and reduced the risk of incomplete submissions when they were asked to complete exercises outside class time. This approach also reduced the likelihood of students postponing revision until immediately before the examinations.

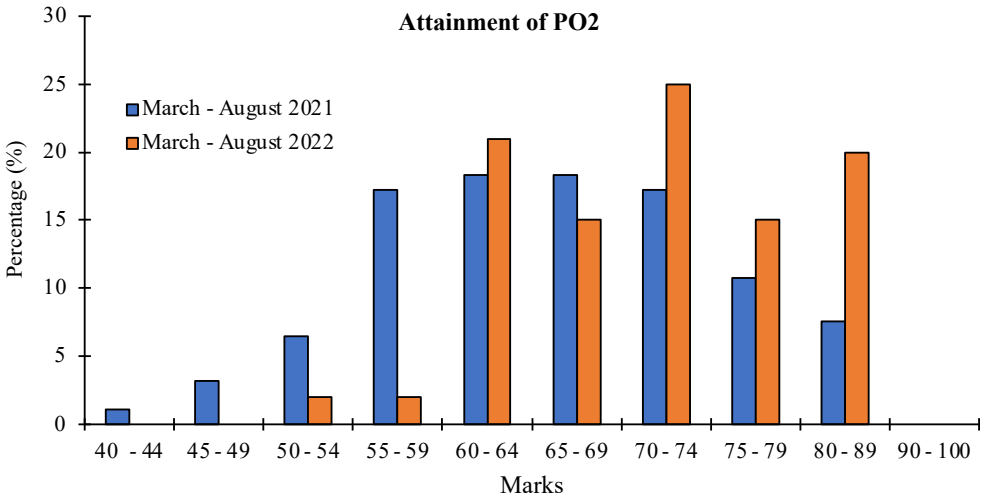

Fig. 9(a) *Comparison of the PO2 Attainments*

The implementation of online flipped classrooms has been shown to improve students' academic attainments in Geotechnical Engineering. This teaching method emphasises active learning and student involvement. It allows students to review instructional materials during the initial 60 minutes of a class session before the virtual lecture, maximising the effectiveness of in-class time for collaborative and interactive activities. Enhancements in students' performance were similarly reported by Zhang et al. (2023), who implemented a flipped-classroom-based learning approach for teaching Hydrology Engineering. It was found that the average score on the final exam for this course improved, and the failure rate decreased.

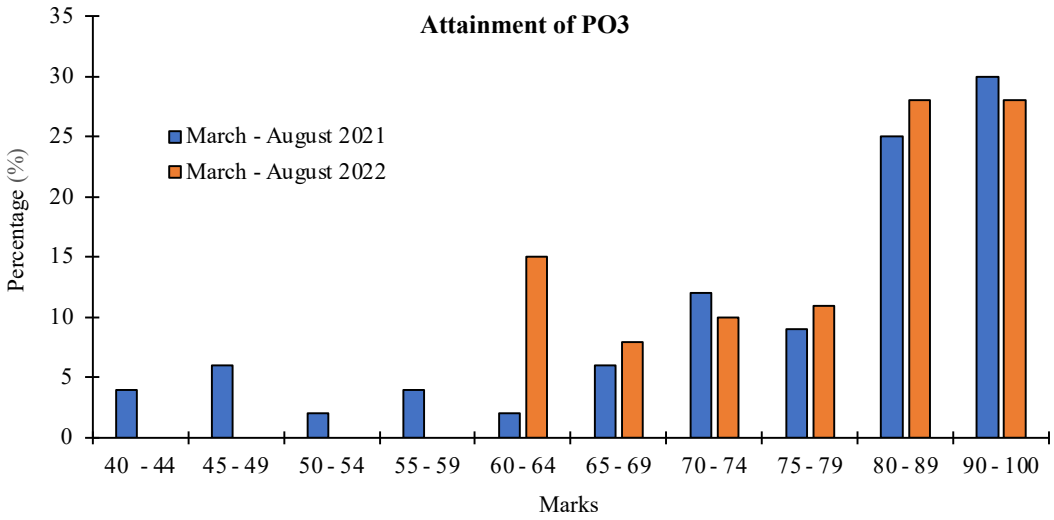

Fig. 9(b) *Comparison of the PO3 Attainments*

Overall, the Synchronised Online Flipped Classroom model using the 3-60 approach has demonstrated significant potential to improve students' academic attainment. By promoting active learning, critical thinking, and self-regulation, this approach enhances student engagement and satisfaction, ultimately leading to better educational outcomes.

Based on the marks attained, the results seem to indicate that the 2022 cohort outperformed the 2021 cohort. Thus, a t-test was conducted to assess whether there was a significant difference in performance, between the two cohorts following implementation of the Synchronised Online Flipped Classroom using the 3-60 Approach. The t-test was performed for each CO and PO to compare the performance of the 2021 and 2022 cohorts, with the null hypothesis (Ho) with the null hypothesis (H_O) that the performance of the 2021 and 2022 cohorts was equivalent. The results obtained through the t-test correlation coefficient should be able to fulfil one of the following hypotheses:

Ho: There is no significant difference in CO and PO attainment (p-value more than 0.05).
H_1: There is a significant difference in CO and PO attainment (p-value less than 0.05)

Table 5
Comparison of Course Outcome (CO) attainment between the 2021 and 2022 cohorts using t-tests

CO	Mean (2021)	Mean (2022)	t-Statistic	t-Critical	p	Result
CO1	63.27	84.19	4.574	2.26	0.0013	H_1
CO2	72.78	76.52	0.588	2.23	0.5695	H_o
CO3	68.81	71.37	-0.506	2.26	0.6707	H_o
CO4	61.22	79.78	-5.169	2.26	0.0005	H_1

Table 6
Comparison of Course Outcome (PO) attainment between the 2021 and 2022 cohorts using t-tests

PO	Mean (2021)	Mean (2022)	t-Statistic	t-Critical	p	Result
PO2	65.31	67.97	-0.631	2.22	0.542	H_o
PO3	77.08	80.87	0.921	2.20	0.376	H_o

According to Table 5, the analysis revealed statistically significant differences for CO1 and CO4 at p-values < 0.05. No statistically significant differences were observed for CO2 (p = 0.570) and CO3 (p = 0.614). Furthermore, the results indicated no statistically significant differences between the 2021 and 2022 cohorts for both PO2 and PO3, as shown in Table 6. These findings suggest that implementing the Synchronised Online Flipped Classroom through the 3-60 Approach maintained consistent attainment of programme outcomes across cohorts while improving selected course outcomes, particularly those related to CO1 and CO4. Such results support the effectiveness of the approach in enhancing specific aspects of student learning without compromising broader programme-level achievements.

A closer examination of the results reveals an interesting pattern. While significant improvements were observed in CO4, which is associated with higher-order cognitive skills such as problem-solving and application of engineering concepts, no significant changes were detected for CO2 and CO3. This may indicate that the 3-60 Approach was particularly effective in supporting active learning and knowledge application through its structured problem-solving session during the final 60 minutes of each class. The opportunity for students to engage in guided exercises and discussions may have enhanced their ability to apply theoretical concepts to engineering problems, leading to improved attainment in outcomes that require deeper understanding and analytical thinking.

The significant difference observed in CO1 should, however, be interpreted with caution. Although the statistical analysis indicates a meaningful difference between cohorts, the change cannot be attributed solely to the implementation of the 3-60 Approach. Factors such as variations in student academic backgrounds, cohort characteristics, assessment difficulty, learning motivation, and external learning environments may also have influenced student performance. Since the study compared two different cohorts rather than tracking the same group of students over time, the possibility of cohort effects cannot be excluded. Therefore, the findings should be viewed as evidence of an association rather than definitive proof of causality.

The absence of significant differences in PO2 and PO3 may also be influenced by the mapping of course outcomes: PO2 encompasses CO1 and CO2, while PO3 encompasses CO3 and CO4, which is equally noteworthy. Consequently, substantial changes in programme-level attainment may not be immediately observable after implementing a new teaching strategy in a single course. Nevertheless, the fact that programme outcome attainment was maintained while introducing a different instructional approach suggests that the Synchronised Online Flipped Classroom through the 3-60 Approach was able to support student learning without compromising the broader educational objectives of the programme.

Overall, the findings align with the principles of flipped learning, which emphasise student-centred learning, self-regulation and active engagement. The first 60-minute self-learning component encourages students to take responsibility for their learning, while the live discussion and problem-solving sessions provide opportunities for interaction, clarification and application of knowledge. This structure may help address common challenges associated with online learning, such as reduced attention span, passive participation, and limited interaction, as identified earlier in the study. Despite these encouraging findings, several limitations should be acknowledged.

4. LIMITATION AND RECOMMENDATION

This study acknowledges a limitation and offers recommendations for future research, including:

(i) The study focuses solely on a single course, Geotechnical Engineering, which may not fully represent the Bachelor of Civil Engineering programme. To enhance the generalisability of the findings, it is recommended that future studies expand the scope to include multiple courses within the program.
(ii) In addition, the comparison between cohorts may have been influenced by differences in assessment design, student characteristics, and learning environments.
(iii) Another limitation relates to the maturity level of the students, as the study was conducted among final-year students who are generally more independent, self-regulated and accustomed to managing their own learning. Such characteristics may have contributed positively to the effectiveness of the Synchronised Online Flipped Classroom: 3-60 Approach. Therefore, the findings may not be directly applicable to early-stage undergraduate students who are still adapting to university learning and may require greater instructional guidance.
(iv) Further research is also recommended to investigate its suitability for lower-semester students and fundamental engineering courses, where students may possess different learning needs, levels of academic maturity and readiness for self-directed learning.

5. CONCLUSION

Based on the findings, the objectives of this study were successfully achieved by evaluating the effectiveness of the Synchronised Online Flipped Classroom implemented through the 3-60 Approach in the Geotechnical Engineering course. The division of a three-hour lecture into three structured 60-minute sessions comprising self-learning, live discussion and problem-solving activities effectively addressed several challenges associated with online learning, including reduced attention spans, passive participation and limited interaction. The approach was well received by students, with 93.3% expressing satisfaction and perceiving it as an effective and relevant learning method.

The analysis of students' academic performance further supports the effectiveness of the proposed approach. Statistical analysis using t-tests revealed significant differences in CO1 and CO4 attainment between the 2021 and 2022 cohorts ($p < 0.05$), while no significant differences were observed for CO2, CO3, PO2, and PO3. These findings indicate that the approach contributed to improvements in selected course outcomes, particularly those associated with conceptual understanding and problem-solving skills, while maintaining consistent programme outcome attainment across cohorts. The results also suggest that the approach can enhance student engagement and self-directed learning without compromising broader programme-level educational objectives.

Overall, the Synchronised Online Flipped Classroom through the 3-60 Approach offers a practical and effective framework for online engineering education. The findings provide valuable insights for educators seeking to design engaging and student-centred online learning environments. Future research should explore the applicability of this approach across academic disciplines, lower-semester students, and fundamental courses to further validate its effectiveness.

6. ACKNOWLEDGEMENTS

The authors are grateful to all participants in the study, specifically the students of the Bachelor in Civil Engineering (Semester 7/8), Session I, 2022/2023, Universiti Teknologi MARA, Shah Alam, Selangor.

7. FUNDING

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

8. AUTHORS' CONTRIBUTIONS

Noraida Mohd Saim: Conceptualisation, conducted formal analysis, interpreted the results and wrote the discussion, writing the original draft; Nur Asmaliza Mohd Noor: Prepared the literature review and edited the manuscript; Rohaya Alias: Carried out the questionnaire, distributed it to the respondents (investigation) and wrote the research methodology.

9. CONFLICT OF INTEREST DECLARATION

We certify that the article is the Authors' original work. The article has not received prior publication and is not under consideration for publication elsewhere. This manuscript has not been submitted for publication, nor has it been published in whole or in part elsewhere. We testify to the fact that all authors have contributed significantly to the work, validity and legitimacy of the data and its interpretation for submission to IJELHE.

10. DECLARATION OF GENERATIVE AI IN THE WRITING PROCESS

During the preparation of this work, the authors used ChatGPT (OpenAI), Scite AI and Grammarly to support the writing and revision process. ChatGPT was used to assist with language refinement, manuscript organisation, drafting and improving academic text and enhancing the clarity of explanations and discussions. Scite AI was used to support the literature review process by identifying relevant scholarly publications, evaluating citation contexts and verifying the supporting evidence for academic claims. Grammarly was used to improve grammar, spelling, punctuation, readability, and overall language quality of the manuscript. After using these tools, the authors carefully reviewed, verified and edited all content as necessary and take full responsibility for the accuracy, integrity and originality of the published work.

11. DATA AVAILABILITY/SUPPLEMENTARY MATERIALS

(i) Available upon request: The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.
(ii) Data included in the article: All data generated or analysed during this study are included in this published article.

12. REFERENCES

Abdullah, B., & Azizan, M.T. (2017). A Flipped Classroom Technique in Improving Students' Grade of Transport Phenomena Course". In 2017 7th World Engineering Education Forum (WEEF), pp. 279-284. IEEE. https://doi.org/10.1109/WEEF.2017.8467163

Ab Latif, A., Mohd Latib, F. W., Nazarudin, A., Bachok, M. F., & Othman, Z. (2021). Issues and challenges of online learning during covid-19. *Gading Journal for Social Sciences, 24*(4), 43–48. https://ir.uitm.edu.my/id/eprint/56838

Alkhatib, O. J. (2018). An interactive and blended learning model for engineering education", *Journal of Computers in Education, 5*(1), 19-48. https://doi.org/10.1007/s40692-018-0097-x.

Bergmann, J., & Sams, A. (2012). Flip your classroom: Reach every student in every class every daily, 1st ed. *International Society for Technology in Education*. https://doi.org/10.1111/teth.12165

Chen, L. (2022). Designing online discussion for HyFlex learning. *International Journal of Educational Methodology, 8*(1), 191–198. https://doi.org/10.12973/ijem.8.1.191

Chiang, Y.H. & Wang, H.C. (2015). Effects of the in-flipped classroom on the learning envi-ronment of database engineering", *International Journal of Engineering Education, 31*(2), 454-460. https://www.researchgate.net/publication/282242281_Effects_of_the_In-flipped_Classroom_on_the_Learning_Environment_of_Database_Engineering

Danker, B. (2015). Using flipped classroom approach to explore deep learning in large classroom. *IAFOR Journal of Education, 3*(1), 171-186. https://files.eric.ed.gov/fulltext/EJ1100618.pdf

Demirel, E.E. (2016). Basics and key principles of flipped learning: Classes upside down. *International Journal of Languages, Literature and Linguistics, 2*(3), 109-112. doi.org/10.18178/ijlll.2016.2.3.77

Divjak, B., Rienties, B., Iniesto, F., Vondra, P., & Žižak, M. (2022). Flipped classrooms in higher education during the COVID-19 pandemic: findings and future research recommendations. *International Journal of Educational Technology in Higher Education, 19*(1). doi.org/10.1186/s41239-021-00316-4

Fulton, K. (2012). The Flipped Classroom: Transforming Education at Byron High School: A Minnesota High School with Severe Budget Constraints Enlisted YouTube in Its Suc-cessful Effort to Boost Math Competency Scores", T.H.E. *Journal Technological Hori-zons in Education, 39*, 18. Retrieved from The Free Library. https://www.thefreelibrary.com/The+flipped+classroom%3a+transforming+education+at+Byron+High+School%3a+a...-a0289214915

Ghaderizefreh, S., & Hoover, M. L. (2018). Student satisfaction with online learning in a blended course. *International Journal of Digital Society, 9*(3), 1393–1398. doi.org/10.20533/ijds.2040.2570.2018.0172

Hagen, E. J., & Fratta, D. (2014). Hybrid Learning in Geological Engineering: Why, How, and to What End? Preliminary Results. *In Geo-Congress 2014: Geo-characterization and Modeling for Sustainability*, pp. 3920-3929, 2014. https://doi.org/10.1061/9780784413272.380

Haghi, M. (2020). The effective integration of flipped classroom in ELT contexts: A review of recent literature. *2nd MEC TESOL Conference*. https://dx.doi.org/10.24093/awej/MEC2.9

Hung, L.N.Q. (2022). EFL students' perceptions of online flipped classrooms during the covid-19 pandemic and beyond. *International Journal of Learning, Teaching and Educational Research, 21*(9), 460-476. doi.org/10.26803/ijlter.21.9.25

Jia, C., Hew, K.F., Jiahui, D., & Liuyufeng, L. (2023). Towards a fully online flipped class-room model to support student learning outcomes and engagement: A 2-year design-based study. *The Internet and Higher Education*, 56, 100878. https://doi.org/10.1016/j.iheduc.2022.100878

Kanagaraj P, Sakthivel R, Christhumary PC, et al. (2022). Nursing Student's Satisfaction With Virtual Learning During COVID-19 Pandemic in India. SAGE Open Nursing;8. doi:10.1177/23779608221144933

Kim, T.H., Kim, J.S., Yoon, H.I. et al. (2021). Medical student education through flipped learning and virtual rotations in radiation oncology during the COVID-19 pandemic: a cross sectional research. *Radiation Oncology 16*, 204. doi.org/10.1186/s13014-021-01927-x

Lee, J.W., (2020). The roles of online instructional facilitators and student performance of online class activity. *Journal of Asian Finance, Economics and Business, 7*(8), 723–733. https://doi.org/10.13106/jafeb.2020.vol7.no8.723

Li, Y. & Daher, T. (2016). Integrating innovative classroom activities with flipped teaching in a water resources engineering class. *Journal of Professional Issues in Engineering Education and Practice. 143*(1), 1-6. https://doi.org/10.1061/(ASCE)EI.1943-5541.0000297

Mavromihales, M., & Holmes, V. (2016) Delivering manufacturing technology and workshop appreciation to engineering undergraduates using the flipped classroom approach. *International Journal of Mechanical Engineering Education, 44*(2), 113-132. https://doi.org/10.1177/0306419016637487

McClelland, C. J. (2013). Flipping a Large Enrollment Fluid Mechanics Course–Is it Effective?" *In 2013 ASEE Annual Conference & Exposition*, pp. 23.607.1 - 23.607.9. https://doi.org/10.18260/1-2--19621

Merrett, C.G,. (2023). Analysis of flipped classroom techniques and case study based learning in an introduction to engineering materials course. *Advances in Engineering Education, 11*, 2-29. doi.org/10.18260/3-1-1153-36038

Meena S., Arvind Kumar, Asha Bala, Sayali Pataskar, Ram Baja. (2023). Analysing Faculties Perspective towards Psychological Outcomes of Online Education. *Tuijin Jishu/Journal of Propulsion Technology, 44*(4), 455-461. doi.org/10.52783/tjjpt.v44.i4.862

Milman, N, "The flipped classroom strategy: What is it and how can it be used?" in *Distance Learning, Vol.17*, Iss. 4, 71-72, 2022. https://www.researchgate.net/publication/311396228_The_flipped_classroom_strategy_What_is_it_and_how_can_it_best_be_used

Monzonis, N. C., Mendez, V. G., Ariza, A. C., & Magana, E. C. (2020). Flipped classroom in COVID-19 times: a cross-talking perspective. IJERI: *International Journal of Educational Research and Innovation*, (15), 326–341. doi.org/10.46661/ijeri.5439

Mukhtar, K., Javed, K., Arooj, M., & Sethi, A. (2020). Advantages, Limitations and Recommendations for online learning during COVID-19 pandemic era: Online learning during COVID-19 pandemic era. *Pakistan Journal of Medical Sciences, 36*(COVID19-S4). doi.org/10.12669/pjms.36.COVID19-S4.2785

November, A., & Mull, B (2012). Flipped learning: a response to five common criticisms. *Education Technology Solutions*. n.50 p.42-44,46; October/November 2012, (50), 42–44,46. https://search.informit.org/doi/10.3316/aeipt.198860

Ortigosa-Blanch, A. and Planells-Artigot, E. (2020). Peruse this! use of an educational social platform for a global entrepreneurship flipped class. In Proceedings INNODOCT/20. *International Conference on Innovation, Documentation and Education* (pp. 111-119). Editorial Universitat Politècnica de València. doi.org/10.4995/inn2020.2020.11855

Persky, A.M., & McLaughlin, J.E. (2017). The flipped classroom-from theory to practice in health professional education. *American Journal of Pharmaceutical Education, 81*(6), 118. https://doi.org/10.5688/ajpe816118

Rechenmacher, A.L. (2020). Emphasizing Underlying Science in Geotechnical Education through Flipped Classroom. *Geo-Congress 2020: Geotechnical Earthquake Engineering and Special Topics*, pp. 702-710. doi.org/10.1061/9780784482810.073

Saterbak, A., Volz, T., & Wettergreen, M. (2016). *Implementing and assessing a flipped classroom model for first-year engineering design*. Adv. Eng. Educ. 5, n3. https://www.researchgate.net/publication/312095304_Implementing_and_assessing_a_flipped_classroom_model_for_first-year_engineering_design

Singh, H., Jaswant, S., Singh, C. K. S., Mohtar, T. M. T., & Mostafa, N. A. (2017). A Review of Research on Flipped Classroom Approach for Teaching Communication Skills in English", *International Journal of Academic Research in Business and Social Sciences, 7*(10). https://doi.org/10.6007/IJARBSS/v7-i10/3362

Smith, E., & Boscak, A. (2021). A virtual emergency: Learning lessons from remote medical student education during the COVID-19 pandemic. *Emergency Radiology, 28*, 445-452. doi.org/10.1007/s10140-020-01874-2

Salifu, A. S., & Owusu-Boateng, O. (2022). Evaluating the Media Platforms, Devices and Challenges Associated with Online Teaching and Learning of Mathematics during the COVID-19 Pandemic. *Asian Research Journal of Mathematics, 18*(10), 92–104. doi.org/10.9734/arjom/2022/v18i1030420

Schmidt, S.M., & Ralph, D.L., "The flipped classroom: A twist on teaching", *Contemporary Issues in Education Research, 9*(1), 1-6, 2016. https://doi.org/10.19030/cier.v9i1.9544

Zainuddin, Z., & Attaran, M. (2016). *Malaysian students' perceptions of the flipped classroom: a case study", Innovations in Education and Teaching International, 53*(6), 660–670. https://doi.org/10.1080/14703297.2015.1102079

Zhang, H., Zhang, J., Wang, J., & Zhang, H. (2023). *Integrating mobile learning and SPOC-based flipped classroom to teach a course in water supply and drainage science and engineering*. Comput. Appl. Eng. Educ., 1–14. doi.org/10.1002/cae.22604