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Utilizing flipped classroom approaches offered in a joint programme: opportunities and challenges

Moghaddasi, Hamed [1]
University of Strathclyde, Department of Civil and Environmental Engineering, Glasgow, UK

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ABSTRACT

This paper presents the lesson learnt the first implementation of an online course, 'Soil Mechanics', in a Joint International Education Programme in partnership between the University of Strathclyde (UK) and a Chinese University. While the original plan was to deliver this course face-to-face (F2F), the online mode of delivery was later adopted due to the spread of the COVID pandemic. This prompted the implementation of alternative pedagogical approaches, such as the flipped classroom approach (FLA), and offered to opportunity to assess new modes of learning. The new delivery method presents a number of learning and teaching challenges, such as the effectiveness of online resources, the language barriers of students, and the customization of traditional assessments based on the need for online courses. The paper discusses all aspects of teaching and learning strategies utilised in this module and compares them with a similar module taught F2F by the author in a traditional framework at the University of Strathclyde. Academic achievements (as demonstrated through assessments), students' satisfaction and engagement, and instructor reflection are among key measures used to evaluate the performance of the new approach. As the module is intended to be presented F2F class format in the upcoming years, the idea of maintaining the same teaching and learning strategy or revoking it will be discussed.

[1] *Corresponding Author: Dr Moghaddasi*
e-mail address: hamed.moghaddasi@strath.ac.uk

1 INTRODUCTION

Joint international undergraduate programmes in STEM hold immense importance as they foster international collaboration among staff and students, promote cross-cultural competence, and prepare the workforce with innovative thinking, adaptability, and resilience. In pursuit of this objective, a collaborative joint international undergraduate programme has been established between the Civil and Environmental Department at the University of Strathclyde and a Chinese university. The plan was to develop a joint Civil and Environmental Engineering(CEE) curriculum in which some modules are delivered in Mandarin by Chinese staff and others are delivered by staff from University of Strathclyde. The start of this programme coincided with the spread of the COVID pandemic. To adapt to the educational restrictions, online mode of delivery has been selected for the first implementation of the module.

This allowed alternative pedagogical learning theories to be implemented. Among them, the flipped classroom approach (FLA) has been dominantly employed for this module, in which instructional videos, interactive virtual labs, and online quizzes have been provided to students as pre-class teacher-centered content, and they were actively engaging in the class for student-centered activities like questions and answers(Q&As) sessions and teachers' feedback and recaps (Akçayır and Akçayır 2018). It has been shown that the FLA is a cost-effective learning method that can generate high students' satisfaction and performance (Baytiyeh and Naja 2017, Prevalla and Uzunboylu 2019). Hardebolle et al. (2022) implemented FLA in engineering education and concluded that this method can eliminate the prior knowledge gap observed between different genders. However, effectiveness of FLA under the challenges associated with joint international programmes, such as language barrier and disparities in students' prior knowledge, remains to be addressed.

In this study, a comprehensive overview of the pedagogical methodologies employed for the administration and instruction of the Soil Mechanics module are summarized and discussed. Since the online mode of delivery has been adopted for teaching and learning activities, innovative teaching strategies such as virtual labs, virtual study groups, and online discussion forums have been created to enhance students learning experience.

2 METHODOLOGY

The soil mechanics module is among the fundamental modules taught in the early years of civil and environmental undergraduate studies. The purpose of the soil engineering module is to provide civil engineering students with an introduction to the physical and mechanical properties of soils used in construction and landscaping. A critical review of the existing curriculum between two universities has been performed to ensure academic rigour and standards across both universities. Upon reviewing the curriculum, it was found that there were a number of educational challenges. Particularly for the Soil Mechanics module, these challenges, along with the remedial pedagogical strategies, have been briefly reviewed.

2.1 Curriculum Alignment

The soil mechanics class is not the first module covering geotechnical engineering topics at University of Strathclyde. UK students have the chance to sit for the 'Fundamentals of Civil Engineering' module to briefly learn the basics of soils as

engineering materials. However, this module was the first to aim at covering geotechnical engineering and geology at the Chinese University. To prepare Chinese students, the FLA has been implemented, in which preparatory materials (e.g., online videos and worked examples) have been provided to them before the live classes, and classroom time is then dedicated to interactive discussions, problem-solving, and collaborative activities. The use of online pre-class content also helped the program to be delivered in a compact version compared to the normal F2F program.

2.2 Language barrier of overseas students

The key obstacle for overseas students is the language barrier, which impacts students' ability to comprehend lectures, read module's materials, and complete assignments. Through communication with Chinese students, it was found that they experienced unequal language proficiency, affecting their academic performance (Zhu and O'Sullivan, 2022). As demonstrated by Fass-Holmes and Vaughn (2019), non-English-speaking students can achieve academic success if suitable teaching and learning strategies are implemented. One remedy was to provide transcripts of all oral materials, such as lectures and recorded videos, to allow students to have a self-paced learning experience. Also, various types of assessments, such as laboratories, online quizzes, and final exams, have been designed to provide equal opportunities for students with varying levels of language proficiency to showcase their learning capabilities. The laboratory assessments have been done in groups to establish peer support systems among students of different language levels.

2.3 Assessment and Grading Consistency

The traditional system of assessment has been replaced by a good diversity of assignments and feedback content such as mini-test quizzes, laboratories, and final exams. In all assignments, one of the main concerns was the lack of transparency, where students could not distinguish which learning outcomes were being measured (Hunt and Chalmers 2012). So the targeted learning outcomes have been vividly explained in the assignment descriptions. The questions of why we assess, what we assess, and how this assessment triggers learning opportunities were addressed. It was noted that Chinese students were not fully aware of Strathclyde policies on late submission, personal circumstances, and avoiding plagiarism. These details have been formally provided to them via the Strathclyde Online Learning Platform (MyPlace) and informally raised during the live class sessions.

2.4 Global pandemic challenges

The rapid spread of the COVID pandemic enforced the joint international programme to be delivered online. While overseeing digital tools has been established to assist students, limited hands-on activities and limited social interaction were feared to impact the success of these programmes. A key strategy employed for online instruction in soil mechanics involved leveraging the resources developed by University of Strathclyde's distance learning programme for integration into the current curriculum. The primary advantage here was breaking down the significant topics of each week into smaller segments, providing students with the opportunity to address and fill their specific knowledge gaps before live sessions. Another

educational intervention was to develop virtual laboratories in which students watched the lab videos and worked out the laboratory report(May et al 2023). Here, interactive laboratory videos have been created in which informal quizzes along with instant feedback have been developed to assist students in their learning process. Interactive technologies have also been implemented in online quizzes (mini-tests), where instant feedback has been generated for MCQs to allow immediate clarification.

3 RESULTS AND DISCUSSION

To assess the success of the delivery, the assessment results and students survey have been analysed for the soil mechanics module taught in the joint international programme (referred to as the online module) and compared with the performance of UK students in the F2F educational setting (referred to as the F2F module). Similar assessments have been used in both online and face-to-face modules, which consisted of online quizzes (20%), laboratories (20%), and final exams (60%). Students were required to achieve 40% to pass the module. In order to determine student satisfaction, the results of a survey conducted in both online and F2F modules are depicted in Figure 1. It should be noted that a response rate of approximately 10% was recorded for both surveys. Students were overall satisfied with the taught modules in both programmes, but the level of satisfaction is higher in the online module with an embedded FLA. In the online module, they expressed the following comments for improvement:

‘Hopefully each test will give you a specific process, not just an answer’

‘Please add a detailed explanation to the answer to each section of the test. It might be helpful, thank you’

‘It is suggested to advance the opening time of tutorial.’

From these comments, it appears that students need further feedback for automated online quizzes and additional feedback on their laboratory reports. Also, it should be planned that learning materials for all teaching weeks, including online tutorial questions, are available at the start of the module. This will ensure that students have high preparation time before the class, which can foster higher level of thinking in the class. A similar observation was made by Sandnes et al (2006) regarding the delivery of modules from Western universities to Chinese universities, highlighting that students' language proficiency should be considered when designing course content.

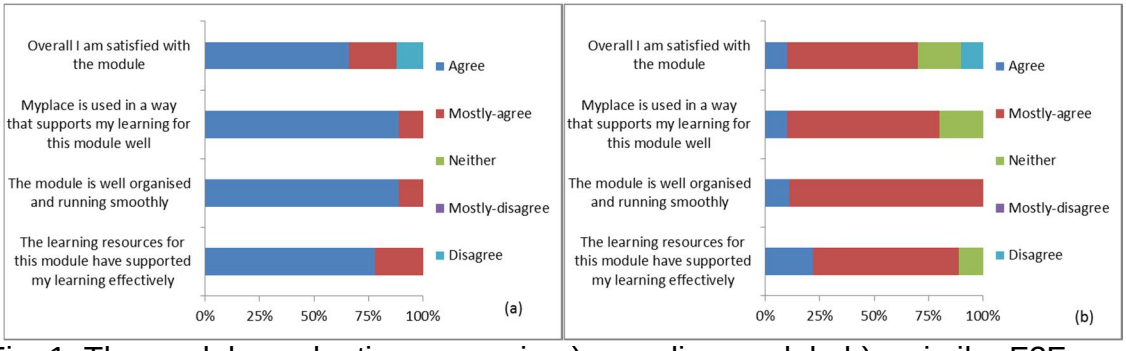

Fig. 1. The module evaluation survey in a) an online module b) a similar F2F module

The overall performances of students for two programmes is plotted in Figure 2a, where an average mark of 61% is achieved for F2F module compared to 59% in the online module. It should be noted that 93 students were participating in online module, compared to 101 students registered in F2F module. It can be seen that

similar learning performance has been achieved among students attending F2F modules, which can be attributed to the opportunities for live interaction between instructor and students and the excess number of F2F sessions compared to online sessions. In the online module, it seems medium to high achieving students could efficiently use the online resources and achieve better performance with few non-engaging students noted in comparison to the F2F module. Overall, since similar average marks have been achieved between these two programmes, it can be confirmed that the FLA could be an effective alternative to the traditional F2F learning environment.

Among assessments, one laboratory was similar between the two modules and used here for comparing students' specific performance. The physical laboratory has been arranged in an F2F module, while this has been replaced with a virtual laboratory in online module. In both programmes, students could achieve high marks for this assessment, as shown in Figure 1b, with average marks of 83% and 76% recorded for the F2F and online modules respectively. Students' lack of familiarity with online labs and uncertainty about expectations can contribute to the low performance of Chinese students. (see May et al 2023). While the use of interactive videos with embedded Q&As features could promote an active learning experience, they need to be enhanced by allowing students to manipulate virtual apparatus, embedding adaptive learning paths in the videos, and including simulation-driven experiences.

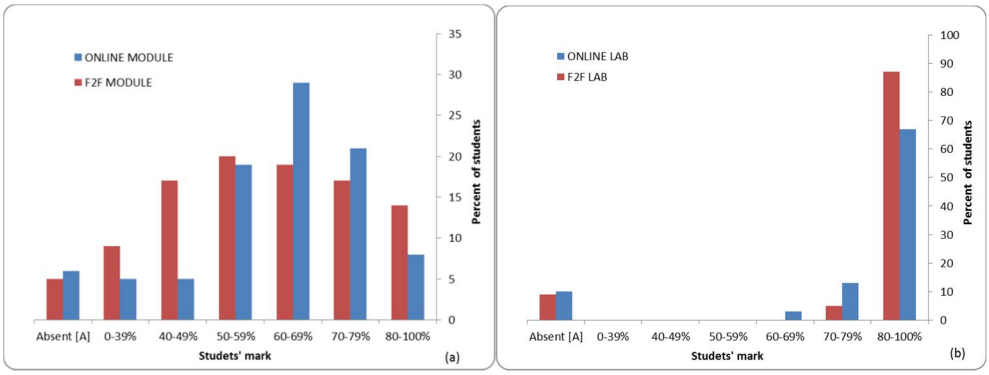

Fig. 2. Students' marks a) in overall assessment b) in Laboratory assessment

4 FUTURE PEDAGOGICAL IMPROVEMENTS

4.1 Technology enhanced learning environment

Students' survey revealed that STEM students are enthusiastic to see tangible engineering solutions used in real-world engineering practice. Although educational technologies have found their way into the soil mechanics module through the incorporation of virtual laboratories and interactive quizzes, their potential for reinforcing theoretical concepts with real-world practical applications, particularly through the rigorous implementation of engineering simulations, has yet to be fully harnessed. Due to a lack of prior knowledge in the early years of the undergraduate (UG) study, the integration of simulations into the curriculum will pose a challenge to a fundamental module like soil mechanics, as students have not been prepared for in-depth analysis of complex engineering problems in 3D.

One pedagogical approach here is to incorporate recent digital technology to allow students to explore and visualise real engineering problems without the necessity of prior knowledge (Rehman, 2023). In soil mechanics, students understand the flow of

water in 1D and 2D. In the upcoming teaching period, it is intended to use ANSYS Discovery, a real-time FEM software, to expand the application of soil mechanics beyond simple 1D and 2D geometry. Although year 2 students are not fully aware of the theory behind FEM, they are still able to utilise ANSYS Discovery as this software requires a minimum number of input parameters, such as mesh types and sizes. For example, the multi-stage dewatering system has been taught in the class and students did a simple 2D simulation to estimate the flow of water in soils. Using ANSYS Discovery with extensive drawing tools, students can quickly build complex 3D geometry and obtain the total head and flow vectors without knowing the rigor mathematical framework, as shown in Figure 3.

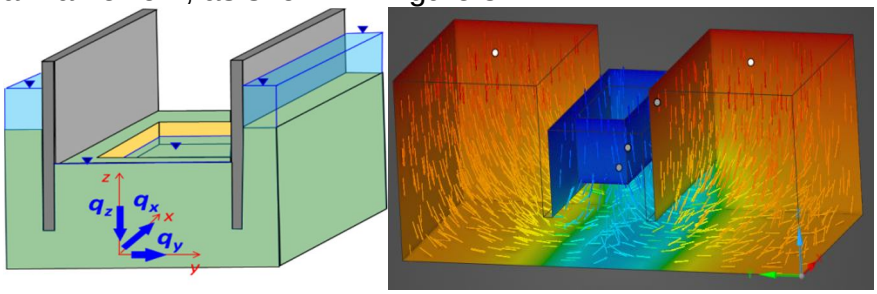

Fig. 3. Dewatering methods a) schematic representation b) numerical simulations

4.2 Revised methodologies for a F2F teaching module

The ongoing teaching round for this module is a F2F. It is essential to adapt existing pedagogical methods to accommodate this change for the future planning of engineering education. Examining various studies incorporating FLA in teaching, Van Alten et al (2019) indicated that students' perceptions and achievements can improve when FLA is integrated with F2F activities, rather than completely replacing them. This approach addresses a common drawback of FLA, where students often lack sufficient opportunities to ask questions during the lecture(see Hotle and Garrow 2016).Similarly, the author's experience revealed that pre-class activities could offer accessibility and flexibility options to students and that they could use them to develop self-regulation skills. Also, students' surveys confirmed that students prefer to have teaching materials in advance to use them as excellent revision tools for exam preparation. Therefore, it is planned to keep some pre-class resources, such as introductory videos for each subject and online quizzes. However, it is expected that more student-centred activities, like problem-based learning opportunities in laboratory sessions and extra tutorial sessions, can be organised in the new curriculum design. Also, the online virtual laboratories are worth being preserved even if teaching is delivered F2F round, and can be augmented with in-depth feedback sessions and 'virtual' teaching technology (e.g., simulation-driven software). This can create an autonomy-supported teaching environment, where students can change the design parameters and see instant outcome. The previous students' survey was conducted by the university, which could not measure all aspects of teaching in a joint international program. A revised survey aims at measuring the students experience with the FLA, the influence of language barriers, students' preferences on keeping online resources for F2F teaching, and the use of technology-enhanced teaching has been prepared and attached in Appendix A.

5 Conclusion

The paper have addressed the educational methodologies and resources used for the first delivery of the soil mechanics module in a joint international programme

involving the University of Strathclyde. The COVID pandemic imposed unprecedented restrictions and challenges on both instructors and students, which made traditional F2F classes an unfeasible option. The paper describes innovative educational solutions, such as using a flipped classroom approach and virtual laboratories, to overcome not only these challenges but also those typically faced in joint international programmes, such as language barriers and curriculum alignment between partnered universities. Since a similar F2F module has been run in Strathclyde, it has been used for comparing two different programmes in terms of assessment performance and students' engagements. Despite the challenges, similar students' performance in terms of overall assessment has been observed between the F2F module and the joint international module. However, it was clear that students experiencing physical laboratories could show better performance compared to those performing virtual labs in an online setting. A pedagogical remedy here would be to equip the soil mechanics module with a technology-enhanced learning framework. As an example of this technology, simulation-driven engineering software has been suggested, and its application in soil mechanics has been demonstrated. Finally, the revised teaching strategies have been suggested for future implementation of the class in a compacted F2F setting. Overall, the study offers empirical evidence regarding academic performance, student satisfaction, and engagement, aiding educators in making informed decisions regarding the adoption of FLA within challenging joint international programs.

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APPENDIX A-REVISED STUDENTS' SURVEY

Flipped classroom experience:

1. How effective did you find pre-class content in preparing you for in-class discussions and activities? Very effective-effective-neutral-not effective-not at all effective

2. During in-class sessions, how beneficial were the activities and discussions facilitated by the instructor in reinforcing the pre-class content? Very Beneficial-Beneficial-Neutral-Not Beneficial-Not at All Beneficial

3. To what extent do you believe virtual laboratories (LABs A and B) enhance your understanding of geotechnical engineering concepts? Significantly enhance - Enhance neutral- do not enhance- detract from understanding.

Language barrier:

4. Did you face any language barriers while engaging with the online content or live class? If yes, please elaborate.

5. What strategies do you personally use to overcome language barriers in your academic endeavors? (Select all that apply.) Seeking help from professors or tutors-collaborating with classmates- utilising language support services- Self-study and practice- other (please specify)

Keep online resources for FTF class (blended learning)?:

6. If you prefer to continue having online resources, what are the main reasons for your preference? (Select all that apply.) Flexibility in learning; access to recorded lectures for review; convenience - Improved understanding of course materials;- Other (please specify)

7. If you are against continuing online resources, what concerns or drawbacks do you have? (Select all that apply.) Lack of personal interaction- technical issues Reduced engagement with course content- other (please specify)

Technology-enhanced learning:

8. Do you prefer to learn engineering software in the lecture to understand real-world problems such as water flow in 2D and 3D? strongly prefer - Prefer neutral- do not prefer -strongly do not prefer

9. Do you prefer to use engineering software instead of a physical laboratory? strongly prefer -Prefer- neutral-do not prefer- strongly do not prefer

Students' engagement and satisfaction:

10. How satisfied are you with the overall blend of live classes and online learning? very satisfied- Satisfied- Neutral-Dissatisfied, and Very Dissatisfied