34th Australasian Association for Engineering Education Conference
3 - 6 December 2023 – Gold Coast, QLD

Comparing the Pros and Cons: An Analysis of Online and Offline Assessment in Engineering Education

Yit Yan Koh[a] and Chiang Liang Kok[b]
Newcastle Australia Institute of Higher Education[a,b]
Corresponding Author Email: yityan.koh@newcastle.edu.au

ABSTRACT

CONTEXT

The context of this research focuses on the dynamic landscape of engineering education and the evolving nature of assessment methods within this field. As educational practices continue to transform, and with the COVID-19 Pandemic that changes the landscape of higher education, traditional face-to-face (F2F) assessments are being complemented or even replaced by online alternatives.

PURPOSE OR GOAL

This article presents a systematic comparison of online and offline assessment methods in the context of engineering education, aiming to identify their respective benefits and limitations. Online assessments offer flexibility, convenience, and accessibility, allowing students to engage with the material at their own pace. However, concerns about academic integrity necessitate robust anti-cheating measures. Offline assessments, though more secure, may pose limitations in terms of accessibility.

APPROACH OR METHODOLOGY/METHODS

This research followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to produce the review. Such guidelines provide a comprehensive and transparent assessment of the available literature on this topic.

ACTUAL OR ANTICIPATED OUTCOMES

The findings suggest that both assessment methods are effective, but online assessments offer advantages in formative assessment, feedback, and flexibility. However, face-to-face assessments still play a critical role in summative evaluations and ensuring academic integrity.

CONCLUSIONS/RECOMMENDATIONS/SUMMARY

Understanding both methods' implications is crucial for adapting to the changing educational landscape and enhancing engineering education's effectiveness.

KEYWORDS

Online assessment, face-to-face assessment, engineering education, systematic review.

Introduction

Engineering education equips students with the knowledge and skills necessary for successful careers in various engineering disciplines. Assessment methods have undergone significant transformations as the educational landscape continues to evolve. Traditional face-to-face (F2F) assessment approaches are gradually being complemented or even replaced by online alternatives. This article delves into comparing online and offline assessment methods in the context of engineering education, aiming to shed light on their respective benefits and limitations.

The assessment of student learning outcomes is a critical component of engineering education. It serves not only as a measure of academic achievement but also to evaluate the effectiveness of instructional practices and curriculum design. The advent of online technologies and digital learning platforms has opened new possibilities for assessment in engineering education. Online assessment methods offer flexibility, allowing students to access exams and assignments remotely and complete assessments conveniently. This flexibility accommodates diverse learning styles, enabling students to engage with the material in a manner that suits their needs. Moreover, online assessments have the potential to transcend geographical barriers, providing equal opportunities for students who may face constraints in accessing traditional educational institutions.

However, integrating online assessment methods also raises concerns about assessment integrity. Ensuring the credibility and authenticity of online assessments pose challenges, such as the potential for academic dishonesty, including cheating and plagiarism. Educational institutions must implement robust anti-cheating measures, such as secure browsers and remote proctoring, to maintain the integrity of online assessments.

In contrast, offline assessment methods, which have long been the traditional approach in engineering education, are conducted in a controlled environment with direct supervision. In-person exams allow for stricter monitoring, reducing the likelihood of cheating and promoting assessment integrity. Offline assessments also provide real-time interaction and clarification of doubts between instructors and students, fostering more profound engagement with the subject matter. However, offline assessments may pose limitations in terms of accessibility, particularly for students who face geographical or personal constraints.

This article compares the benefits and limitations of online and offline assessment methods in engineering education. By exploring existing literature and insights from previous studies, this analysis provides valuable insights into the evolving landscape of assessment practices within the field. It is important to note that this research is conducted through a systematic review approach, analysing and synthesising existing knowledge rather than relying on primary data collection.

The subsequent sections of this article will delve into the specific aspects of online and offline assessment, examining factors such as flexibility and convenience, accessibility and reach, assessment integrity, feedback, timeliness, and more. By comprehensively exploring the advantages and limitations of each method, this article aims to support educators in making informed decisions regarding assessment practices in engineering education.

Overall, understanding the implications of online and offline assessment methods is crucial for adapting to the changing educational landscape and ensuring the effectiveness of engineering education. We can identify strategies to enhance assessment practices and promote meaningful learning experiences for engineering students by critically examining the benefits and limitations.

Methodology

This research followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to produce the review. Such guidelines provide a comprehensive and transparent assessment of the available literature on this topic. The primary research question

was, "What are the advantages and disadvantages of online and offline assessment methods in engineering education?" This the research question set, the inclusion criteria have been set to be (a) studies published in peer-reviewed journals, (b) studies comparing online and offline assessment practices in engineering education, (c) articles focusing on engineering and assessment methods, (d) papers are published between January 2000 and June 2023, and (e) articles are available in the English Language. On the other hand, the exclusion criteria for this are (a) Conference papers, book chapters, editorials, and review articles, (b) studies that do not directly compare online and offline assessment methods, (c) non-English articles and (d) articles with insufficient data or inadequate reporting.

A comprehensive search was conducted in SCOPUS, with the following keywords and Boolean operators: "online assessment OR offline assessment OR electronic assessment OR traditional assessment" AND "engineering education" AND "journal article." The search was limited to articles published between January 2000 and December 2023.

A single source, SCOPUS, is used in this research. The initial search in SCOPUS retrieved a total of 713 articles. After applying the inclusion and exclusion criteria at the title and abstract level, 127 articles underwent full-text screening. During the full-text screening, 103 articles were excluded for not meeting the research question or needing a direct comparison between online and offline assessment methods. The final dataset includes 24 articles for qualitative synthesis; another 19 articles were removed due to a need for more addressing of the research scopes. The final number of articles that have the highest correlation to the current scope of research is five. Figure 1 shows the PRISMA process adopted in this study.

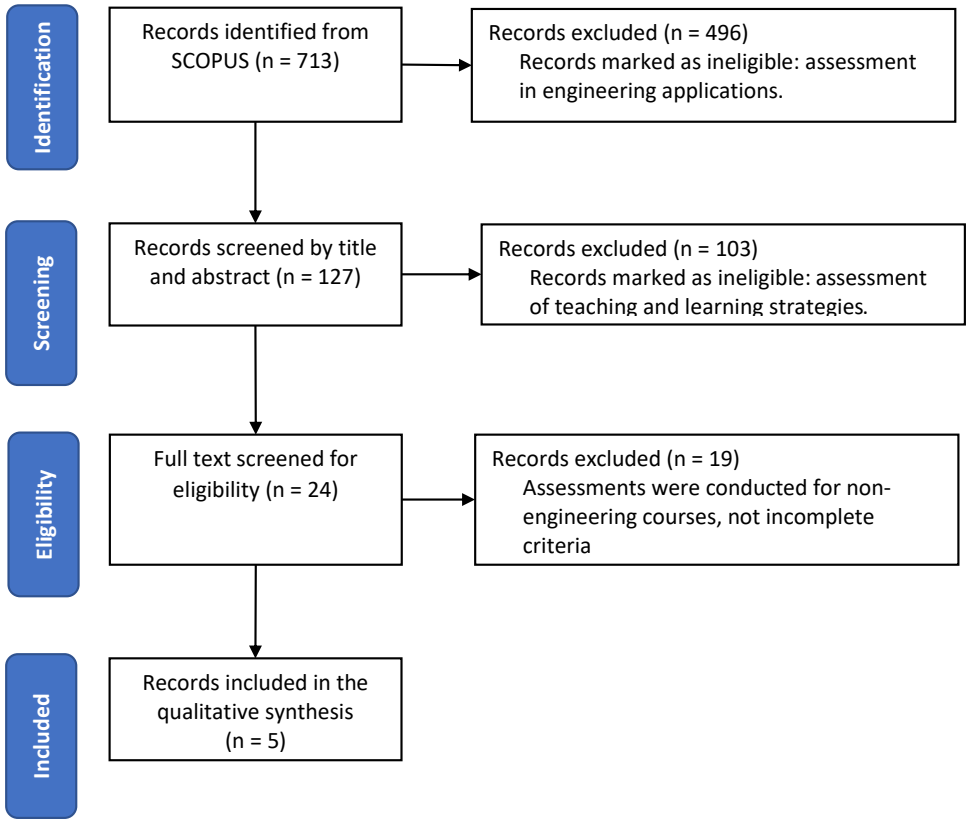

Figure 1: Reporting items for the systematic review using the Preferred Reporting Items for Systematic Reviews (PRISMA)

Due to the heterogeneity of the included studies, a narrative synthesis approach was employed to summarise and compare online and F2F assessments in engineering education based on various comparison criteria. Key findings were organised thematically and presented descriptively.

Results and Analyses

Despite the limited number of articles that met the selection criteria, the included studies offered a comprehensive comparison of online and F2F assessments. The selected five articles spanned diverse geographical regions, covering assessment practices from Australia (Nikolic et al., 2023) and Singapore (Teo & Pueh, 2020) in the East to Turkey in the Middle East (Gurkan & Cigdem, 2002) and from Austria (Orthaber et al., 2020) to the United States (Rane & MacKenzie, 2020) in the west. These articles collectively provided valuable insights into the effectiveness and limitations of both online and F2F assessments in engineering education.

The five papers have been analysed based on various themes, including the type and mode of assessments, their effectiveness, relevance to specific courses, and academic integrity. Each theme is discussed in detail in the following sections. By delving into these topics, it is aimed to provide a comprehensive understanding of the similarities and differences between online and F2F assessments in engineering education.

Type of Assessments

There are two primary types of assessments used in educational settings: formative assessment and summative assessment. Adopting the definition (Airasian, 1994), formative assessments are "interactive and used primarily to form or alter an ongoing process or activity". On the other hand, summative assessments "come at the end of a process or activity, when it is difficult to alter or rectify what has already occurred". Formative assessments, such as quizzes, class discussions, observations, and self-assessments, are usually conducted throughout the semester. It aims to provide real-time feedback for students' understanding and allow academics to identify strengths and weaknesses of students towards specific course contents. On the other hand, summative assessments are conducted at the end of the learning period, such as the end of the semester, to evaluate students' overall learning achievement following the learning outcomes set for the course. Summative assessments provide a final evaluation of the performance through grades or scores.

(Gurkan & Cigdem, 2002) uses weekly online formative assessments that last for seven weeks. The authors hinted that the study was limited to investigating the effect of the quiz method on success. In contrast, the quizzes' individual and collective effects were unclear. Nonetheless, the author reported that students who underwent the online formative assessments performed better than those in the F2F assessments.

Both Formative and Summative (Rane & MacKenzie, 2020) and (Orthaber, Stütz, Antretter, & Ebner, 2020). (Rane & MacKenzie, 2020) reported the study over the two-semester period, where the assessment for one semester was conducted face-to-face while another was conducted online. (Orthaber, Stütz, Antretter, & Ebner, 2020), on the other hand, focused on the type of online assessment while highlighting that the course consists of summative, formative, and diagnostic assessments.

The study by (Teo & Pueh, 2020) reported using quizzes in the online assessment, but there needed to be more information if it was a summative or formative assessment. Further research on the university website reveals that the course consists of a laboratory, quiz, and final examination (NUS, 2023). Hence the online assessment performed by

Based on the analyses, these studies have employed both summative and formative assessments to compare online and f2f assessments, thereby facilitating a comprehensive comparison review.

Modes of Assessments

From the analysis performed by (Nikolic et al., 2023), this paper adopted some of the modes of assessments, which could be conducted in the face-to-face or online mode by the shortlisted papers:

- Online Quizzes: Tasks conducted in an electronic format through an e-learning platform, comprising quiz-like questions or multiple-choice questions (MCQ). This includes the examinations that are conducted through the Learning Management Systems.
- Numerical (Assignments and Exams): Assessments involving numerical answers, often based on calculations, are completed in a written format.
- Visual: Assessments centred around visual documents such as mind maps and supporting evidence like completion certificates.
- Written (Project-based): Written assessment tasks associated with project work, often including a project report.
- Written (Reflective & Critical Thinking-based): Written assessments emphasise reflective and critical thinking skills, such as self-reflections on personal experiences, strengths, and weaknesses.

(Gurkan & Cigdem, 2002) uses weekly online assessments in the form of Online Quizzes (MCQ) and Online Numerical Assessments (short answers). MCQ is also used by (Teo & Pueh, 2020) in the quiz component of the course.

The assessment in the study (Rane & MacKenzie, 2020) consists of three 50-minute exams, a final examination, a group project and eight homework assignments with 5 – 7 questions each. The examination consisted of most questions requiring a numerical answer and some requiring descriptive answers. The course used in the study of (Orthaber et al., 2020) consists of tests as formative assessments and examinations as summative assessments.

In the study conducted by (Rane & MacKenzie, 2020), the examination consisted of questions that required students to perform calculations to obtain a final value. Questions are posed to students randomly, and each problem has 100 different versions. All versions have identical text but different numerical values. The author reported that such a setup ensured students could not simply memorise the answer, which made cheating more difficult. (Orthaber, Stütz, Antretter, & Ebner, 2020) described the assessment design to be "convergent" and "divergent". Convergent questions are best suited for factual knowledge. In contrast, divergent questions are best for testing background knowledge, where students must work constructively to obtain the final answer to the question.

Although some of the assessment methods are not reported, they have still been used in the online assessments of engineering courses, such as code submission and oral or research-based writing assessments.

Students' Performance of Assessment

Analysing the articles based on students' performance of the assessments, it turned out that all papers reported that the online assessment produced a better result in their studies.

(Orthaber, Stütz, Antretter, & Ebner, 2020) reported that the designed online assessments were well structured into meaningful sub-questions, and errors carried forward were accounted for. This addresses the rigidity of the online assessment in engineering problems, where students would have a perfect concept, but due to carelessness, they lose the accuracy in the solution.

(Teo & Pueh, 2020) demonstrated the results through normally distributed class scores for the quiz, highlighting that the online quizzes were challenging enough to test and differentiate students' understanding sufficiently.

Both (Rane & MacKenzie, 2020) and (Gurkan & Cigdem, 2002) frequent quizzes and multiple attempts at the quizzes and reported that a better performance is obtained through such an approach. Both reported the ease of grading, where students can access their scores online,

review the mistakes, and improve immediately. Comparatively, students would need to wait for a more extended period for the f2f assessment feedback, which, by the time of receiving the feedback, students might have lost interest or have forgotten about what they have done.

The online assessment is preferred for the speed of feedback, flexibility, and the opportunity to have multiple attempts compared to F2F assessments.

Area of Courses

(Teo & Pueh, 2020) and (Orthaber et al., 2020) used online assessment for Engineering Mechanics. On the other hand, (Orthaber et al., 2020) designed the online assessment mainly to foster objectivity of the examination and timesaving in terms of setting questions and grading the answers.

The research by (Gurkan & Cigdem, 2002) were on Sensors and Transducers. With its emphasis on theoretical understanding, calculations, and real-world application, online assessments can be strategically incorporated to effectively evaluate students' knowledge and skills.

Engineering Economy, a course with more descriptive content, was placed on the experiment table by (Rane & MacKenzie, 2020) for the online assessment.

The approach was adopted by (Teo & Pueh, 2020) and (Rane & MacKenzie, 2020) due to the large class size and the rapid conversion due to the Pandemic. On the other hand, (Gurkan & Cigdem, 2002) started the research on online assessment to incorporate online assessment into the formative assessment to improve students' performance. One key highlighted by (Orthaber et al., 2020) was the limitation of such assessments in testing students on the sketching skills in the online assessments, such as the Freebody diagram for the problem.

Academic Integrity

While studies presented focus on the benefits of having online assessments over f2f assessments, increasing notice has also been given to studying the academic integrity among students towards online assessments. Therefore, online assessments are suitable for formative assessments, while f2f assessments are still best for summative assessments.

(Nikolic, et al., 2023) did not compare the effectiveness of online and f2f assessments but provided an extensive discussion on academic integrity in engineering education. Natural language processing (NLP) models have gained significant attention in educational assessments in recent years. A comprehensive study conducted by (Nikolic et al., 2023) that explores the efficacy and limitations of utilising ChatGPT, an advanced NLP model, in various modes of assessments revealed that online quizzes, code submission, numerical-based assessments, and critical thinking-based written assessments, ChatGPT revealing its remarkable strengths in these domains. Conversely, ChatGPT's challenges in visual, oral, and research-based written assessments are also discussed, highlighting the areas that require further refinement to leverage ChatGPT's potential as an assessment tool fully.

Discussions

The findings presented have provided a better understanding of the benefits and challenges of online and f2f assessments in engineering education and the implications of maintaining academic integrity in both online and f2f assessments.

The F2F summative assessment is still preferable to reduce the additional effort to deal with potential academic misconduct, maintaining academic integrity among students. This aligns with the recommendation proposed by (Nikolic et al., 2023), where the invigilated f2f examination is recommended, especially when the risk/reward of cheating is high. The online assessment is suggested to be the formative assessment for the course. The online assessments provide the benefits such as immediate feedback, accessibility, flexibility, progress tracking, engagement, and interactivity, which fits perfectly into the formative assessment characteristics. (Nikolic, et al.,

2023) suggested using online assessment for zero-assessment-marks assignments to confirm threshold concepts and unlock future content, implying the benefits of using online assessment to monitor students' understanding and progress in the course.

Additionally, the F2F assessment is most suitable for courses emphasising calculations, as it evaluates students' step-by-step workings, showcasing their understanding of underlying concepts. However, the unprecedented circumstances of the Pandemic compelled the authors to transition their courses to online examinations. In the case of assessments heavily reliant on calculations, students were required to solve problems on paper, scan their solutions, and upload them at the end of the examination. Regrettably, this transition gave rise to various challenges during the submission process. Issues such as blurred scanned copies, difficulty uploading files to the portal, corrupted files, and even large file sizes resulted in a wave of complaints from students regarding the online examination setup. Academics also encountered complications during the marking of scripts, as they were required to mark on the Portable Document Format (.pdf), which made drawing and sketching challenging. Moreover, the constant need to open, save, and close multiple files significantly slowed the marking process.

The formative online assessment proves effective for courses that primarily deal with factual knowledge, as highlighted in the study by (Orthaber et al., 2020). For instance, the author's course, Engineering Fluid Mechanics, incorporates three online quizzes, including multiple-choice questions to assess students' fundamental understanding of Fluid Mechanics. The instant feedback provided at the end of each quiz empowers students to learn immediately from their mistakes and reinforce their comprehension.

Several key factors need to be considered when examining the academic integrity of online and offline assessments. Both online and offline assessments present challenges related to cheating and plagiarism, hence the implementation of effective measures to prevent academic dishonesty. Numerous forms of undetectable academic dishonesty may or may not be recognised by educators. For instance, the authors' university adopted un-invigilated examinations for engineering courses, assuming that students would approach the assessment with complete integrity. However, the absence of invigilation allowed students to engage in illicit activities, such as discussing solutions through mobile phones or face-to-face interactions when taking the examination in the same room. From the example given by (Rane & MacKenzie, 2020), where students received questions with identical wording but different numerical values to deter cheating if one student possessed the correct solution and shared it with others, fellow students could replicate the solution procedure using their numerical values to arrive at the required answer. Similarly, the university in the study by (Orthaber et al., 2020) encountered challenges when errors in numerical values, resulting from carelessness, were propagated throughout the assessment despite the correctness of the methodology used. These instances underscore the need for robust measures to address undetectable forms of academic dishonesty and preserve the integrity of the assessment process.

The highlighted study by (Nikolic et al., 2023) emphasises that ChatGPT cannot replace students in oral assessments, making additional oral examinations or vivas essential to ensure students' complete integrity during evaluations. The university implemented an oral examination process at the end of assessments to address undetectable forms of academic dishonesty. Randomly selecting students from the class, these brief 5 – 10-minute oral examinations serve as an additional layer of scrutiny. Any students exhibiting "suspicious" behaviour or providing questionable answers are flagged and referred to the Student Academic Conduct Officer for further investigation into academic misconduct. While this approach helps mitigate the likelihood of misconduct during examinations, it also burdens academics to ensure assessments maintain their integrity.

Conclusion

In conclusion, online and F2F assessments have unique advantages and limitations in engineering education. Even though face-to-face assessment is still the author's preference, the

faculty and institutions should consider the specific needs of their courses and students when selecting assessment methods. A balanced approach that combines the strengths of both modalities may offer a comprehensive evaluation of engineering students' progress and learning outcomes. As technology continues to evolve, continuous monitoring, adaptation, and research in this domain are essential to optimise assessment practices and enhance the overall effectiveness of engineering education.

References

Airasian, P. (1994). *Classroom Assessment* (2nd ed.). New York: McGraw-Hill.

García-Castelán, R., González-Nucamendi, A., Robledo-Rella, V., Neri, L., & Noguez, J. (2021). Face-to-face vs. Online learning in Engineering Courses. *2021 IEEE Frontiers in Education Conference (FIE)*, (pp. 1-8). Lincoln, NE, USA. doi:10.1109/FIE49875.2021.9637177

Gurkan, S., & Cigdem, H. (2002). Formative quizzes in the learning of sensors and transducers: Online vs paper-based. *Computer Applications in Engineering Education, 30*(6), 1919-1930. doi:10.1002/cae.22565

Lara-Prieto, V., & Niño-Juárez, E. (2021). Assessment Centre for senior engineering students: In-person and virtual approaches. *Computers and Electrical Engineering, 93*. doi:10.1016/j.compeleceng.2021.107273

Nikolic, S., Daniel, S., Haque, R., Belkina, M., Hasssan, G., Gundy, S., . . . Sandison, C. (2023). ChatGPT versus engineering education assessment: A multidisciplinary and multi-institutional benchmarking and analysis of this generative artificial intelligence tool to investigate assessment integrity. *European Journal of Engineering Education, 48*(4), 559-614. doi:10.1080/03043797.2023.2213169

NUS. (2023, June 19). *National University of Singapore.* Retrieved from BEng (Mechanical Engineering) Major Courses Syllabus: https://cde.nus.edu.sg/me/wp-content/uploads/sites/11/2023/06/NUSME_Core-Courses-19062023.pdf

Orthaber, M., Stütz, D., Antretter, T., & Ebner, M. (2020). Concepts for E-assessments in STEM on the example of engineering mechanics: How to assess complex engineering problems electronically. *International Journal of Emerging Technologies in Learning, 15*(12), 136-152. doi:10.3991/ijet.v15i12.13725

Rane, V., & MacKenzie, C. (2020). Evaluating students with online testing modules in engineering economics: A comparison of student performance with online testing and with traditional assessments. *Engineering Economist, 65*(3), 213-235. doi:10.1080/0013791X.2020.1784336

Teo, O., & Pueh, L. (2020). Challenges for conducting the online assessment for A large class in engineering mechanics. *Advances in Engineering Education, 8*(4), 1-5.

Copyright Statement