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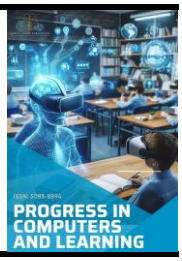

Improving Digital Communication among Engineering Students in Online Learning

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ABSTRACT

The shift to online learning during the COVID-19 pandemic highlighted significant challenges in digital communication among engineering students. This study investigates methods to enhance communication in virtual learning environments to bridge the gap between in-person and online interactions. A comprehensive approach was undertaken, including surveys across Malaysian universities to identify barriers such as technical proficiency, collaboration, and engagement difficulties. Innovative solutions like the integration of tools such as OneNote, Padlet, and game-based platforms, alongside structured activities like One-Minute Self Introductions (OMSI), were implemented to foster interactive and inclusive communication. Results indicated improved engagement and communication efficacy, underscoring the potential of hybrid models incorporating online and in-person learning. This research culminates in providing scalable strategies for digital communication enhancement, ensuring sustainability in future hybrid educational frameworks. The findings offer practical insights into addressing communication barriers and enhancing learning outcomes in engineering education post-pandemic

1. Introduction

Communication is crucial in the teaching and learning process as it serves as a foundation for knowledge and idea exchange between individuals. Teachers use it as a tool to deliver subject matter and explain ideas in the classroom. Effective communication in the classroom not only can ensure good interaction between teachers and students but also foster student-to-student and student-to-content engagement [1,2].

Online learning/teaching in tertiary institutions has become inevitable for health and safety precautions because of possible future pandemic outbreaks [3-5]. Many schools were forced to close and conduct online teaching, but this affected the student's academic performance significantly and caused dissatisfaction [6,7] Furthermore, online classes cannot duplicate in-person interaction between students and teachers in a physical classroom. The preliminary survey among 71 undergraduate students showed that 80% of them expressed a preference for face-to-face

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communication. Notably, 64% of them eagerly requested support in improving their communication skills. In general, students experience challenges and communication barriers in online learning. These include limited vocabulary or language proficiency, difficulties in explaining concepts via online platforms, reluctance to speak up opinions due to nervousness and struggles with collaborating with members from diverse backgrounds. Besides, poor internet connectivity, unfamiliarity with online tools, disruptive study environment and delayed responses or feedback from teachers also hinder the effectiveness of online learning [8-10]

During the pandemic era, we acknowledged the possibility that teaching and learning may remain fully online or at least hybrid in the future. This urged the need to create a more conducive online environment that effectively enhances the communication skills of students. However, studies focusing on digital communication are scarce and pose great challenges within engineering education, especially in developing effective strategies to enhance student engagement in online learning environments. The current study aims to enhance communication of engineering students through usage of interactive digital tools to enhance online teaching, online discussion, online interaction/engagement and learning experience. The research objectives are included as follows:

i. To evaluate the existing methods and tools employed for digital communication in online learning.
ii. To create an effective environment and pedagogy that fosters student communication and interaction on an online platform.

2. Methodology

This study employed a structured methodological approach to evaluate existing online teaching practices, introduce innovative tools and analyze their effectiveness in improving communication and engagement among engineering students in online and hybrid learning environments.

2.1 Assessment of Current Online Teaching Methods and Tools

A survey questionnaire (Table 1) was developed using the Qualtrics (USA) software to gather feedback from students on their experiences with online learning, including satisfaction levels and communication barriers. It was reviewed and commented on by 2 education experts from the Faculty of Science and Engineering, University of Nottingham Malaysia (UNM). Online platforms (e.g. MS Teams, Zoom and Google Meet) were evaluated for their ability to support online lessons. Ethical approval was secured from the UNM Human Ethics Committee (Application ID: HCL131222) before dissemination. The survey targeted engineering students from several public and private universities across Malaysia. A total of 298 valid responses were obtained for analyses.

Online platforms and game-based tools were implemented to improve online learning [11-13]. There was a total of six different tools employed namely (i) OneNote: a collaborative platform enabling instructors and students to write equations, sketch diagrams, and interact in real-time [14], (ii) Padlet, a web-based interactive tool allowing students to share multimedia content and communicate anonymously, fostering openness and creativity [15], (iii) Zoom's Breakout Room allowing small group discussions, individualized attention and guidance [16], (iv) One-Minute Self-Introduction (OMSI) enabling students to record short videos sharing their background, interests, and aspirations, which promoted inclusivity and strengthened their sense of belonging [17], and (v) Blooket, Kahoot and Socrative were integrated into lectures as game-based platforms, fostering

engagement and reinforcing key concepts through interactive and enjoyable learning activities [18-21].

Table 1
Summary of the survey questionnaire

Sections	Questions
Student's particulars	• Gender, age, nationality, university, year of enrolment, program level and year of study.
Online tools/equipment	• Which device do you use the most? • Which online platform do you use mostly? • Provide ratings of the features that you use the most (whiteboard, share screen, chat box, reaction/emojis and camera) (Ratings: strongly disagree, somewhat disagree, neither agree nor disagree, somewhat agree, strongly agree). • Which of the following tools are mostly used? (Kahoot, Quizz, Slido, Padlet, Socrative, Jamboard, Booklet, Word wall, Random name picker, others).
Learning experience	• How long have you attended online lesson? • Provide the ratings of online lectures are engaging, online example classes are engaging, online laboratory are engaging, physical lectures are engaging, physical example classes are engaging, physical laboratory are engaging, and instructors are familiar with online tools/platform used (Ratings: definitely not, probably not, might or might not, probably yes, definitely yes). • How is your academic performance during online classes? • Provide the ratings of lecturers able to conduct online lessons effectively, it is conducive to do team project online, it is conducive to do experiment online (Ratings: definitely not, probably not, might or might not, probably yes, definitely yes).
Recommendation	• Areas for improvement? • In the future, do you think students will choose virtual/online learning?

2.2 Statistical Analysis

The data collected from the survey were analyzed using R statistical software, with significance determined at a 95% confidence level ($P < 0.05$), as described below:

i. Cronbach's Alpha: This was used to assess the reliability of the survey instrument. Values greater than 0.7 were considered to indicate acceptable internal consistency.
ii. Chi-Square Test: This test was applied to evaluate associations between categorical variables, such as the relationship between gender and preferences for online learning.

These statistical analyses offered valuable insights into the effectiveness of the implemented tools and strategies, identifying gaps in existing online learning practices and enabling the introduction of innovative methods to improve communication, engagement, and learning outcomes.

3. Results and Discussion

Table 2 provides a snapshot of the demographic composition of a group, showing gender distribution with 56% male and 42% female. Age-wise, the majority falls in the 20-22 years old range (47%), followed by 23-25 years old (38%), 17-19 years old (13%), and a small percentage in the 26-30 years old range (2%). The majority are Malaysian (88%), while the remaining are non-Malaysian (12%). About 79% and 21% attend a Private University and a government-owned University, respectively. Furthermore, 76% of the group is pursuing a bachelor's degree, while 24% are in a foundation program. The total number of students in the survey after data cleaning was 298 students.

Table 2
Survey Students' Demographic Profile

Demographic		Frequency	Percentage (%)
Gender	Male	166	56
	Female	127	42
	Prefer not to answer	5	2
Age	17-19 years old	39	13
	20-22 years old	139	47
	23-25 years old	113	38
	26-30 years old	7	2
Nationality	Malaysian	262	88
	Non-Malaysian	36	12
Type of university	Private university	235	79
	Government-owned university	63	21
Enrolment Programme level	Foundation program	73	24
	Bachelor degree program	225	76

3.1 Online Tools and Learning Experience

Figure 1 shows a strong preference for MS Teams as the primary communication and collaboration tool for online activities. Google Meet and Zoom follow as the next popular choices but MS Teams stands out as the preferred platform. Figure 1 also highlights the significance of laptops as the primary device used as compared to smartphones (47 students), tablets (17 students) and desktops (10 students). Interestingly, one participant reported using all devices except the desktop, showcasing the diversity in device usage but still emphasizing the laptop's dominance.

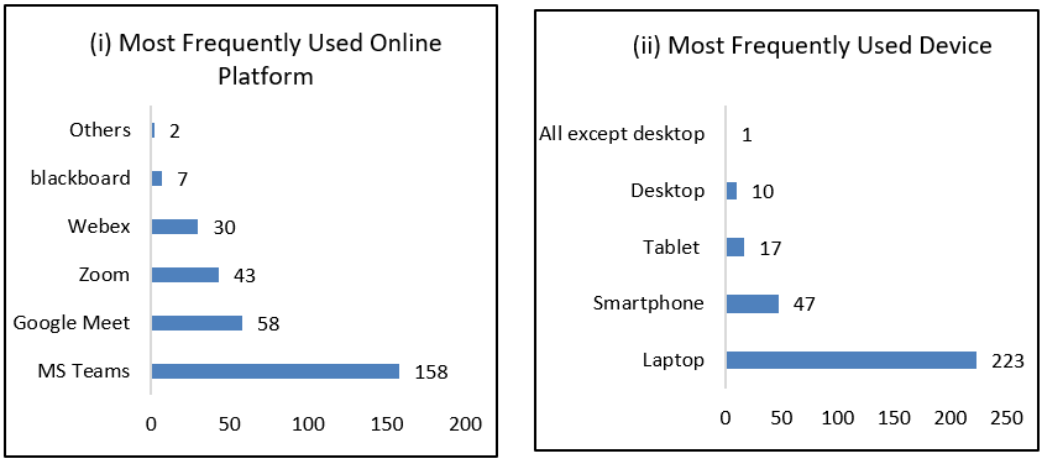

Fig. 1. Survey results of most frequently used (i) Online Platform and (ii) Device

Table 3 presents data on three constructs related to engagement in different modes of learning. The "Online Platform" construct assesses students' preferences for various features of the online platform, showing a satisfactory level of internal consistency (Cronbach's alpha = 0.763). The "Engagement of Online Mode" construct measures students' perceptions of engagement during online lectures, example classes, and laboratories, with reasonable internal consistency (Cronbach's alpha = 0.730). Similarly, the "Engagement of Physical Mode" construct evaluates engagement during physical lectures, example classes, and laboratories, demonstrating a high level of internal consistency (Cronbach's alpha = 0.844). Overall, the Cronbach's alpha values indicate good internal consistency (e.g. the questions or statements in the scale are consistently measuring what they intend to measure or in other words, people who answer one question positively are likely to answer the others positively too, and vice versa.) within each construct's items.

Table 3
Analysis for Engagement in Different Modes of Learning: Online Platform and Physical Mode

Construct	Sub-construct	alpha
Online Platform	a. Do you like using the whiteboard feature? b. Do you like the share screen feature? c. Do you like to use the chat box? d. Do you like to use the reactions/Emojis expression? e. Do you like to turn camera on? f. Do you like the gallery/group together feature? g. Do you like to use the polling feature?	0.763
Engagement of online mode	a. Do you think that lessons were engaging during the online lectures? b. Do you think that lessons were engaging during the online example classes? c. Do you think that lessons were engaging during the online laboratory?	0.730
Engagement of physical mode	a. Do you think that lessons were engaging during the physical lectures? b. Do you think that lessons were engaging during the physical example classes? c. Do you think that lessons were engaging during the physical laboratory?	0.844

Table 4 illustrates students' preferences for various features of the online platform. Share Screen emerges as the most favoured feature, with 50% of students expressing a strong liking for it, followed by Reactions/Emojis (41.28%) and Chat Box (43.62%). Some features, such as Whiteboard, Chat Box, Reactions/Emojis, and Polling, receive a notable number of "Neither Like nor Dislike" responses, suggesting mixed feelings among students. Turn Camera On and Gallery/Group features received relatively fewer positive responses and a considerable number of "Somewhat Dislike" and "Strongly Dislike" responses, indicating that they are less favoured.

Table 4
Students' Preferences for Online Platform Features and Level of Liking

Feature	Strongly Like	Somewhat Like	Neither Like nor Dislike	Somewhat Dislike	Strongly Dislike
Whiteboard	44	144	81	20	9
Share screen	149	111	23	9	6
Chat box	111	130	43	9	5
Reactions/ emojis	123	115	36	15	9
Turn camera n	10	41	84	97	66
Gallery/group	40	105	106	30	17
polling	122	123	40	6	7

In order to find out if there is a relationship between gender and the preference for reactions/emojis, a Chi-square test of independence was performed. The null hypothesis was “There is no significant difference in the distribution of response rates between males and females on the Likert scale”. The P-value of 0.0043 (less than 0.05, therefore we reject the null hypothesis) indicates that there is a significant association between reactions/emojis and gender.

Figure 2 highlights the popularity of certain interactive tools like Kahoot and Quizizz, which are widely used by students, while also revealing the lower usage frequency of other tools like Socrative and Wordwall. Kahoot is the most widely used recorded at 40.9% and the least used is wordwall (0.47%).

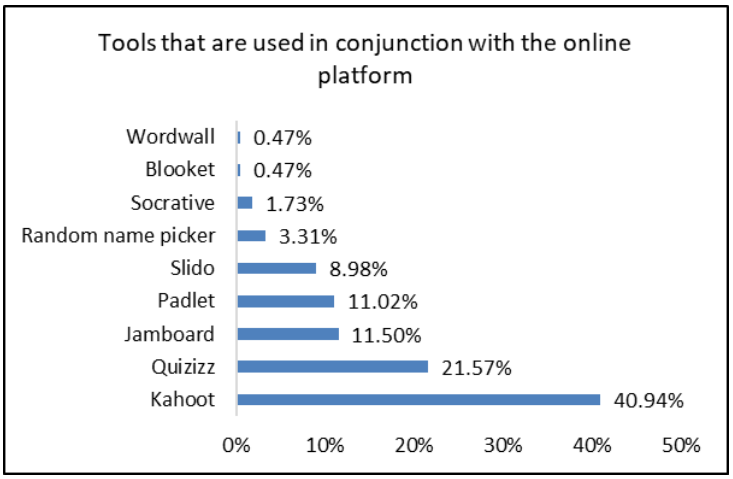

Fig. 2. Tools used in the online platform during online lessons

Table 5 shows that most students expressed moderate engagement, with "Somewhat Like" being the most common response for both "Online Lectures" and "Online Example Classes." However, "Online Laboratory" elicited a more diverse range of engagement levels, with a notable number of students indicating stronger disliking. Additionally, neutral responses ("Neither Like nor Dislike") were prevalent across all lesson types.

Table 5
Students' Preferences for Engagement Levels in Online Lessons

Engagement of Online Mode	Strongly Like	Somewhat Like	Neither Like nor Dislike	Somewhat Dislike	Strongly Dislike
Online lectures	24	102	104	51	17
Online example Classes	29	117	90	47	15
Online laboratory	9	49	67	92	81

Table 6 shows that most students expressed positive engagement across all physical lesson types, with "Somewhat Like" being the most common response. Notably, the "Physical Laboratory" received the highest number of "Strongly Like" responses (177 students), indicating a high level of engagement, and no students expressed "Strongly Dislike" for this lesson.

Figure 3 shows a comparison of students' responses, using a Likert scale of 1-5, to two different questions related to their experiences with team projects and experiments. For the question "Team Project", 34 and 72 students expressed a low preference for ratings of 1 and 2, respectively. However, most students showed relatively higher preference with 72 students giving a rating of 2, 91 students rating of 3, and 72 students rating of 4. However, only 29 students gave rating of 5.

Table 6
Students' Preferences for Engagement Levels in Online Lessons

Engagement of Physical Mode	Strongly Like	Somewhat Like	Neither Like nor Dislike	Somewhat Dislike	Strongly Dislike
Physical lectures	90	133	53	16	6
Physical example Classes	110	128	45	11	4
Physical laboratory	177	80	30	11	0

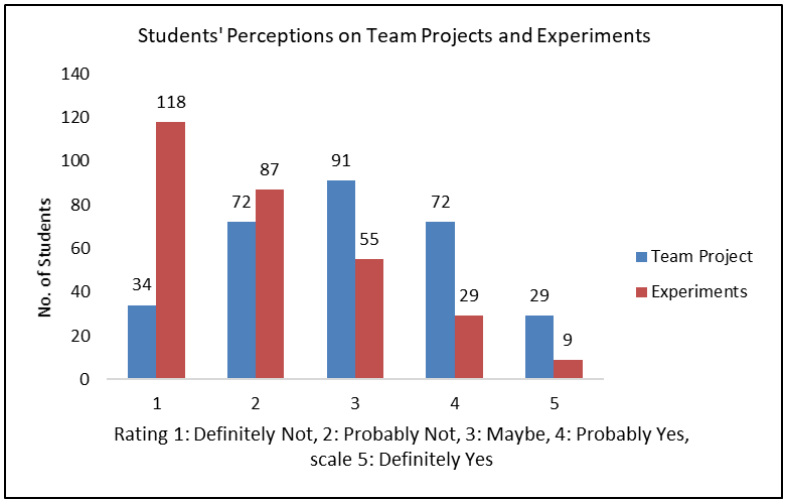

Fig. 3. Comparison of students' perceptions on team projects and experiments

On the other hand, for the question "Experiments", most students (118 students, 40%) rated it with a low preference (rating of 1). A significant number expressed neutral to positive views, with 87 students giving a rating of 2, 55 students with a rating of 3, and 29 students with a rating of 4. Only 9 students rated the experiments as highly conducive (rating of 5).

The analysis in Figure 4 focused on students' perceptions of their academic performance in online and physical classes. Out of 298 students, approximately 133 students felt their performance was better in physical classes, while about 84 students believed it was better in online classes. Additionally, 81 students reported their performance was the same in both settings.

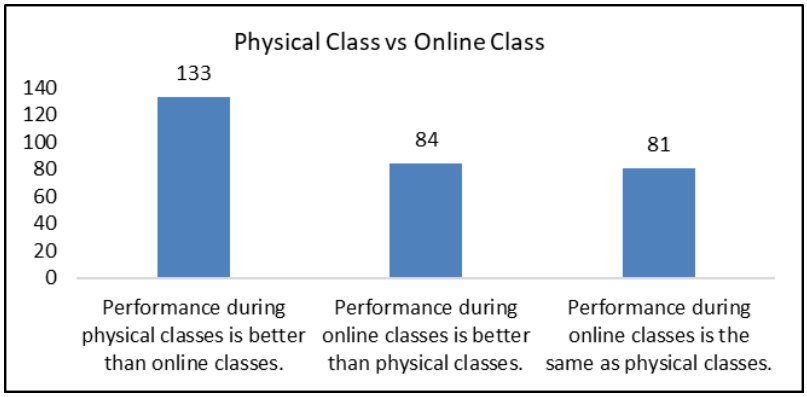

Fig. 4. Comparison of academic performance (online vs. physical classes)

3.2 Recommendations

Based on Figure 5, students have expressed the need for improvement in various aspects of online classes. Engagement with lecturers received the highest count, highlighting the desire for increased interaction and clearer communication. Students also expressed the importance of engagement with classmates and effective team discussions, indicating a need for collaboration and interactive group activities [22]. Additionally, user-friendly features in online platforms, better question and answer sessions, and timely feedback to students were mentioned as areas for improvement. Overall, the aspects that students wish to see improvement in online classes include engagement with lecturers and classmates, effective team discussions, user-friendly features, question and answer sessions, and feedback to students.

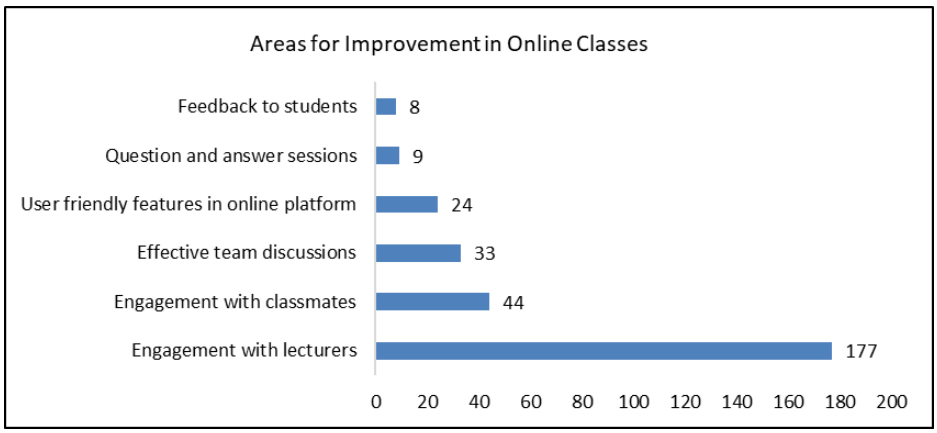

Fig. 5. Areas for improvement in online classes

Figure 6 shows that the responses reflect a variety of opinions on the necessity of physical classes in contrast to online classes.

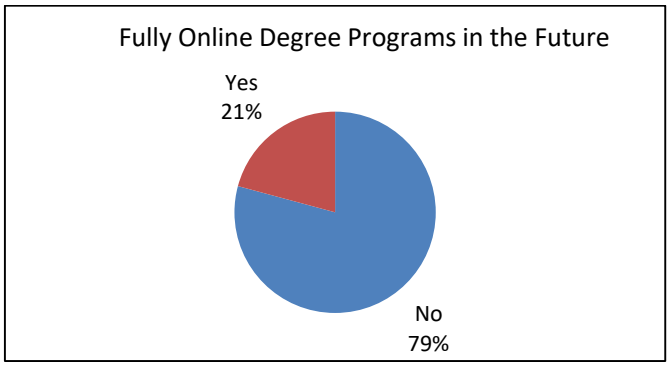

Fig. 6. Preference for fully online degree programs in the future

The following shows the summary of the responses on preference for fully online degree programs in the future.

Opinions of students who voted “Yes”:

i. Online classes are convenient and can be accessed from anywhere, suitable for students who live far away from campus.
ii. Some students find online learning cheaper as they can avoid travel and room rental expenses.

iii. Online classes offer more flexibility in managing time, allowing students to balance other commitments, such as work or family.
iv. Virtual classes often provide recorded lectures, allowing students to view them at their own pace.
v. Advancements in AI and online tools could enhance the online learning experience.
vi. Some students find online classes less distracting and more conducive to their learning style.
vii. Fully online classes can provide access to education for international students.
viii. Opinions of students who voted “No”:
ix. Physical classes allow for face-to-face interactions with peers and lecturers, which some students find crucial for networking and communication skills.
x. Certain courses involve lab work or hands-on experience, and may not be effectively conducted in a fully virtual setting.
xi. Some students believe that online exams may lead to increased cheating.
xii. Fully virtual environments may limit students' ability to experience campus life, engage in extracurricular activities, and build friendships.
xiii. Online learning requires self-discipline and may not be suitable for all students who may lack motivation or struggle with distractions.
xiv. It is believed that physical classes are more effective for learning and comprehension.
xv. Virtual campuses may lack the facilities, equipment and resources.

Overall, while online classes offer certain conveniences, many students still value the benefits of physical classes, especially in fostering social connections and practical learning experiences. The preference for a hybrid model that integrates both modes of instruction appears to be a popular choice among respondents which is supported by Figure 7. It appears that a significant number of respondents had expressed a preference for a hybrid model of learning that combines both online and physical classes. This preference is supported by the high ratings for the convenience and accessibility of online learning and supported by findings reported from literature [23,24]. However, for certain fields such as healthcare and engineering, physical labs are considered necessary for effective learning.

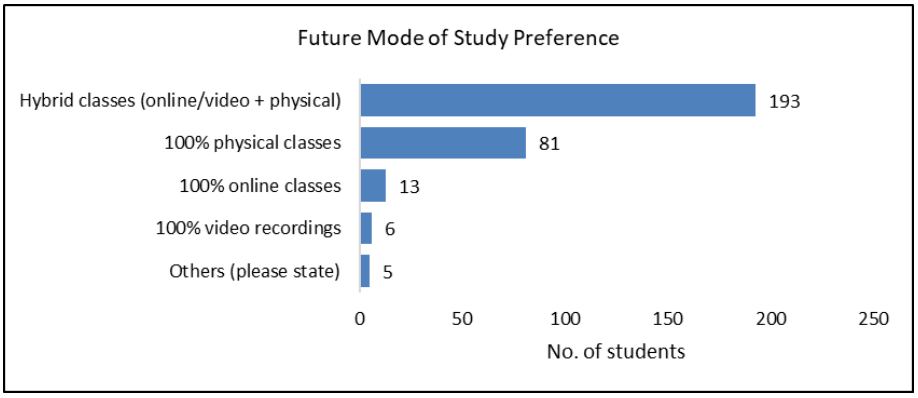

Fig. 7. Future mode of study preference: online, physical or hybrid?

4. Conclusions

Survey data from 298 students revealed a predominance of males (56%), individuals aged 20–22 (47%), and Malaysians (88%), with most enrolled in private universities (79%) and bachelor's programmes (76%). Reliability analysis showed good internal consistency for online platform usage ($\alpha = 0.763$) and engagement ($\alpha = 0.730$). Students favoured features like "Share Screen" but disliked turning on cameras and showed a clear preference for physical classes, particularly laboratories, though interactive tools like Kahoot and Quizizz improved focus during online sessions. MS Teams and laptops were the preferred tools, and team projects were rated more positively than online

experiments. While most students felt proficient with online platforms, many lacked formal training. Internet quality was generally adequate, with the home being the primary study location. Despite recognising the convenience of online learning, students valued the social connections and hands-on experiences of physical classes, highlighting a preference for a hybrid model that combines the strengths of both approaches, particularly in engineering education. Future studies should include expanding the sample sizes (e.g. diverse groups of participants from wider collection of universities), conducting longitudinal studies to obtain a more dynamic view of the online learning experience among the students and carry out a more detailed analysis to examine the technical challenges faced by students with the aim to better inform the future development of online learning tools.

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