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PAPER

Exploring the Impact of Different Education Channels for Fundamental Engineering Courses: A Student's Perspective

Fadia Elissa (✉), **Rajaa Alqudah**, **Majd Batarseh**

Princess Sumaya University for Technology, Amman, Jordan

f.elissa@psut.edu.jo

ABSTRACT

This study examines the impact of different education channels for fundamental engineering courses from a student's perspective, including online, face-to-face, and blended learning, on student engagement and satisfaction. By examining these channels, the research aims to provide an inclusive understanding of the challenges and opportunities presented by these different channels, drawing on student experiences. Findings suggest that while online delivery channels offer flexibility and accessibility, the lack of engagement, interaction, and direct feedback makes face-to-face learning much more preferable. Education should incorporate a practical communication approach to understanding the message of the complex engineering curriculum and feedback, while minimizing noise. The paper concludes with suggestions for improving approaches to enhance learning outcomes in both face-to-face and online classrooms, informed by feedback from the recipient student body.

KEYWORDS

online learning, face-to-face learning, fundamental engineering courses, blended learning, challenges, opportunities, student satisfaction

1 INTRODUCTION

Learning methods have undergone reform in recent years. Advancements in technology and varying social needs have led to the evolution of learning methods, from being fully face-to-face to fully online and now to a mix of both. It might be necessary to "reimagine education," as recommended by the United Nations, which stresses the need to build more resilient learning models that go beyond traditional classroom teaching, embracing technology-enabled, student-centered, and competency-based approaches [1] [2]. Education is a fundamental pillar; therefore, research into different learning approaches and channels is crucial in any society to maintain sustainable progress and development.

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Through education, individuals gain not only knowledge but also skills and values that empower them to make meaningful contributions to their communities and careers. Engineering education fosters critical thinking and problem-solving abilities; nonetheless, it has been slow to leverage online educational resources, particularly in undergraduate programs. Reasons for the slow progress could include hands-on activities, mathematical-intensity topics, computational software tools licensed only on campus, and the need for a community among engineering students [3]. However, in the post-pandemic world, some aspects of online learning could be integrated and improved upon to enhance traditional face-to-face classroom education.

Given the importance of various factors affecting online teaching and the fact that students are the primary stakeholders in any educational system designed to support their learning, researchers should learn from experience and apply these lessons to prepare for an uncertain future [4]. This requires studying the effects of online learning, including its opportunities and challenges, particularly from the students' perspective. The present research focuses on identifying the students' preferred and non-preferred aspects of online education as a whole. A survey was conducted among engineering students at a mid-sized university specializing in technology-related disciplines. The university previously focused on face-to-face instruction, but it is now combining both face-to-face and online modes to thoroughly investigate the dynamics of traditional, online, and blended learning. This paper presents the results of conducted surveys and interviews, an inclusive analysis of students' perspectives, and suggestions for improving online engineering education to enable educational sustainability in this evolving digital era.

The remainder of the paper is organized as follows: Section 2 presents some related work, and Section 3 describes the methodology implemented in this work. Section 4 presents the results and a discussion of the results. The conclusions and future work are presented in Section 5.

2 RELATED WORK

This section provides an overview of related work on teaching and learning strategies, assessment methods, and the challenges associated with various learning environments, including online, face-to-face, and blended formats. The following subsections will explicitly explore these aspects across multiple modes of educational delivery, drawing on the literature.

2.1 Teaching and learning strategies

The foundation of education is formed from teaching and learning processes. These interrelated processes involve both the instructor and the student, and are not only about the transmission of knowledge, but also about facilitating critical thinking, problem-solving, and meaningful engagement. Instructors need to adopt diverse instructional strategies tailored to students' needs, learning styles, and the context in which education takes place. Learning, on the other hand, is an active process through which students acquire, adopt, and apply knowledge and skills [5] [6]. Whether in traditional classrooms, online platforms, or blended learning settings, teaching and learning should create a dynamic environment that fosters intellectual growth, particularly in fundamental engineering courses.

The community of inquiry (CoI) framework, developed by [3] [7], is a widely used model for understanding and improving online and blended learning environments. It focuses on the interaction between three core elements that contribute to effective learning: cognitive presence, social presence, and teaching presence. Cognitive presence involves constructing knowledge through reflection and critical thinking. Social presence refers to participants' ability to present themselves as engaged individuals. The teaching presence confirms that the course is designed, structured, and aligned with learning goals. The model states that by effectively addressing these three components in any educational channel, educators can enhance student satisfaction.

There are different learning styles, one of which is Kolb's learning style. Kolb's learning style is a model that describes how people learn through experiencing, reflecting, thinking, and doing [8]. This approach enables educators to tailor their teaching methods to match different learning preferences. The study in [9] shows that the project-based learning (PjBL) approach is suitable for blended learning, both online and in-person, and works well with all Kolb learning styles.

Online education requires instructors to transition from the traditional teaching paradigm to new teaching methods that align with technological developments. Student feedback and consultation on teaching styles are crucial for assessing the overall learning experience and enhancing it [10].

The students in [11] advocated for the implementation of online learning techniques. However, most users preferred a blended model of face-to-face and e-learning rather than relying exclusively on either.

2.2 Assessment and scaffolding

Assessment is a tool for supporting learning and a means of measuring academic performance. Effective assessment strategies are essential for enhancing student learning and overall academic success.

Assessment is an integral part of the engineering curriculum and has direct relevance to quality assurance in engineering education [12]. Feedback comments on students' performances are essential because they help students know their strengths and their areas for improvement. Engineering Instructors should employ diverse assessment methods and implement effective evaluation practices that meet the demands of modern education.

Assessment practices vary across different delivery modes, including face-to-face, online, and blended learning environments, each offering unique advantages and challenges. In face-to-face settings, assessments allow for immediate feedback and direct interaction. However, online assessments leverage digital tools, providing flexibility, yet they also face issues such as academic integrity concerns and technical difficulties. Blended assessments combine both modalities, blending in-person evaluations with online components, which tends to maximize engagement.

The case study in [13] explores the implementation of a multi-course PjBL approach combined with online assessment in electrical engineering courses. Student feedback indicated enhanced motivation and learning outcomes through the completion of a unified project across multiple subjects, accompanied by continuous online assessments. This approach ensured more practical and hands-on learning, and students noted that it is adaptable for future blended or fully online engineering education.

Scaffolding in education refers to guidance from instructors, especially during the early stages of learning, that facilitates students in achieving their learning goals [14]. With the new trends in learning, scaffolding is no longer implemented solely through face-to-face instruction; the form of instruction that emerges between teachers and students is now mediated by technology and online settings. Therefore, it is crucial to identify the type of support that is most suitable for students, particularly in a fully online learning environment. In [14] a Meta-analysis is used to investigate the types of scaffolding that can be implemented in an online learning environment, and it mentions that instructional designs are very important to ensure the effectiveness of scaffolding in online learning.

Assessment is an essential part of the teaching-learning process, as it enables instructors to determine whether and how effectively students are meeting learning objectives. It is evident that assessment and scaffolding form a dynamic feedback loop: assessment guides scaffolding decisions, and scaffolding enhances assessment effectiveness by promoting deeper learning. This synergy ensures that instruction is focused on nurturing student competence.

2.3 Challenges

Sloan's online learning consortium has defined the five pillars of high-quality online education as learning effectiveness, student satisfaction, faculty satisfaction, access, scale, and cost [7]. Taking these factors into consideration, the authors designed and conducted surveys among engineering faculty members and students to systematically investigate the challenges encountered during the abrupt transition from face-to-face to online instruction.

The study in [15] surveyed students and faculty at a minority-serving institution to identify challenges arising from the sudden shift to online engineering education during the COVID-19 pandemic. The study identified various logistical, technical, and pedagogical issues. It also proposed interventions to address these challenges.

Adopting various learning styles and solutions, such as virtual labs, online assessments, and learning management systems, will help alleviate challenges. Many institutions are considering blended models that combine the strengths of both online and face-to-face education. The author in [16] states that higher education should implement systematic, flexible strategies and use methods that collect meaningful data and serve multiple purposes to enhance teaching and learning, particularly in online and blended learning.

Despite the flexibility of online learning, challenges are inevitable; both instructors and students face challenges. While the work in [17] discusses the challenges and insights of engineering education from the perspective of instructors, this work demonstrates the challenges from the perspective of students. Together, these studies provide a balanced view of the opportunities and challenges of online learning.

For engineering students who rely heavily on hands-on lab work and practical sessions, challenges are magnified [4]. Theoretical learning also suffered; many students found it difficult to comprehend complex concepts in a virtual environment [9]. Although some students enjoyed the flexibility and shorter commute of the online setup, reduced motivation and a lack of peer interaction also affected the overall learning experience. Table 1 presents a summary of some previous work related to engineering education in the realm of online learning and teaching, highlighting the key aspects discussed.

Table 1. Summary of key aspects of studies on online engineering education

Paper	Study Focus	Methodology	Sample	Key Aspects
[10]	Blended online teaching and learning strategies' effectiveness	Mixed-methods: surveys and case studies	Chemical Engineering students and instructors involved in blended online courses	Synchronous and asynchronous methods improved engagement and learning.
[11]	Challenges and opportunities of online teaching and learning in engineering	Mixed-methods: surveys and interviews	Engineering students and instructors	Online learning presented both significant challenges and opportunities. Institutions need to address technology gaps and improve support systems.
[15]	The implementation and challenges of online engineering education	Quantitative observational study using surveys and course data	Engineering students and instructors engaged in online education	Online education was adaptable but faced challenges.
[16]	Students' perceptions of online learning experiences	Quantitative survey-based study	Engineering Students who experienced the shift from campus to online teaching	Some students appreciated the flexibility in online learning, yet many reported decreased interaction and engagement.
[18]	The impact of online educational platforms on academic performance	Quantitative and analytical study	Engineering students taking online courses	Students' academic results were not different between online and offline learning.
[19]	Engineering students' perceptions of the benefits of online lectures	Quantitative and analytical study	Engineering students taking online courses	Students showed relative acceptance of online lectures, with positive perceptions.
[20]	ICT engineering students' perceptions of project-based online learning	Qualitative study	ICT engineering students engaged in project-based online learning	Students found project-based online learning to be thought-provoking, yet with challenges in communication and engagement.
[21]	Suitability of online engineering education programs	Quantitative review and analysis of structured data	Electrical and Computer Engineering Institutions	Online engineering education is rapidly expanding, offering various synchronous and asynchronous delivery methods and presenting many challenges.
[22]	Factors affecting engineering students' learning satisfaction	Quantitative survey-based study	Engineering students	Many factors influenced learning satisfaction. Limited interaction and technical issues modeled significant challenges during online learning.

It is evident from the literature that online learning offers opportunities but also presents many challenges. The classroom cannot be seen as a collection of separate entities; there should be synergy between the instructor and the student. To bridge the gap in the literature, this work will consider the classroom as a proper communication model—an interactive process in which instructors and students actively share ideas, ask questions, provide feedback, and build understanding together, minimizing challenges and noise. Feedback will be collected from the student body through interviews and surveys.

3 METHODOLOGY

3.1 Classroom as a communication medium

There are different communication models throughout the literature. The interaction communication model (ICM) is a framework that helps understand how

communication occurs between individuals or groups. Treating the classroom as an ICM emphasizes that communication is a two-way process in which both the sender and the receiver play active roles. Below is a breakdown of the proposed communication model.

Sender: The instructor who designs and delivers the curriculum.

Receiver: Engineering students who receive and engage with the instructor.

Message–curriculum: The engineering content that is intended to be taught to the students.

Channel: The medium through which the message is delivered. Channels might include face-to-face lectures and online platforms.

Noise: Any factors or challenges that distort the message, making it difficult for students to fully understand the message.

Feedback–assessment: The methods used to evaluate and provide feedback on student learning, such as self-assessments, surveys, and both formative (ongoing assessments during the semester) and summative (evaluations of student learning at the end of the semester) assessments.

Figure 1 shows the proposed communication process in education. The Sender (Instructor) communicates through the Channel to deliver the Message (Curriculum) to the Receiver (Student). Noise represents any obstacles that might hinder understanding. Feedback (Assessment) helps the instructor understand how well the message was received and whether adjustments are needed.

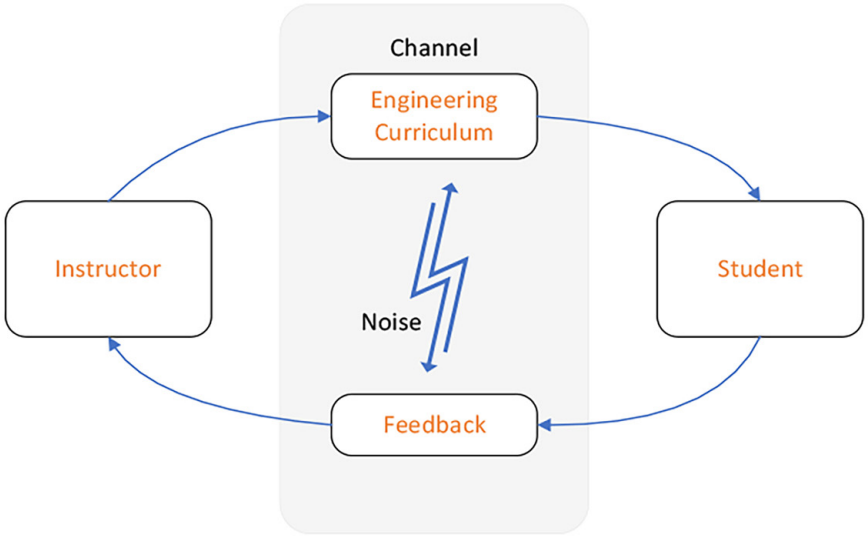


Fig. 1. Proposed communication model in education

The core participants in communication are the sender and receiver. The sender, the instructor, is responsible for creating and delivering the message. The main responsibilities of the instructor are to design the message, communicate it effectively to students through the chosen channel, and monitor how it's being understood. The receiver, in this case the student, should receive, interpret, and provide feedback through participation and assessments.

The communication process elements are the message, channel, noise, and feedback. The message is the content that is intended to be delivered and taught. For

the engineering fundamental courses, the message has a mathematical dimension, including circuit analysis, electromagnetism, problem-solving, and complex engineering concepts that may not be tangible [4].

Communication channels in education can be categorized into face-to-face, online, and blended learning approaches. Each of these channels uses different methods and tools to deliver engineering educational content and facilitate interaction. Face-to-face learning, also known as traditional classroom-based education, involves students and instructors interacting in person. Online learning, on the other hand, occurs over the internet through screens. A blended approach is a combination of online and face-to-face learning, where some components of the course are delivered in person and others online.

Each channel type has its own strengths and challenges, and the choice of channel depends on many factors. An effective channel ensures that the message is easily understood by the receiver, with minimal noise to maintain message clarity, and provides constructive feedback to confirm understanding and address any issues.

Assessment acts as a vital feedback loop in the learning process, continuously notifying both students and instructors about progress toward learning objectives. For instructors, assessment data should guide the refinement of teaching methods to ensure instruction is responsive to student needs.

In this paper, students' preferences for different channels of delivering fundamental engineering courses will be explored. The channel affects both the instructor's ability to deliver the message effectively and the student's ability to understand it. Focusing on students' perspectives provides valuable insights into how they experience and perceive the message in the different channels. By understanding the benefits and challenges of the channels presented, instructors can improve the overall learning experience.

3.2 Sampling and data collection

This study adopts a new approach by analyzing students' perspectives on learning in both online and face-to-face environments, using the classroom as a model of communication. The study aims to identify all potential noise in both channels, ensuring the message is perceived in the best possible manner. The research questions aim to explore how these factors—tools, noise, feedback, preferences, and challenges—affect learning in each channel. The research questions are listed below, and Figure 2 provides a visual representation of them.

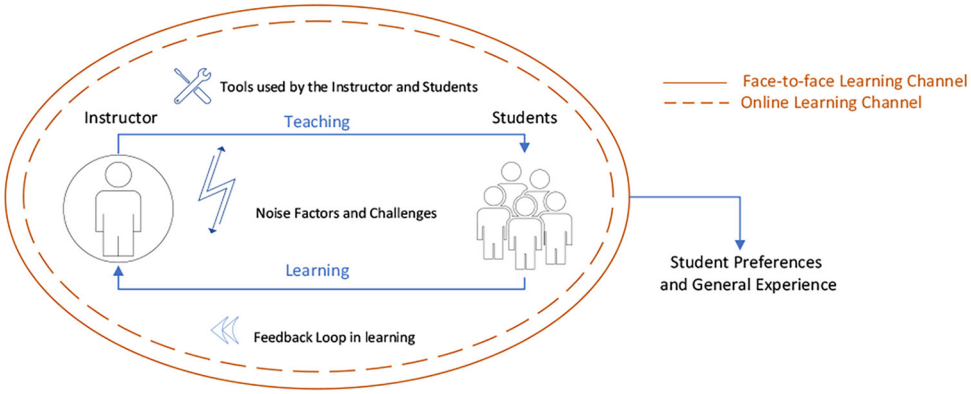


Fig. 2. Research questions visualization

- What **tools** are commonly used by instructors (senders) and students (receivers) in online and face-to-face learning channels, and how do these tools influence the learning experience?
- What are the key **noise factors and challenges** that impact communication effectiveness in online versus face-to-face learning environments, and how do they differ between the two settings?
- How does the **feedback loop** function in online and face-to-face learning environments, and what is its role in enhancing student understanding and performance?
- What factors influence **students' preferences** for online or face-to-face learning channels, and how do these preferences affect engagement and academic performance?
- What are the **general experiences, challenges, and preferences** of students regarding online, face-to-face, and blended learning environments?

To relate the CoI framework to this work, the core elements are interpreted through a communication-based classroom model. In this model, the instructor acts as the sender, students as receivers, instructional methods and technologies as tools, and learning effectiveness is influenced by noise that may interfere with message delivery. Feedback forms the loop that connects instructors and students, supporting continuous clarification and improvement [20].

Teaching is reflected in course design, tool selection, and facilitation strategies that support clear communication in both online and face-to-face settings. Cognitive presence refers to students' ability to process and apply information, which can be hindered by distractions or limited interaction. Social presence refers to the level of engagement and interaction that contributes to effective communication and feedback.

Noise varies across learning channels. In online learning, it may include technical issues, reduced non-verbal cues, and external distractions. In face-to-face settings, noise may arise from classroom conditions, time constraints, or commuting fatigue. Identifying these factors is essential for improving instructional clarity.

Feedback plays a central role in reducing noise and reinforcing understanding. Regular feedback enables instructors to assess comprehension and helps students monitor their learning progress, improving outcomes across both modalities.

Students' preferences for online, face-to-face, or blended learning are shaped by their experiences with tools, noise, and feedback. Examining these perspectives supports a clearer understanding of engagement and learning effectiveness, particularly in fundamental engineering courses. Quantitative and qualitative data were collected using a survey questionnaire and semi-structured interviews to answer the research questions above. Below are the data collection tools.

Survey questionnaire. This survey involved 107 undergraduate students enrolled in fundamental engineering courses at a mid-sized engineering university. Students were selected using convenience sampling and represent the target population that is familiar with both online and face-to-face educational channels. Students were mostly second, third-, and fourth-year engineering students, with a gender distribution of 67% males and 33% females.

The survey consisted of multiple-choice and Likert-scale questions designed to identify patterns in student preferences and experiences. A Google Form was used to create the survey, which was shared face-to-face during classes to ensure its effectiveness.

Semi-structured interviews. After completing the survey, seven engineering students were selected for one-on-one interviews to explore their learning

experiences in more depth. These interviews provided insights into what challenges the students encountered and their channel preferences. The interviews lasted 10–20 minutes and were led face-to-face.

The following questions guided the semi-structured interviews:

- What are the challenges (noise) you encountered in online teaching?
- What kind of challenges have you met while doing your assignments/tasks during online classes?
- What channel do you prefer? Face-to-face, online, or blended learning?
- Some extra comments.

4 RESULTS AND DISCUSSION

This section presents the results provided by the students in response to the research questions discussed above. Quantitative survey responses and qualitative interview data were analyzed to identify key themes related to student preferences and challenges across various learning channels.

4.1 Survey results

Participants demographics. Table 2 provides demographic data on the participants' characteristics, including gender, enrolled program, and year of study.

Table 2. Demographics of respondents (N = 107)

Demographic	Category	Number	Percentage
Gender	Males	72	67.3%
	Females	35	32.7%
Program	Networks and Information Security Engineering	43	40.2%
	Electrical Power and Energy Engineering	37	34.6%
	Electronics Engineering	10	9.3%
	Computer Engineering	10	9.3%
	IT students	5	4.7%
	Communications Engineering	2	1.9%
Year of Study	Second	35	32.7%
	Third	51	47.7%
	Fourth	18	16.8%
	Fifth	3	2.8%

The primary objective of this study is to investigate how students notice online learning and face-to-face learning, with a particular focus on fundamental engineering courses. Regarding the upcoming questions, the students were asked to list the fundamental courses they took online and those they later took face-to-face. Figures 3 and 4 show students' enrollment in online and face-to-face courses, respectively.

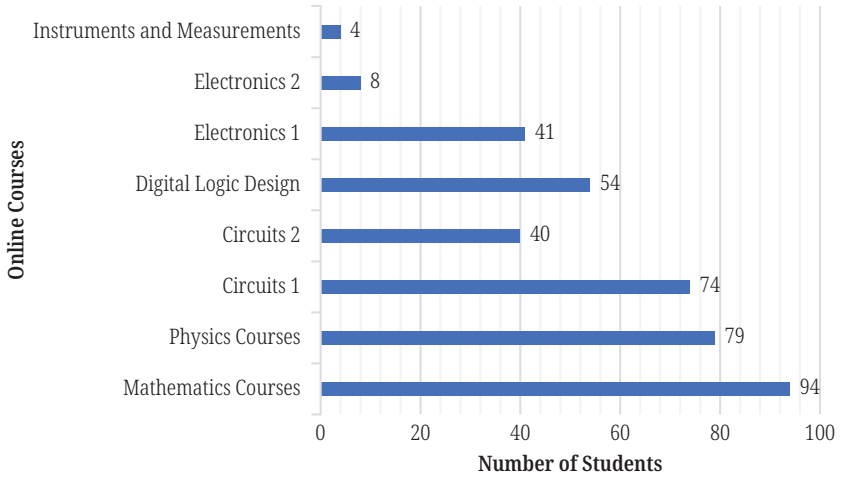


Fig. 3. Student enrollment in online courses

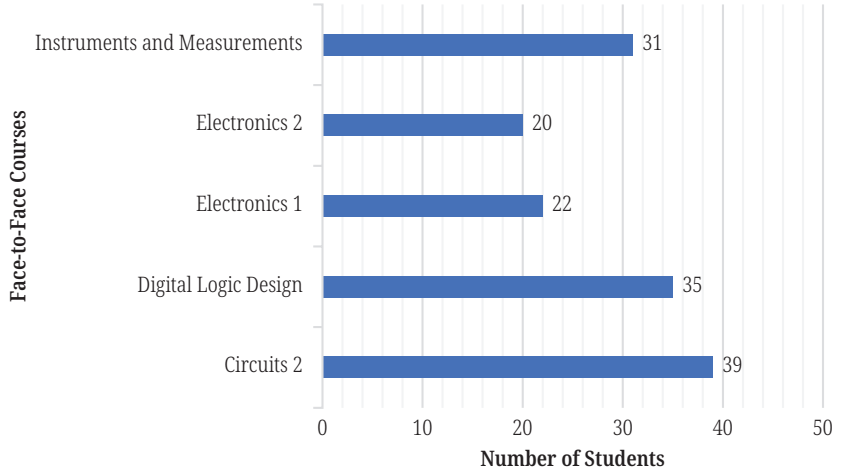


Fig. 4. Student enrollment in face-to-face courses

To examine the learning process through the lens of a communication model, the results were analyzed and organized according to the research questions above and outlined in the following sections.

Tools for online and face-to-face learning environment for both senders and receivers. Selecting a tool to use in an online class can vary depending on individual preferences. As shown in Figure 5, in online classes, most students primarily used laptops, followed by mobile devices, and, lastly, desktops.

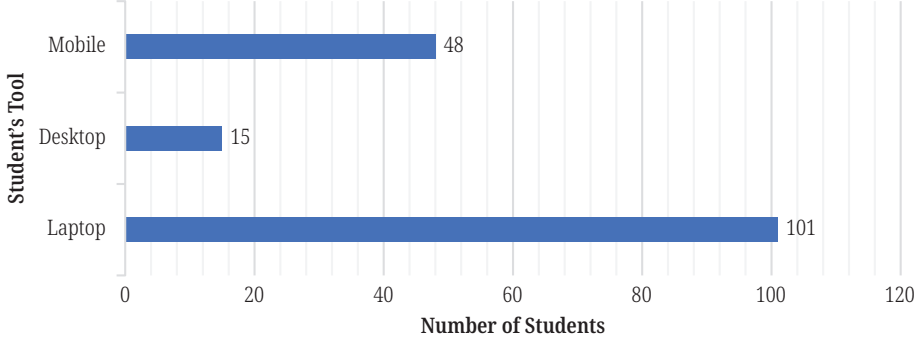


Fig. 5. Student's or receiver's tool for online classes

The charts in Figures 6 and 7 show whether students prefer instructors to use a whiteboard/writing pad, slides, or a mix of both for online and face-to-face sessions. The combination of both the whiteboard and the slides yielded the highest percentage for both learning channels. Moreover, it can be seen that using slides alone is the least preferable approach, especially in face-to-face lectures.

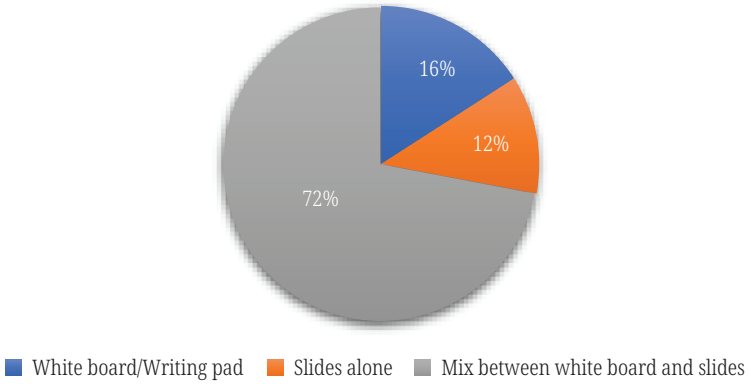


Fig. 6. Students' preferences for instructors' different teaching tools for online classes

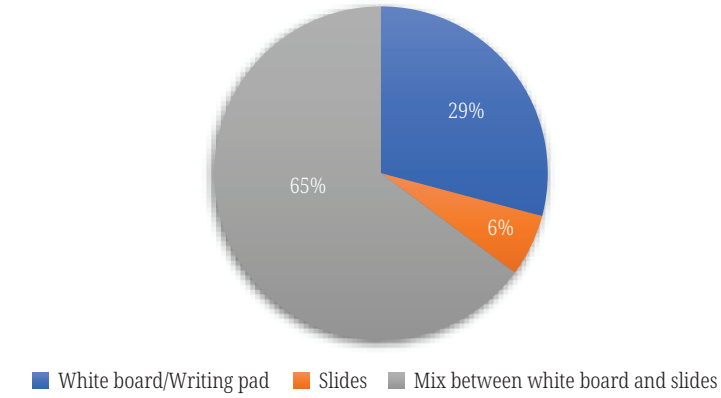


Fig. 7. Students' preferences for instructors' different teaching tools for face-to-face classes

In the case of online learning, some instructors use live synchronous sessions, while others combine live lectures with recorded ones. Figure 8 shows that 57% of students preferred live sessions, while 43% preferred recorded sessions, suggesting greater engagement.

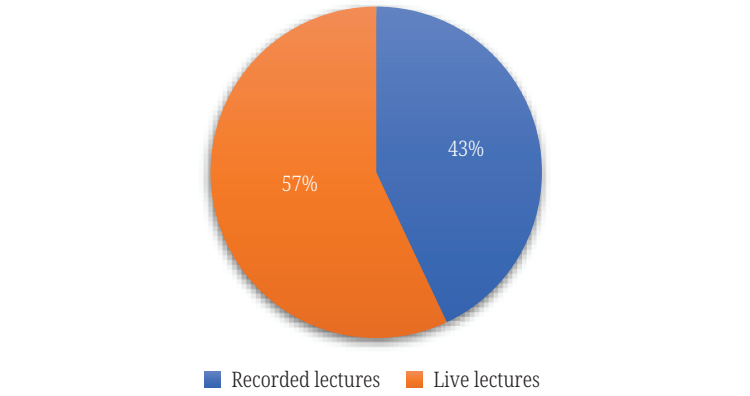


Fig. 8. Students' preference for online learning – live versus recorded lectures

In summary, this section discusses the communication tools used for both face-to-face and online learning. The results show that laptops are the most commonly used devices by students for attending online lectures. A combination of whiteboard and slides is the preferred method for delivering the curriculum across both learning channels. Additionally, live sessions are favored over recorded ones for online learning. This suggests that increased engagement and interaction lead to a more effective learning experience.

Noise factors impacting the effectiveness of face-to-face and online learning channels. The message in online and face-to-face learning channels may not be easily understood due to several factors, which can be considered as noise in the communication system. Factors considered to interfere with the learning process are discussed below for each channel.

1. Online learning noise factors: The following statements are factors that affect online learning:
   - Instructor's camera improves students' understanding.
   - Students' cameras boost the instructor's engagement.
   - Students' cameras help them stay focused.
   - Students' participation energizes the instructor and class.
   - Classmates' participation improves students' learning.
   - Classmates' cameras help students focus.

   Figure 9 illustrates the results of a survey on students' opinions about these factors, representing the number of students who agreed, disagreed, or saw no impact with each statement. This helps identify which elements are perceived as having a positive impact on online learning and which are considered noise. The x-axis shows the statements. The stacked bars represent students' agreement, disagreement, and indifference towards each statement.

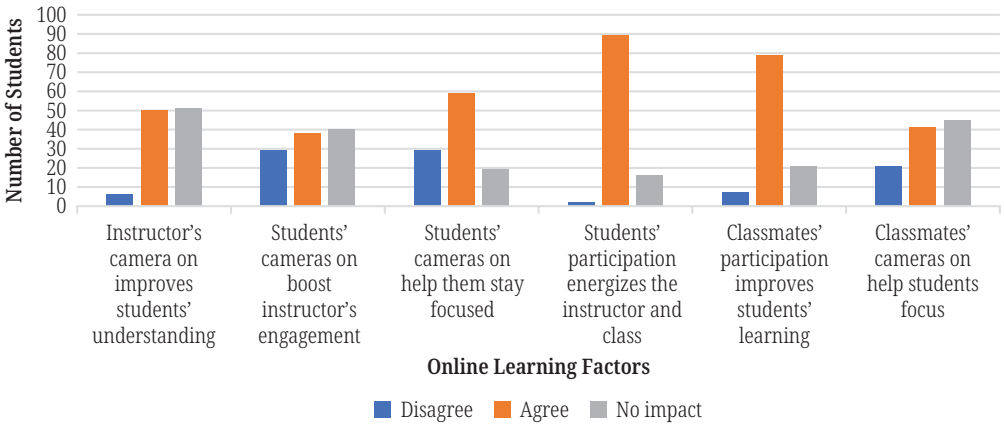


Fig. 9. Perceived impact of online learning factors on students

It is clear from the chart above that students' self-participation and colleagues' participation have a big positive impact on the online learning process. Additionally, having the student's camera on during an online class increases both the student's focus and the instructor's energy, a setup similar to that in face-to-face classes.

2. Face-to-face noise factors: Considering that attending face-to-face lectures involves commute time and preparation time, the following questions examine the impact of this time as a potential noise factor in the face-to-face channel.

   It is observed that 43.4% of the students take 30 minutes to an hour to reach the university, and around 40% take 30 minutes to an hour to get ready. These numbers

are illustrated in Figures 10 and 11. The approximate time required for the whole process is around 45 minutes to an hour.

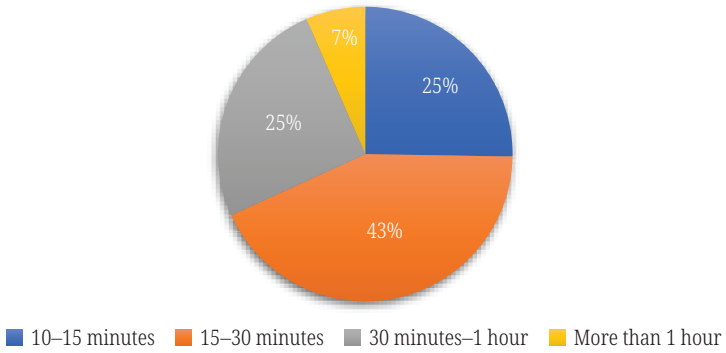


Fig. 10. Time needed to commute to campus

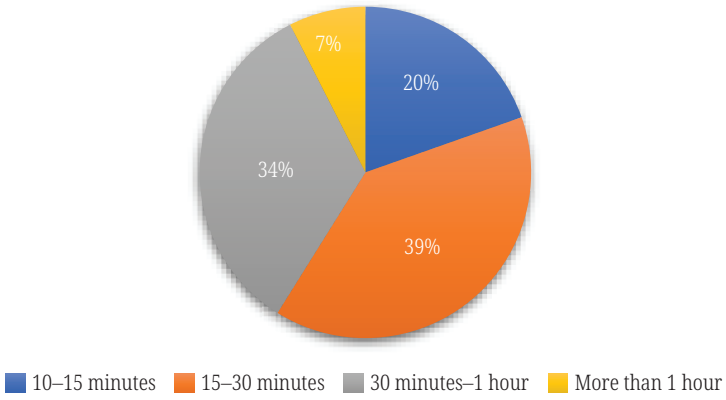


Fig. 11. Time needed to get ready to go to campus

The majority of students initially took their prerequisite courses online and later continued with the subsequent courses in a face-to-face format. When difficulties were encountered, they were asked whether completing the prerequisite online had affected their current academic standing. The pie chart in Figure 12 shows that about 72% of students reported that this negatively affected their understanding.

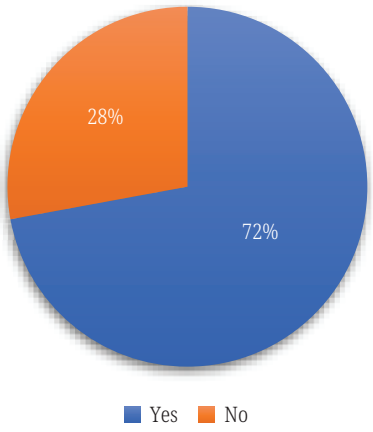


Fig. 12. Prerequisite course taken online and its negative impact on current face-to-face learning

The column chart in Figure 13 highlights additional challenges that may be contributing to a lack of comprehension of the material. It is observed that, in addition to having the prerequisite online, more than half of the students state that the current courses' complexity could also be a reason. However, they also state that not having a recording to refer back to is another challenge.

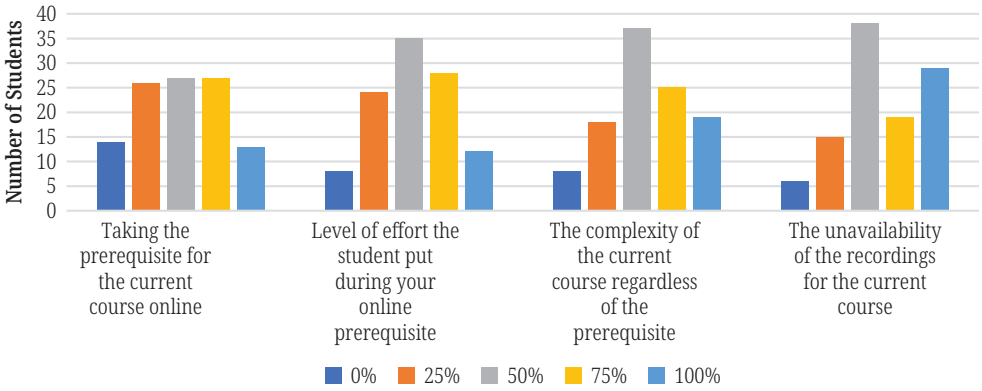


Fig. 13. Noise factors in current face-to-face lectures

In summary, commute time, the prerequisites for the current online courses, and the complexity of the courses themselves were all considered factors contributing to face-to-face channel noise. Furthermore, the unavailability of recordings for face-to-face sessions can also be considered a source of noise. It appears that students greatly benefit from having access to recordings.

Feedback loop in the learning process. In a communication system, the feedback loop is a crucial concept that ensures the message has been received and understood correctly, allowing for adjustments when needed. In education, two feedback loops can be considered: an Instructor Feedback Loop and a Self-Feedback Loop, as shown in Figure 14. The former one states that instructors assess student performance and provide feedback to improve understanding and skills. The latter, the Self-Feedback Loop, allows learners to evaluate their progress, identifying areas for improvement.

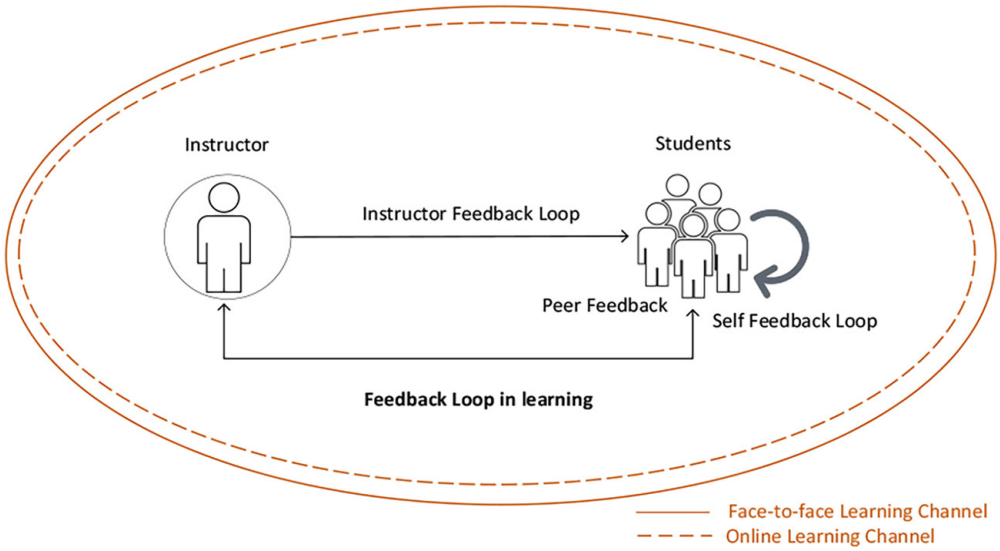


Fig. 14. Feedback loop

1. Instructor feedback loop: Assessment plays a significant role as a form of feedback. Both formal (e.g., quizzes, exams, assignments) and informal (e.g., class participation, peer feedback) assessments provide students with valuable insights into their learning progress. These assessments tell students whether they're on track and highlight specific areas where they need to focus more.

   Considering informal assessments, as shown in Figure 9, "Perceived Impact of Online Learning Factors on Students," it is noted that student and colleague participation can serve as acknowledgment signals and peer feedback, positively affecting the learning process.

   Regarding the formal assessment, the results shown in Figure 15 demonstrate the students' preferences and how the grade distribution better suits them. Around 58% of students stated that whether they prefer computerized, non-computerized, on–campus, or off-campus assessment depends on the type of course.

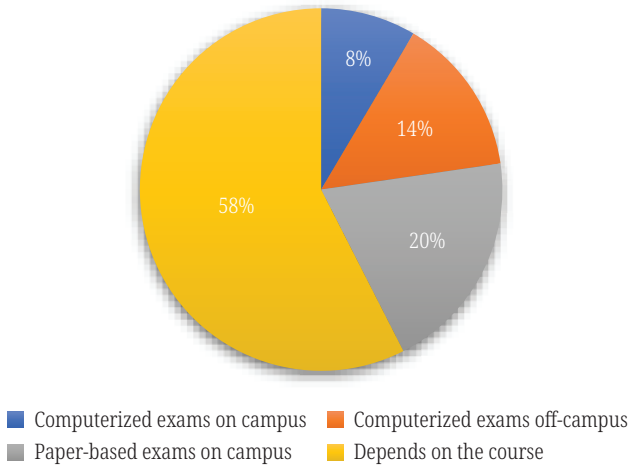


Fig. 15. Students' exam preference

For the Course Assessment, as shown in Figure 16, the numbers were close, but a larger portion of the students preferred two separate exams, a first and a second exam, and a smaller portion preferred class work.

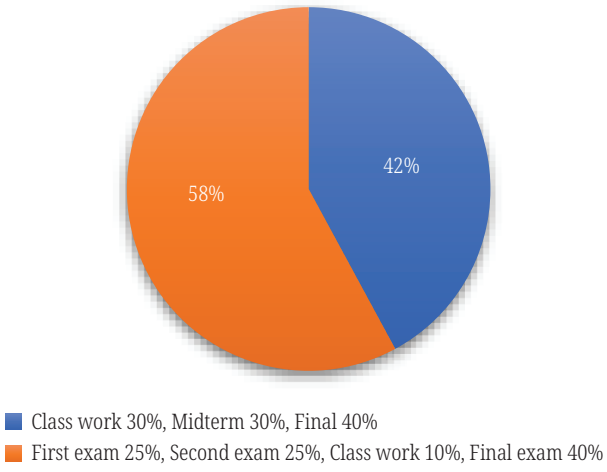


Fig. 16. Preference of course assessment distribution

In the case class portion, which is worth 30 points, most students prefer it to be distributed equally among assignments, quizzes, and a final project, with 10 points per component. The distribution preference is illustrated in Figure 17.

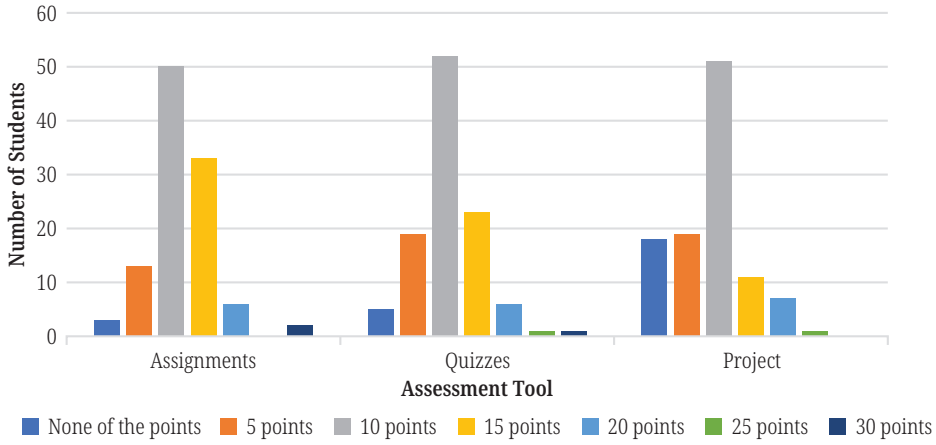


Fig. 17. Grade distribution of the assessment tools

2. Self-feedback loop: In communications, self-checking can mean continuously monitoring message comprehension during the learning process. This self-check process can be viewed as formative feedback, where students recognize gaps in their knowledge and take steps to address them (such as revisiting recorded lectures, asking for clarification, taking notes, and requesting retransmissions).
3. The bar chart in Figure 18 shows four areas where students can seek help after attending an online class: recordings, office hours, textbooks, and colleagues. Recordings are considered the most common resource for students who still don't fully understand the material. Office hours come second, followed by colleagues, while the lowest percentage of students reported going back to textbooks.

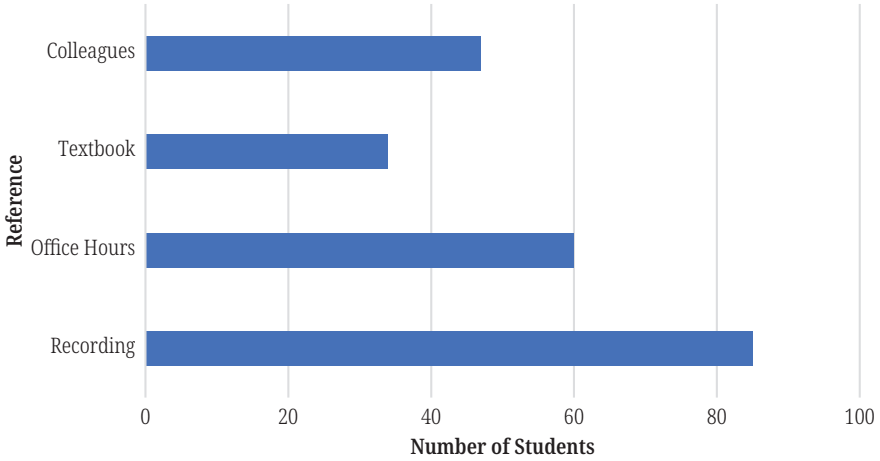


Fig. 18. Reference in case questions are needed

The textbook referral was considered the least used by students. Around 60% of the students stated that they have textbooks for some of their courses. However, 43% of students refer to it sometimes, and 30% use it only to solve questions, as shown in Figures 19 and 20, respectively.

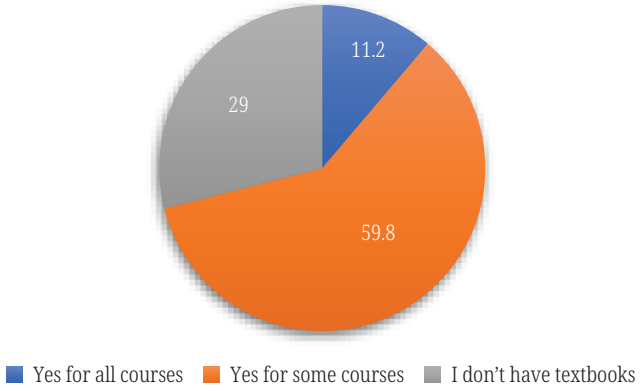


Fig. 19. Owning textbooks

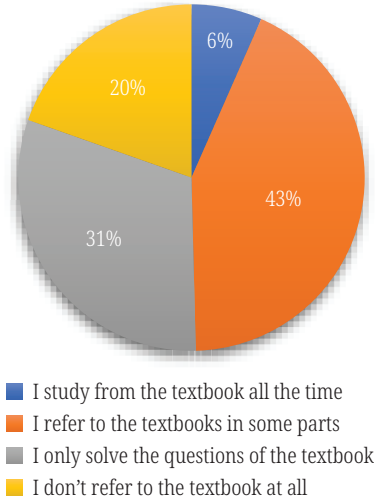


Fig. 20. Textbooks used as a learning resource in the course

Regarding the effort put into studying and the self-check process for online and face-to-face learning, the percentages shown in Figure 21 are quite close, suggesting comparable levels of study effort across the two learning modes.

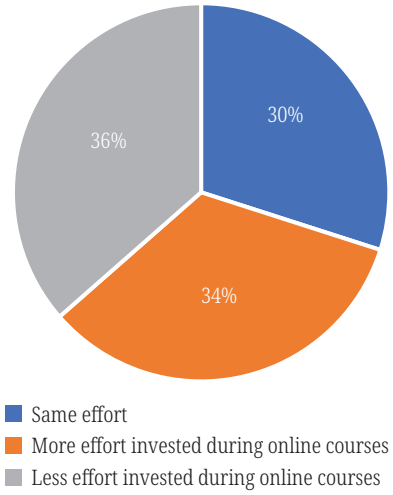


Fig. 21. Effort invested by students across the online and face-to-face learning channels

The feedback loop, whether it's instructor or self-feedback, is a continuous improvement cycle involving communication between instructors and students. It fosters a dynamic learning environment, transforming evaluation from a static measure into an active tool for ongoing growth and development.

Preference of learning channels. A question was designed to assess students' overall preference between face-to-face and online channels, examining it from the perspectives of message comprehension, commute, participation, social interaction, and assessment. As shown in Figure 22, it is evident that students prefer face-to-face learning, except for the commuting category, as expected.

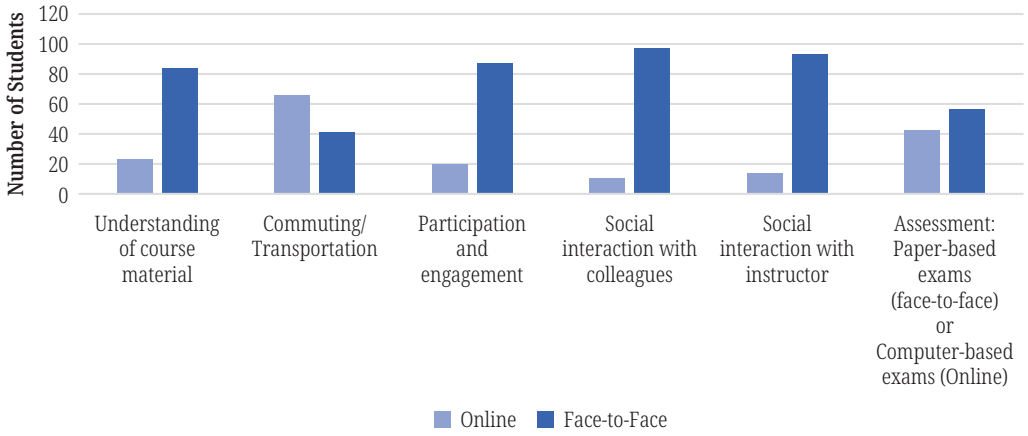


Fig. 22. Preference between online and face-to-face learning

4.2 Qualitative analysis of students' interviews

A semi-structured interview was conducted with seven participants to explore students' perspectives on the impact of online learning on their academic performance. The data were analyzed thematically, and for each theme, illustrative quotes were selected to represent participants' views as shown in Figure 23. The following section presents the key findings, highlighting the major themes derived from the interviews.

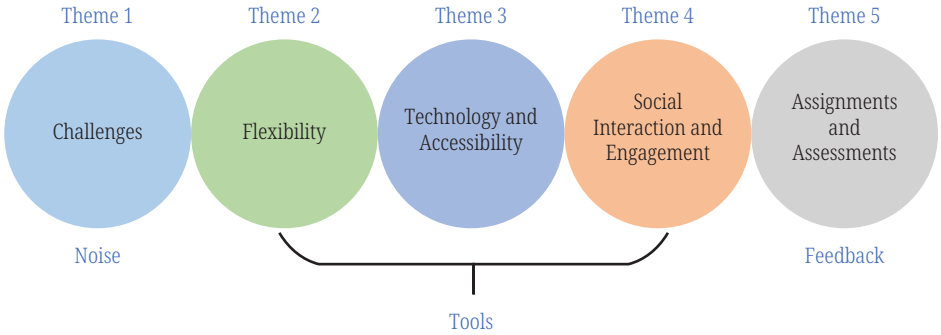


Fig. 23. Interview themes

Theme 1: Challenges with online learning: A recurring theme in the interviews was the difficulty participants faced in adapting to online learning. Many reported feeling bored and struggling to focus.

- **Participant 1:** "I struggle with staying focused. It is very boring watching an online class."
- **Participant 2:** "I can't stay focused at home; the environment doesn't encourage you to study or work where everyone else in the family is doing different tasks."
- **Participant 5:** "I can't focus well during online lectures."
- **Participant 7:** "It is very boring to me; I can't raise my hand easily and can't focus much."

Theme 2: Flexibility: Another theme that emerged was the flexibility of online learning, which some participants appreciated, while others noted issues with time management and procrastination.

- **Participant 1:** "I like face-to-face lectures better as a I commit to a certain time."
- **Participant 3:** "The presence of recordings makes me want to postpone everything."
- **Participant 4:** "I like online learning, since I can study at my own pace and my own convenience."
- **Participant 5:** "Online lectures are spread throughout the day, which keeps me occupied for longer hours."
- **Participant 6:** "It is hard to be on top of things, as you are occupied all throughout the day."

Theme 3: Technology and accessibility: Students discussed how technology plays a significant role in their online learning experience. Some participants highlighted challenges faced in fundamental engineering courses.

- **Participant 1:** "Solving equations in engineering is complex, and doing it online makes it harder as the steps are not clear."
- **Participant 4:** "I have issues with the use of technology. The lecturer is not equipped while using online tools, and the camera is not directed properly. Quality of teaching isn't the best. Moreover, the use of WhatsApp groups for communication, was a bit annoying, as I didn't know who is in the group."
- **Participant 5:** "I hate the use of slides during lectures."
- **Participant 6:** "Online learning is stressful, especially for mathematical and scientific classes."

Theme 4: Social interaction and engagement: Many participants highlighted the impact of online learning on their social interaction and engagement. Increased stress was common.

- **Participant 3:** " It is easier to study when others are around, reliability on others to comprehend the lectures."
- **Participant 5:** "Online learning is more challenging for me. I don't get the support I need from instructors or colleagues."
- **Participant 6:** "No interaction with the instructor makes it really hard to concentrate and comprehend the material during face-to-face lectures, more questions pop up which keeps you more engaged. Moreover, group work is much harder."
- **Participant 7:** "Hard to know others in your course, and hard to communicate with the instructor during office hours."

Theme 5: Assignments and assessments: Many participants highlighted the impact of online learning on their overall grades.

- **Participant 1:** "Too many assignments, it was really overwhelming."
- **Participant 2:** "Too many assignments, yet so little help is offered from instructors and colleagues. Moreover, one-way exams are unfair."
- **Participant 3:** "The only time I failed an exam was one I started taking online courses; there were limited time for exams."
- **Participant 4:** "Instructors were not available on the spot, which made communication a bit challenging."
- **Participant 5:** "I am getting lower grades in online learning."
- **Participant 7:** "Not easy to follow up on assignments. Also, online exams are the worst; they are very stressful and not fair."

In summary, the interviews exposed mixed thoughts on online learning. While some participants appreciated the flexibility, others found the lack of social interaction between instructors and colleagues challenging. Understanding the curriculum was also a prominent issue, especially for fundamental engineering courses.

The preference for face-to-face learning was consistent across all key themes discussed, as shown in Table 3 below, based on the sample of participants.

Table 3. Interview results summary

Theme	Preferred Online Learning	Preferred Face-to-Face Learning
Challenges	0	4
Flexibility	1	3
Technology and Accessibility	0	4
Social Interaction and Engagement	0	4
Assignments and Assessments	0	5

These results suggest that while flexibility remains a notable benefit of online learning, the drawbacks have a significant impact on student satisfaction and engagement. The complete lack of preference for online learning indicates a strong overall leaning toward in-person education for fundamental engineering courses.

4.3 Summary of results

The findings thoroughly answer the research questions by highlighting students' perspectives on the similarities and differences between face-to-face and online learning across multiple angles. A summary of these findings is presented below. To facilitate interpretation, the results are organized into three main categories: tools, challenges, and feedback.

Tools:

- Students prefer engaging in live, interactive sessions, with a combined use of whiteboard and slides being the favored method of instruction across both online and face-to-face learning.
- Recorded lectures serve as a valuable backup for missed classes, providing flexibility, though they typically offer less engagement compared to live sessions.

- The percentages for studying efforts and self-assessment in both online and face-to-face learning are very similar, indicating that students put comparable effort into studying across the two channels, especially for fundamental engineering courses.
- Students identified key differences between online and face-to-face learning in terms of interaction, engagement, and flexibility.

Challenges:

- For online classes, active student participation and keeping cameras on significantly improve focus and students' engagement.
- For face-to-face classes, one main challenge is the commute and preparation time.
- The absence of immediate interaction in online learning can lead to a misunderstanding of the curriculum and some frustration.
- Although online learning was appreciated for its accessibility and convenience, students often struggle a stay focused during online lectures, which can delay their learning success.
- Students show a clear preference for face-to-face teaching in fundamental engineering courses across various categories, except commuting and transportation.

Feedback:

- A feedback loop fosters a dynamic learning environment and serves as an active tool for ongoing development. This highlights the importance of clear communication between instructors and students in both online and face-to-face modalities.
- Face-to-face learning was often preferred for fostering deeper student-instructor relationships and immediate feedback.

The perceptions shared by students provide valuable guidance for the continued development of online and blended learning modalities. From the key findings above, a recommended context for instructors with respect to improving online teaching programs is suggested below:

- Encourage active participation, promote student interaction, and address focus challenges during online lectures by breaking lectures into shorter segments with frequent breaks and asking multiple questions during the class using polls.
- Utilize a combination of whiteboard and slide presentations, and incorporate live sessions for real-time interaction alongside recorded lectures for backup.
- Foster self-assessment and feedback by integrating regular quizzes and exercises to help students monitor their progress, and offering constructive feedback.

Overall, the findings show that learning effectiveness across online and face-to-face environments is fundamentally shaped by the three presences of the CoI framework. Teaching presence emerged through students' strong preferences for structured live sessions, clear instructional design, and interactive delivery methods. Cognitive presence was closely tied to message clarity, sustained focus, and the reduction of communication noise, particularly in mathematically intensive engineering content. Social presence was reflected in the importance of peer interaction, participation, and student–instructor engagement in supporting motivation and learning persistence. Across all modalities, weaknesses in any of these presences were associated with reduced engagement and conceptual understanding.

Table 4 maps the CoI framework within a communication-theoretic structure, transforming its conceptual constructs into functional components of the educational process. Teaching presence is embedded in instructional design and channel selection, cognitive presence is reflected in message clarity and noise reduction, and social presence is expressed through interaction and participation structures. The feedback loop integrates these dimensions into a dynamic learning system, enabling continuous adaptation and improvement. This integrated framework provides a coherent theoretical foundation for analyzing students' experiences across online, face-to-face, and blended learning environments.

Table 4. Mapping the community of inquiry framework to the proposed communication-based classroom model

Core Element	Proposed Communication Model	Meaning in This Study	Results from Study
Teaching Presence	Sender + Channel + Tool Selection	Instructor design, organization, and facilitation of learning through appropriate tools and delivery modes	Preference for live sessions, combined use of whiteboard and slides, structured delivery, interactive teaching approaches
Cognitive Presence	Message + Noise	Students' ability to process, understand, and apply engineering concepts under varying levels of communication interference	Difficulty with equations in online learning, reduced focus, conceptual misunderstanding, preference for face-to-face clarification
Social Presence	Interaction + Participation	Degree of student–student and student–instructor engagement, visibility, and communication	Importance of participation, camera use, peer interaction, strong preference for face-to-face engagement
CoI Integration Mechanism	Feedback Loop	Continuous interaction between teaching, cognitive, and social dimensions through assessment and reflection	Assessment structures, self-feedback behaviors, use of recordings, office hours, peer support, continuous clarification

Together, these results frame learning as an integrated communicative process in which teaching, cognitive, and social presences jointly determine educational quality, providing a coherent theoretical foundation for the conclusions that follow.

5 CONCLUSION AND FUTURE WORK

This study investigated students' preferences and experiences across online, face-to-face, and blended learning channels in fundamental engineering courses through a communication-based classroom model. By conceptualizing education as a structured communication process—where instructors act as senders, students as receivers, the curriculum as the message, learning modalities as channels, and assessment as feedback—the study provides a coherent framework for understanding how learning effectiveness is shaped by interaction quality, message clarity, and the presence of noise.

The findings indicate a clear preference for face-to-face learning, driven not by the physical environment itself, but by the quality of interaction, immediacy of feedback, and clarity of communication it enables. Online learning, while offering flexibility and accessibility, was associated with increased communication noise, reduced engagement, and weaker conceptual understanding, particularly for mathematically intensive and conceptually complex engineering content.

When interpreted through the CoI framework, the results highlight the central roles of teaching, cognitive, and social presence in shaping learning effectiveness. Face-to-face environments were perceived as more supportive of all three presences through stronger interaction, sustained attention, and continuous feedback. The proposed communication model integrates these dimensions into a unified framework, positioning learning as an interactive system in which channel design, interaction structures, and feedback mechanisms collectively determine educational quality. These findings suggest that effective engineering education should prioritize communication quality and engagement design across modalities, with blended models offering a promising pathway for sustainable and resilient instructional practice.

5.1 Limitations of the study

This study has several limitations that should be considered when interpreting the findings. First, the sample was obtained through convenience sampling from a single institution, which limits the generalizability of the results to other universities, disciplines, and cultural contexts. Second, the study focused exclusively on engineering students, and therefore, the findings may not directly transfer to non-engineering educational contexts without further validation. Third, the sample size, particularly for the qualitative interviews, was relatively small, which may limit the breadth of perspectives captured. Finally, the study relied on self-reported data, which may be subject to response bias and subjective interpretation. These limitations highlight the need for future studies using larger, multi-institutional samples, diverse academic disciplines, and mixed-method designs with validated instruments to strengthen the external validity and generalizability of the proposed framework.

5.2 Future work

Future work will explore the integration of artificial intelligence (AI) into this communication framework, particularly in supporting personalized learning pathways, adaptive feedback systems, intelligent tutoring, and real-time learning analytics. Investigating AI-driven scaffolding, automated formative assessment, and adaptive content delivery may provide new mechanisms for reducing noise, enhancing cognitive presence, and strengthening feedback loops across all educational channels.

5.3 Ethical statement

Based on the IRB Protocol Number 2026-0027 review, participation in this study was voluntary. Participants were informed about the purpose of the research, and no personally identifiable information was collected. Participants were also informed of their right to withdraw from the study at any time without penalty.

This study was conducted in accordance with established ethical principles, ensuring integrity, transparency, and respect for all participants.

5.4 Conflict of interest

The authors declare that they have no conflict of interest.

5.5 Funding

No funding was received for this research project.

6 REFERENCES

[1] United Nations, "Policy brief: Education during COVID-19 and beyond," United Nations, New York, NY, USA, Policy Brief, 2020, pp. 1–26. https://doi.org/10.18356/21e7d903-en

[2] C. E. Stoian, M. A. Fărcașiu, G. M. Dragomir, and V. Gherheș, "Transition from online to face-to-face education after COVID-19: The benefits of online education from students' perspective," *Sustainability*, vol. 14, no. 19, Art. no. 12812, 2022. https://doi.org/10.3390/su141912812

[3] D. R. Garrison and J. B. Arbaugh, "Researching the community of inquiry framework: Review, issues, and future directions," *The Internet and Higher Education*, vol. 10, no. 3, pp. 157–172, 2007. https://doi.org/10.1016/j.iheduc.2007.04.001

[4] M. G. Batarseh, R. K. Alqudah, and F. B. El Issa, "Online labs in modern engineering education: Global reality or restricted concept?" in *Proceedings of the 2023 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM)*, Singapore, 2023, pp. 401–405. https://doi.org/10.1109/IEEM58616.2023.10406896

[5] J. Biggs, C. Tang, and G. Kennedy, *Teaching for Quality Learning at University*, 5th ed. Maidenhead, U.K.: McGraw-Hill Education, 2022.

[6] D. Khodadad, "Creating a supportive and effective learning environment for engineering students: Pedagogical Strategies, engagement, and enhanced outcomes," *International Journal of Engineering Pedagogy (iJEP)*, vol. 13, no. 8, pp. 33–50, 2023. https://doi.org/10.3991/ijep.v13i8.41755

[7] J. Bourne, D. Harris, and F. Mayadas, "Online engineering education: Learning anywhere, anytime," *Journal of Engineering Education*, vol. 94, pp. 131–146, 2005. https://doi.org/10.1002/j.2168-9830.2005.tb00834.x

[8] M. Queiruga-Dios, M. J. Santos Sánchez, M. Á. Queiruga-Dios, P. M. Acosta Castellanos, and A. Queiruga-Dios, "Assessment methods for service-learning projects in engineering in higher education: A systematic review," *Frontiers in Psychology*, vol. 12, Art. no. 629231, 2021. https://doi.org/10.3389/fpsyg.2021.629231

[9] N. Jalinus, Z. M. Ganefri, M. A. Zaus, R. E. Wulansari, R. A. Nabawi, and H. Hidayat, "Blended and collaborative networks approach: Online learning integrated project and Kolb learning style in mechanical engineering courses," *International Journal of Online and Biomedical Engineering*, vo1. 8, no. 15, pp. 4–16, 2022. https://doi.org/10.3991/ijoe.v18i15.34333

[10] L. D. Lapitan Jr., C. E. Tiangco, D. A. G. Sumalinog, N. S. Sabarillo, and J. M. Diaz, "An effective blended online teaching and learning strategy during the COVID-19 pandemic," *Education for Chemical Engineers*, vol. 35, pp. 116–131, 2021. https://doi.org/10.1016/j.ece.2021.01.012

[11] E. Mushtaha, S. Abu Dabous, I. Alsyouf, A. Ahmed, and N. R. Abdraboh, "The challenges and opportunities of online learning and teaching at engineering and theoretical colleges during the pandemic," *Ain Shams Engineering Journal*, vol. 13, no. 6, Art. no. 101770, 2022. https://doi.org/10.1016/j.asej.2022.101770

[12] N. P. Subheesh and S. S. Sethy, "Assessment and evaluation practices in engineering education: A global perspective," in *Proceedings of the 2018 3rd International Conference of the Portuguese Society for Engineering Education (CISPEE)*, 2018, pp. 1–5. https://doi.org/10.1109/CISPEE.2018.8593451

[13] A. Khandakar, M. E. Chowdhury, M. S. Khalid, and N. Zorba, "Case study of multi-course project-based learning and online assessment in electrical engineering courses during COVID-19 pandemic," *Sustainability*, vol. 14, no. 9, Art. no. 5056, 2022. https://doi.org/10.3390/su14095056

[14] N. F. Jumaat and Z. Tasir, "Instructional scaffolding in online learning environment: A meta-analysis," in *Proceedings of the 2014 International Conference on Teaching and Learning in Computing and Engineering*, 2014, pp. 74–77. https://doi.org/10.1109/LaTiCE.2014.22

[15] S. Asgari, J. Trajkovic, M. Rahmani, W. Zhang, R. C. Lo, and A. Sciortino, "An observational study of engineering online education during the COVID-19 pandemic," *PLoS ONE*, vol. 16, no. 4, Art. no. e0250041, 2021. https://doi.org/10.1371/journal.pone.0250041

[16] P. Warfvinge, J. Löfgreen, K. Andersson, T. Roxå, and C. Åkerman, "The rapid transition from campus to online teaching – how are students' perception of learning experiences affected?" *European Journal of Engineering Education*, vol. 47, no. 2, pp. 211–229, 2022. https://doi.org/10.1080/03043797.2021.1942794

[17] R. Alqudah, M. Batarseh, and F. El-Issa, "Exploring online teaching's impact on instructors in core engineering courses: Insights, challenges, and future directions," *Computers & Applications in Engineering Education*, vol. 33, no. 1, Art. no. e22807, 2025. https://doi.org/10.1002/cae.22807

[18] L. Mamedova, A. Rukovich, T. Likhouzova, and L. Vorona-Slivinskaya, "Online education of engineering students: Educational platforms and their influence on the level of academic performance," *Education and Information Technologies*, vol. 28, no. 11, pp. 15173–15187, 2023. https://doi.org/10.1007/s10639-023-11822-5

[19] V. I. Manea, T. Macavei, and C. Pribeanu, "Perceived benefits of online lectures during the pandemic: A case study in engineering education," *Pro Edu. Int. J. Educ. Sci.*, vol. 3, no. 4, pp. 35–41, 2021. https://doi.org/10.26520/peijes.2021.4.3.35-41

[20] M. Mielikäinen and E. Viippola, "ICT engineering students' perceptions on project-based online learning in Community of Inquiry (CoI)," *SAGE Open*, vol. 13, no. 3, pp. 1–22, 2023. https://doi.org/10.1177/21582440231180602

[21] W. Ibrahim and R. Morsi, "Online engineering education: A comprehensive review," in *Proc. 2005 ASEE Annu. Conf. & Expo.*, Portland, OR, USA, 2005, pp. 10.973.1–10.973.10. https://doi.org/10.18260/1-2--14337

[22] M. Al-Nasa'h and F. A. Awwad, "The effect of the COVID-19 pandemic among undergraduate engineering students in Jordanian universities: Factors impact students' learning satisfaction," in *2021 Innovation and New Trends in Engineering, Science and Technology Education Conference (IETSEC)*, 2021, pp. 1–7. https://doi.org/10.1109/IETSEC51476.2021.9440500

7 AUTHORS

Fadia Elissa received her BSc and MSc degrees from King Abdullah II School of Engineering, Princess Sumaya University for Technology (PSUT), Jordan, in 2010 and 2014, respectively, in Telecommunications and Electrical Engineering. She is currently a Lecturer in the Electrical Engineering Department at PSUT, where she teaches several engineering courses. Her research interests include educational technology, engineering education, and communication skills development.

She is passionate about education reform, youth development, and mentoring students for academic and career success (E-mail: f.elissa@psut.edu.jo).

Rajaa Alqudah received her B.S. degree in Computer Engineering from Yarmouk University, Jordan, in 2003, her M.Sc. degree in Computer Engineering from Northeastern University, USA, in 2007, and her Ph.D. degree in Computer Engineering from Syracuse University, USA, in 2011. She currently serves as an Associate Professor of Computer Engineering at King Abdullah II School of Engineering, Princess Sumaya University for Technology (PSUT), Jordan. Prior to academia, Rajaa spent more than 10 years in industry at Intel Corporation, working in pre-silicon validation (E-mail: r.alqudah@psut.edu.jo).

Majd Batarseh (M'03–SM'19) received a B.Sc. degree in Electrical Engineering from the University of Jordan, Amman, Jordan, in 2004 and the M.Sc. and Ph.D. degrees in Electrical Engineering from the University of Central Florida, Orlando, USA, in 2007 and 2010, respectively. She is currently an Associate Professor in the Electrical Engineering Department at King Abdullah II School of Engineering, Princess Sumaya University for Technology, Amman, Jordan. Her research interests include power electronics, renewable energy, modern electrical energy systems and education (E-mail: M.Batarseh@psut.edu.jo).