Challenges and Prospects of E-Learning in Engineering Education: A Case Study from Palestinian Universities Post-COVID-19

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Abstract—When COVID-19 closed campuses worldwide, colleges suddenly had to swap lecture halls for laptops, and engineering programs struggled most because so much of the field depends on workshops and labs that cannot be moved online. This paper looks at the roadblocks and open spaces that distance learning created for engineering students at Palestinian universities during the crisis and the months that followed. Using both surveys and interviews, the study questioned 108 first- to final-year students from several branches of engineering at two leading institutions. The numbers show that students often fought with poor Internet, missing equipment, lack of hands-on demos, fading motivation, and limited contact with busy lecturers. Written comments reinforced those themes and called for sturdy WiFi, blended classes mixing live and recorded sessions, and additional tutoring that meets industry standards. Together, the results warn that quick fixes will not hold long; faculties must rethink online engineering courses so graduates are skilled, confident, and ready for a tech-driven job market—even when budgets are tight.

I. INTRODUCTION

The integration of digital technologies with higher education gave engineering teaching an all-pervasive image across the globe. According to the World Bank report (2021), more than 60% of engineering programs worldwide now include some form of online or blended learning to guarantee flexibility and access. This trend was further accelerated with the outbreak of COVID-19, where remote emergency instruction became the only viable alternative during the 2020-21 period [1]. The rationale behind this switch was to provide continuity in education with health considerations while revealing serious obstacles related to distance education in fields that heavily rely on hands-on experiences. Challenges in Distance Engineering Education:

A. Practical and Laboratory-Based Learning

Practicing engineering training is hands-on by nature. For example, mechanical and civil engineering curricula include laboratory experiments in material properties, fluid mechanics, and structural analysis, and these tests can hardly ever be implemented properly online. Whereas virtual labs—MIT's Open Learning Library (2019) would seem to be one such example—perform simulations of such experiments, from students' perception and feedback, these often disregard the tactile feedback, real-world considerations, and experimental intricacies of their physical counterparts. A research study conducted by [2] even concluded that students have generally acquired lesser skills compared to those who took part in actual real-world experiments, thus confirming the inadequacy of the present virtual systems. Electrical engineering, on the contrary, has issues mainly arising from hardware-based activities such as circuit testing, power systems, and embedded systems. While tools like Tinkercad Circuits and LabVIEW support virtual experimentation, none of the tools offers a complete substitute for practicing actual troubleshooting and hardware-handling skills deemed proficient for the industry. [3].

B. Software Engineering, Collaborative Work

Of all disciplines, software engineering was perceived to best withstand remote learning, given its digital nature. However, [4] find that project collaboration and peer review, parts of all software courses, suffer from time-zone differences, varying internet access, and difficulties in monitoring the authenticity of group work. Platforms such as GitHub and Jitsi have proved significant but require discipline to use along with infrastructure support.

C. Technological and Infrastructure Barriers

A significant barrier is infrastructural inequity. According to the ITU (2023), approximately 37% of students worldwide lack reliable internet access, with disparities more severe in rural and developing regions. A survey by UNESCO (2022) indicates that students in low-income countries are 3–4 times more likely to face technical difficulties during online classes, which hampers equitable access to quality education.

D. Student Engagement, Motivation, and Assessment

Remote learning environments risk reducing interaction and classroom dynamics. The lack of face-to-face contact

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can diminish peer learning, mentorship, and immediate instructor feedback—elements vital in engineering education [5]. In addition, ensuring academic integrity during online assessments remains an ongoing concern. Innovations such as online proctoring and open-book exams aim to address these issues but raise questions about privacy and fairness. [6].

E. Significance of Addressing These Challenges

Ensuring high-quality, inclusive, and equitable distance engineering education is more critical than ever. The adoption of virtual laboratories, augmented reality, and AI-powered tutoring systems, as suggested by [7], can help bridge gaps but requires institutional support and resource investments. Furthermore, developing flexible assessment frameworks and promoting digital literacy are essential to preparing students for both academic and industry demands.

The purpose of this paper is to critically analyze the multi-dimensional challenges encountered in distance education for mechanical, civil, electrical, and software engineering disciplines. It explores innovative technological solutions, pedagogical models, and policy implications aimed at overcoming these barriers. By synthesizing recent research and case studies, the goal is to contribute to the development of more effective and inclusive remote engineering education systems capable of meeting the evolving needs of students and industry alike.

II. LITERATURE REVIEW

Several studies and approaches have been created around responding to challenges and restrictions with e-learning in engineering education. Apart from pedagogical issues, additional research is required on the security concerns of multimedia data used in online platforms. The following section considers previous studies on the implementation of e-learning, its effectiveness, and other related engineering education issues in different contexts. A study by [8], in Jordan, showed that e-learning has greatly influenced education in engineering, leading to low productivity, lack of efficient online tools, reduced face-to-face communication, health issues, and low motivation. The research also showed the influence of gender and age in the perception of the effectiveness of e-learning. The findings suggest implementing complete solutions, improved digital literacy tools, and mental health support for successful online engineering education. The study by Guan K. Saw [9], part of the EU-funded REMOTE project, examines students' and lecturers' views on remote learning in STEM subjects across four European universities. It categorized 15 problematic areas and five main dimensions: resource availability and access equity. Challenges that emerged were discrepancies in technology access, lowered teacher-student interaction, an increase in academic dishonesty, difficulties of quality assessment, and a lack of infrastructure for remote practical work. A Brazilian study, Kattiana Constantino [10], observed a substantial drop in students' grades in the first post-pandemic semester in 2022, but they slowly improved until they returned to the pre-pandemic level about 2023. The study suggests a short-term adverse effect but also lacks examination of student engagement and mental health due to its one-time data collection approach. Domenico A. Maisano's study [11], on STEM students' and teachers' attitudes towards remote teaching and learning at four European universities, revealed both convergent and divergent attitudes. Technological access, assessment rigor, academic honesty, and interactivity were some of the diverse array of factors evaluated in the study. It also raised questions about the digital divide and the importance of equal access. "This is going to provide a clue to improving online STEM learning in higher education and making it accessible to everybody, especially as demographics can be a barrier. E-learning has emerged as a major educational method in the 21st century, particularly in engineering education. It combines face-to-face interaction with computer-assisted teaching and online access. However, this article by El-Shaimaa Talaat Abumandour [12] showed challenges such as inadequate IT infrastructure, lack of institutional policies, community resistance, and a shortage of trained personnel remain. Public libraries are key in addressing digital divides by offering access to online resources—and lifelong learning, in the form of digital literacy. Technical education and higher engineering education are assuming responsibility for employability by moving away from teacher-centered pedagogies toward project-based learning (PBL) and, along the way, shifting toward competency-based learning. Miguel Valero [13] showed that resistance to this change could come from institutions and bureaucracy, but students, a deeper knowledge, and basic skills/virtues such as teamwork, communication, and self-learning benefit from it. But teachers might not have hands-on experience with this, and students could be confused or make mistakes. Recognizing these issues is important for educators to construct meaningful, competency-based learning experiences at the post secondary level.

III. METHODOLOGY

A. Study Design

A descriptive analytical approach was applied in the investigation since the framework is suitable to investigate the state of e-learning in the engineering programs in the Palestinian universities besides evaluating the challenges that face the students. In this way, the study used both quantitative and qualitative analysis to have a full picture of the researched phenomenon.

B. Study Instrument

The main instrument of data collection was the electronic questionnaire. It was created with the help of examination of past literature and research carried out on the subject of e-learning within the university and engineering calibers. The survey had two major blocks of questions:

- Section One (Quantitative Data): It consisted of a series of closed-ended statements that were developed based on a five-point Likert scale to assess the perceptions of the students concerning the difficulties of e-learning. The questions were grouped in four major axes:
  - Technological and technical difficulties.
  - Issues to do with student skills.
  - Difficulties associated with faculty members.
  - Institutional and infrastructural issues.
- Section Two (Qualitative Data): It contained open-ended queries that gave the respondents a chance to provide their views and recommendations freely, which gave a qualitative touch to the findings.

C. Sample and Population of study

The research involved a sample of engineering students in a number of Palestinian universities. A simple random sampling was used to choose them because they needed to have reasonable representation of the target group. The participants were 108 male and female students, representing different engineering fields, including civil engineering, electrical engineering, computer engineering, and so forth.

D. Procedures of Data Collection

The survey was sent through electronic resources (university email, student groups in social media). The data collection process lasted two weeks to guarantee that the tool accessed as many students as possible.

E. Methods of Qualitative and Statistical Analysis

IBM SPSS Statistics initially assessed quantitative data, but Python 3.13 was chosen for its technical and analytical requirements. Python complements quantitative data with qualitative analysis, providing context and explanation. Libraries like Pandas, NumPy, and Matplotlib facilitate accurate analysis.

IV. Results

Data were collected through an online survey conducted among engineering students from Birzeit University and Palestine Polytechnic University. The survey consisted of 108 male and female students. It included closed-ended questions in which participants expressed their views on a Likert scale and an open-ended question to share their opinions and suggestions regarding the development of the e-learning experience in engineering disciplines. The presentation of the results in this chapter is divided into two main sections:

- Quantitative results, which reflect numerical responses that can be statistically measured.
- Qualitative results, which review the content of students' open-ended responses and analyze them within thematic areas.

A. Quantitative results

a) Demographic Distribution of Participants: The study involved 108 engineering students from Birzeit University and Palestine Polytechnic University, and as shown in Figure 1.A, they are more dominant in male students. Figure 1.B illustrates that most were 20-25 years old, providing greater validity. Figure 1.C shows that the majority were computer engineering and computer science students, followed by mechanical and electrical engineering. The sample included students from different academic years, enhancing the credibility of the quantitative analysis. Figure 1.D displays that most students were in the third and second years, focusing on applied courses and practical laboratories. Students in the first and fourth years also participated, offering a different perspective on the challenges of creating or adapting to distance learning.

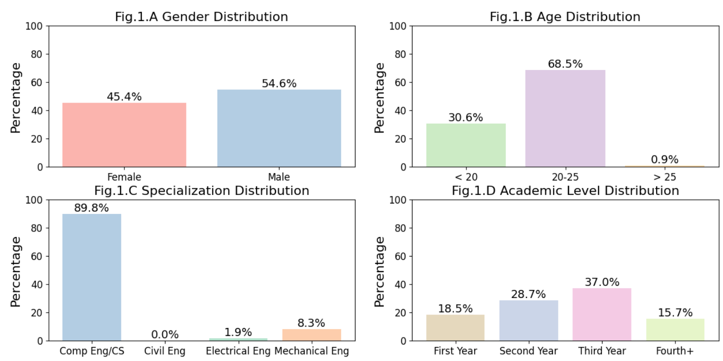

Fig. 1. Demographic Distribution of Participants.

b) The Distance Learning Experience During the Pandemic: The survey revealed that 59.3% of the students experienced e-learning during the COVID-19 pandemic, as shown in Figure (2), indicating that not all the students were inclusive. This suggests differences in the educational infrastructure or department policies. Analyzing the results based on those who did experience e-learning provides a more accurate understanding of the challenges faced by engineering students during the pandemic.

c) Technical Challenges: As shown in Figure (3) The survey displayed that 60% of students reported that poor internet service often impacted their attendance in online labs and lectures. When looking at hardware limitations, only a small percentage (22%) said they did not have a computer capable of running engineering software, while most students disagreed (37%) or strongly disagreed (26%). There was also an indication that 35% of students experienced issues downloading and using engineering software, indicating that the infrastructure and technical support need to be priorities for online engineering education design.

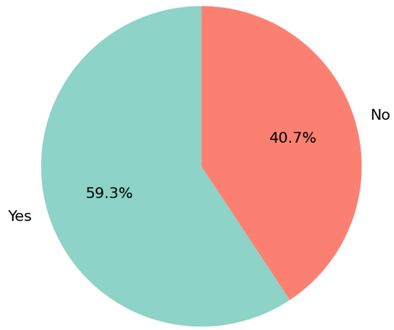

Fig. 2. Student Participation in Online Lectures During COVID-19.

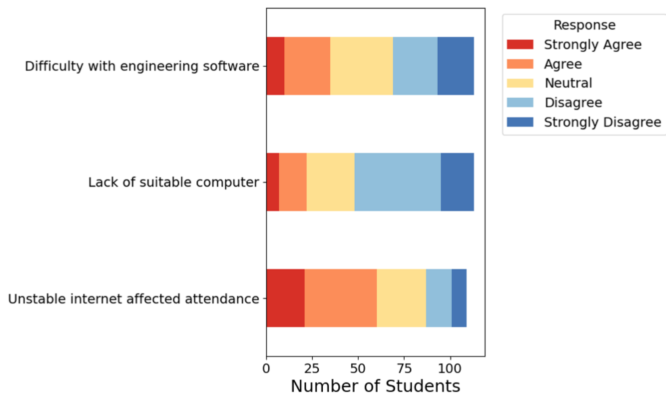

Fig. 3. Student Responses to Technical Challenges During Online Learning.

d) Psychological and Motivational Challenges: Figure (4) of the study shows that many students face mental and behavioral challenges in e-learning due to lack of practical application and multiple activities. About 67% of students struggle with time management, while 69% feel psychologically stressed during distance learning. Moreover, 67% of students have no motivation to study due to impracticability, indicating a lack of psychological readiness for e-learning. These are important issues that need to be addressed in the design of future e-learning in engineering.

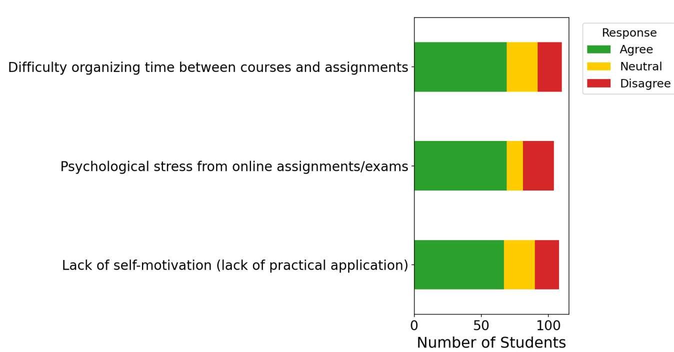

Fig. 4. Student Responses to Psychological and Motivational Challenges.

e) Academic Challenges (Practical Content): The result of the study found that there is a significant practical gap in e-learning for engineering students, as shown in Figure (5), with 68% having problems comprehending their practical courses without coming physically. More than 70% of students reported reduced opportunities to acquire practical skills, which are crucial in engineering. Collaborative work sometimes failed due to logistic problems and remote access. Additionally, 75% of students felt there were insufficient supervised training options, such as virtual simulations and interactive content, which hindered their job readiness.

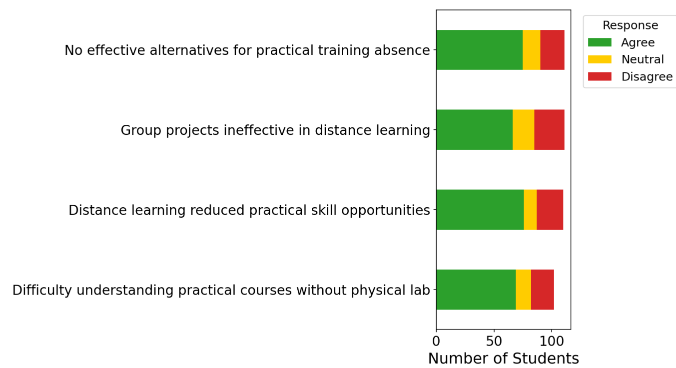

Fig. 5. Student Responses to Academic Challenges.

f) Interaction and Assessment: The survey revealed challenges in student-teacher interaction and assessment mechanisms during distance learning. Figure (6) highlights that the communication with instructors was limited, with over 70% of participants expressing this. Accessing feedback was difficult, with 67% feeling the process was not transparent enough. Additionally, 85% of students believed the exams and results did not provide a fair representation of their ability, implying either poor preparation for exams or technical difficulties reporting assessment through technology. These are impediments to the quality of education.

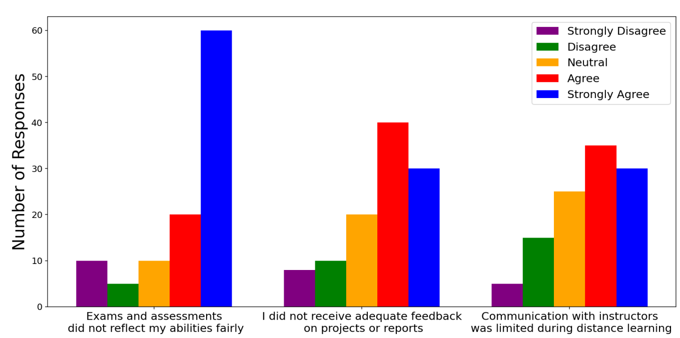

Fig. 6. Students Perceptions of Distance Learning Challenges

g) Descriptive Statistics of Questionnaire Sections: The following table presents the mean and standard deviation for each challenge of the questionnaire, which reflects participants' perceptions across the main constructs.

TABLE I
Mean and Standard Deviation for Each Challenge

Section: Challenges	Mean	Standard Deviation
Section 1: Technical	2.95	0.96
Section 2: Academic	3.67	1.05
Section 3: Psychological	3.74	1.08
Section 4: Distance Learning	3.66	1.06

The Psychological Challenges category was rated the highest (M=3.74), showing students experienced very high psychological challenges as they were learning, and the Technical Challenges category had the lowest mean score (M=2.95), indicating that technical challenges were not as extensive.

h) Overall evaluation of the experience: A significant split of students' opinions on distance learning in engineering courses was obtained. Figure (7) shows that 38% of students found their first year to be "average," while 28.7% and 22.2% rated their experience as "poor." Only 19.4% reported it as "good" and 6.5% as "excellent," indicating that most students' experiences did not meet expectations, especially in applied disciplines like engineering.

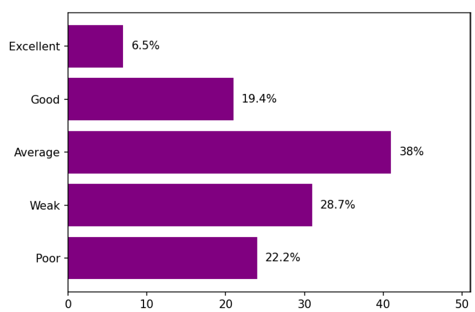

Fig. 7. Students' evaluation of their distance learning experience in engineering majors (N=108).

i) Future Trends in Teaching Methodology: As shown in Figure (8), the majority of students (50.9%) prefer the blended learning approach, which integrates both traditional and online methods to offer greater flexibility and engagement—especially valuable in engineering education. Meanwhile, 43.5% favor fully face-to-face learning, reflecting the continued importance of direct interaction and structured classroom environments. The low preference for fully online learning reflects anxiety about limited interaction, bounded practical experience, and motivation. The findings suggest that there is a need for hybrid models of education that can respond to students' psychological, technical, and academic needs. Hybrid models may provide a more balanced and effective learning environment in light of changes in education over the last few years.

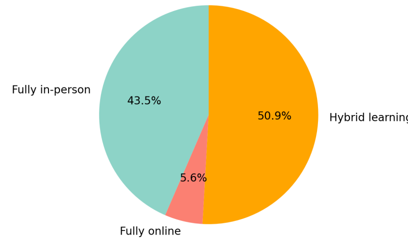

Fig. 8. Students' evaluation of their distance learning experience in engineering majors (N=108).

B. Qualitative results

a) Analysis of Open-Ended Responses: Open-ended responses provided by (41) participants out of 108 were analyzed. These responses demonstrated a clear recurrence of several themes, the most important of which was the call for blended learning: Most participants suggested integrating e-learning with face-to-face lectures, especially in practical courses.

- Improving infrastructure: Multiple requests to get reliable internet and suitable devices.
- Technical support: The need to provide technical assistance and training on engineering software.
- Academic interaction: Enhancing communication with instructors and providing regular and clear feedback.
- Practical aspect: Providing virtual labs or organizing face-to-face meetings for practical courses.

b) Selected quotes from participants:

- "Blended learning is better because it combines convenience with direct practical explanation."
- "We struggle with downloading engineering software; we need continuous technical support."
- "Interaction with professors is very limited, and it doesn't help us feel we're understanding properly."
- "There should have been laboratories or practical workshops, even if only partially."

V. DISCUSSION AND RECOMMENDATION

The results of the current study on e-learning in engineering disciplines at Palestinian universities revealed a number of significant challenges. These challenges are partially consistent with previous literature, but they also reveal distinct local specification, enhancing its value as a local and regional reference. To begin with, the study reaffirmed that students encountered big problems. They failed to connect with lecturers during remote study. Moreover, students could not receive appropriate feedback on their assignments and reports, and there was an idea that exams and evaluations poorly measured what students really could do. These results are consistent with the findings of [8] and [11], who noted poor interaction and fairness in assessment as common impediments to engineering e-learning. Second, concerning the technical challenges, results demonstrated that a considerable number of students faced problems in downloading and running engineering software such as AutoCAD and MATLAB or in not having computers appropriate to running these programs. The number of students who participated in class along with their engagement levels dropped significantly because of poor internet connectivity. These problems match the findings of [9] and [11] from the European REMOTE project. They stressed that infrastructure was satisfactory and reasonable access to tech resources is important. Finally, while a few other things might differentiate this study from others, the following three stand out as such:

- The Palestinian context: While most studies have targeted Europe, Jordan, Egypt, or Brazil, this study aims at presenting grounded evidence on e-learning within Palestinian universities, which are under particular political and economic pressure.
- Exclusive focus on engineering disciplines— As opposed to the studies of [9] and [11], which included STEM disciplines in general, this study focused on the practical and programmatic aspects of engineering, such as laboratory training and technical programs.
- Quantitative and qualitative analyses together: The investigation constituted a statistical evaluation of the closed-ended questions coupled with qualitative feedback from students, thereby lending a humanistic and interpretive dimension that gave depth to the statistical understanding.
- Future Outlook: The study surveyed students' opinions on the optimal approach to engineering education in the future, a forward-looking element not addressed in most previous studies. This enhances the effectiveness of the recommendations and makes them more responsive to the aspirations of the beneficiaries themselves.

The study recommends strengthening digital infrastructure, training academic staff on interactive teaching methods, redesigning assessment systems to include interaction, projects, self-assessment, and group work, integrating blended learning models, and providing psychological support to students. These recommendations aim to create an efficient engineering e-learning model that is appropriate for the local context, taking into account the specification of the Palestinian context and successful international experiences.

VI. CONCLUSION

This research looks closely at the many bumps engineering students in Palestinian universities hit when classes suddenly moved online after COVID-19. Findings show that shaky internet, poor campus hardware, less face-to-face time with teachers, and weak support for lab work together dragged down online learning. Some learners liked the convenience of staying home, but most said loudly that they want a blended approach that pairs remote lectures with the touch-and-feel of real prototypes. Meeting that wish means universities must upgrade networks, buy virtual labs, train staff well, and build teaching designs that welcome everyone. When student voices guide policy and course planning, Palestinian universities can craft tougher, more useful e-learning systems that fit the local engineering scene.

ACKNOWLEDGMENT

We would like to express our appreciation to all who assisted us in completing the research paper, especially students and faculty members from Birzeit University and Palestine Polytechnic University, for their ideas and teamwork.

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