Journal of Educational Research and Reviews
Vol. 12(1), pp. 1-11, January 2024
doi:10.33495/jerr_v12i1.23.143
ISSN: 2384-7301
Research Paper

Evaluating the Impact of E-Learning and Online Assessment on Engineering Education in Oman HEIs during COVID-19: A Mixed-Method Study

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Accepted 4th Dec., 2023.

Abstract. This study investigates the impact of e-learning and online assessments on engineering education in Oman's higher education institutions during the COVID-19 pandemic. The research used a mixed-method approach to collect data from 380 students and faculty members from the Military Technological College and other HEIs in Oman. The qualitative data analysis revealed significant issues with online learning, while the quantitative analysis showed that technical problems affected the majority of students. Assessment data showed an improvement in average performance for first and second-year students in online assessments compared to physical assessments. However, the data was limited to one college in Oman, and future research will focus on other institutions. This study addresses a gap in the literature by examining the effects of e-learning on engineering education in Oman and highlighting the challenges from a regional perspective.

Keywords: E-learning, engineering education, mixed method, online assessment, student performance.

Abbreviations: HE, Higher Education; **ICT**, Information and Communication Technology; **MOOCs**, Massive Open Online Courses; **SARS**, Severe Acute Respiratory Syndrome; **SPSS**, Statistical Package for Social Sciences; **SQU**, Sultan Qaboos University; **UNESCO**, The United Nations Educational, Scientific and Cultural Organization.

INTRODUCTION

The outbreak of the COVID-19 pandemic in March 2020 had a profound impact on academic institutions worldwide. Suddenly, academic institutions had to grapple with a host of unprecedented challenges. As the virus began to spread rapidly, educational institutions around the world had to close their physical buildings and transition to online learning. This shift to virtual learning was also true for the Sultanate of Oman, which swiftly responded to the pandemic by calling on all educational institutions to embrace e-learning. Omani higher education institutions, like many others around the world, quickly transformed from traditional face-to-face instruction to online learning, and then to a blended mode of delivery that combined both online and face-to-face instruction. The success of these transitions relied heavily on the infrastructure of the e-learning system as well as the technological readiness of each institution.

The transition to e-learning provided access to learning materials for both teachers and students, ensuring that the continuity of the learning process was maintained. E-learning in higher education institutions leverages formal and informal technologies to disseminate the university

curriculum to learners and address content module needs. According to research by Mpungose (2020), the most common platforms used by universities to support e-learning were Blackboard and Massive Open Online Courses (MOOCs), in addition to WebCT. However, due to financial considerations, open-source applications such as Moodle were often the first choice. While the pandemic had a significant impact on all educational disciplines, engineering modules faced unique challenges due to the need for hands-on work in labs or workshops. This article presents a study that investigates how e-learning challenges impacted the Omani higher education sector and the engineering discipline and explores potential solutions or ways forward.

This study aimed to address three main objectives related to the impact of e-learning on the Omani higher education sector and the engineering discipline. Firstly, the study aimed to explore the challenges faced by educators and students in terms of technology and academics during the transition to e-learning. Additionally, the study aimed to identify potential opportunities for e-learning to improve the learning experience. Secondly, the study aimed to compare the impact of e-learning on assessment in higher education and to discuss sustainable development options in learning and teaching. Finally, the study aimed to compare the impact of student assessment data during physical, online, and hybrid learning modes and suggest a way forward based on research outcomes.

To achieve these objectives, the study utilized both quantitative and qualitative experimental methodologies. A detailed survey was conducted among participants working in various areas of higher education. The survey results revealed that 82% of participants faced various challenges during the e-learning mode of education, ranging from minor to major issues. Of those who faced challenges, 56% cited technical issues such as difficulty sharing files, slow networks, computer crashes, and accessibility during e-learning as significant challenges. In addition to the survey, the study also utilized qualitative research methods such as interviews with educators and students to gain a deeper understanding of the challenges faced during the transition to e-learning. The study found that the sudden shift to online learning presented challenges such as a lack of technical infrastructure, inadequate training for educators, and limited student engagement. Furthermore, the study compared the impact of e-learning on assessment in higher education and discussed sustainable development options in learning and teaching. The findings showed that e-learning can provide a more flexible and accessible learning experience for students, but it also requires careful consideration of assessment strategies to ensure academic integrity and fairness. The study also highlighted the importance of sustainable development options in learning and teaching, such as the integration of technology in traditional classroom settings and the use of open educational resources. Finally, the study compared the impact of student assessment data during physical, online, and hybrid learning modes and suggested a way forward based on research outcomes. The findings showed that e-learning can provide an effective means of assessing student learning outcomes but requires careful consideration of the design and delivery of assessments to ensure validity and reliability. The study recommended the need for ongoing research to explore the impact of e-learning on assessment in higher education and the development of appropriate assessment strategies for e-learning environments.

Literature Review

It is not easy to trace back the emergence of the distance learning idea; however, the earliest existence of the initial form of distance learning is roughly reported back to the end of the eighteenth century in 1782 (Harting and Erthal 2005, Nicholson 2007). Since then, distance education has gone through various iterations, such as mail, radio; television; and the internet. Distant learning evolved and transformed as an innovative delivery method into different shapes and evolution communication methods. Educational institutes worldwide deliver other programs through distance learning using various techniques mainly based on their available mode of communication (Katane *et al*. 2015). According to the European Commission, E-learning is "the use of up-to-date multimedia technologies and the Internet to improve the quality of learning by facilitating access to resources and services as well as remote exchanges and collaboration" (Uzunboylu 2006). The current E-learning mode mainly relies on information and communication technologies (ICT) related to modernisation and innovative pedagogical methods (Alsoud and Harasis, 2021; Hussain et al., 2022; Khan et al., 2021; Khan et al., 2022). In practice, face-to-face and E-learning are requirements for life.

Hitherto, E-learning passed through different phases, pre-Covid and post-Covid. Pre Covid, E-learning or distance learning was mainly driven by other circumstances such as the financial crunch (1970's fuel crisis, 2008 recession), and events evolved as a result of the terrorist attack in the USA on 11th September 2001 (9/11) (Wallace 2015). Those situations and the economic downturn affected students because of fear of travelling and an increase in tuition fees and living expenses. Interestingly, Noam (1995) presented his hypothesis that higher education will lose its brick-mortar, which will be replaced by technology.

However, in late 2019 contagious disease SARS-CoV-2 was identified in Wuhan, China. The disease spread rapidly around the world, and as a result, in March 2020, WHO (World Health Organization) declared it a pandemic (Mpungose 2020). Almost all countries worldwide went into lockdown, whereas some regions ensured movement restrictions by imposing a curfew. It affected nearly every

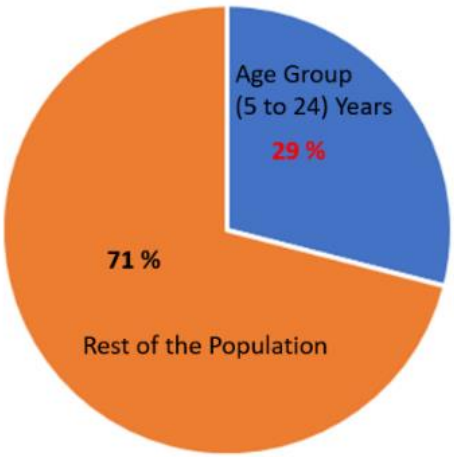

Figure 1. Omani population age group affected their learning process due to COVID-19 [Oman census].

walk of life but significantly impacted the education sector. It went to a standstill at almost all levels (from Nursery schools to universities). According to a UNESCO report, a vast number of around 1.57 billion students worldwide were affected by this pandemic. Looking at Oman, all schools, colleges, and Universities cancelled their conventional method of classes in March 2020. Figure 1 explains census 2020 results which suggest that a total population of around 4.4 million and 1.8 million, which is 29% of the total population, falls under the age group between (5 to 29) years, the group mainly undergoing primary to tertiary education.

Higher Education and E-Learning in Oman before and during the COVID period

Over the past few years, there has been a significant rise in the adoption of E-learning in higher education institutions in Oman, as reported by Al-Musawi (2007) and Hussain et al. (2021). One prominent example of this trend is Sultan Qaboos University (SQU), which began implementing its E-learning system in 2001. At its inception, SQU's E-learning system had only eight online courses available for 900 users, as reported by Al-Senaidi *et al*. (2009). However, within a short period of time, the number of online courses offered grew rapidly to 40 with 3,000 users by the autumn of the same year. This growth in E-learning implementation at SQU highlights the potential for its future expansion and measures the level of E-learning acceptance among academic staff and students. Studies conducted by Abdelraheem and Al Musawi (2003), Akinyemi (2003), and Al-Musawi (2007) have explored the level of acceptance and attitudes towards E-learning in the academic community in Oman. These studies found that academic staff and students generally have a positive attitude towards E-learning, with many recognizing the benefits of this mode of education, including its flexibility, accessibility, and cost-effectiveness. The rise of E-learning in higher education institutions in Oman is not unique to SQU. Other institutions in Oman, such as the Higher College of Technology and the University of Nizwa, have also implemented E-learning systems to facilitate teaching and learning. The Higher College of Technology, for instance, has implemented the Learning Management System (LMS), which allows students to access course materials, participate in online discussions, and submit assignments online. The University of Nizwa has also introduced a similar system, which includes online assessments and virtual classroom sessions. In conclusion, E-learning has become an increasingly popular mode of education in Oman, and its implementation has grown significantly in recent years. The positive attitudes towards E-learning among academic staff and students, as well as the benefits of this mode of education, highlight the potential for its future expansion in Oman's higher education institutions.

Challenges and Effective Practices in E-learning

When it comes to teaching practices in higher education, they can be broadly categorized into two different approaches - teacher-centered and learner-centered, as pointed out by Ravitz et al. (2000) and Mayer (2003). In the teacher-centered approach, the teacher holds the central position in the learning environment, while in the learner-centered approach, both teachers and students share the responsibility of creating a meaningful learning environment, as noted by Moate and Cox (2015). However, with the introduction of E-learning, a new approach emerged - the technology-centered approach, which focuses on the use and function of technology to transfer knowledge or present data. In this approach, technology takes the central position in the learning environment. The technology-centered approach emphasizes the use of the latest E-learning tools and how technology can develop learners' cognitive abilities.

However, a significant challenge with this approach is that

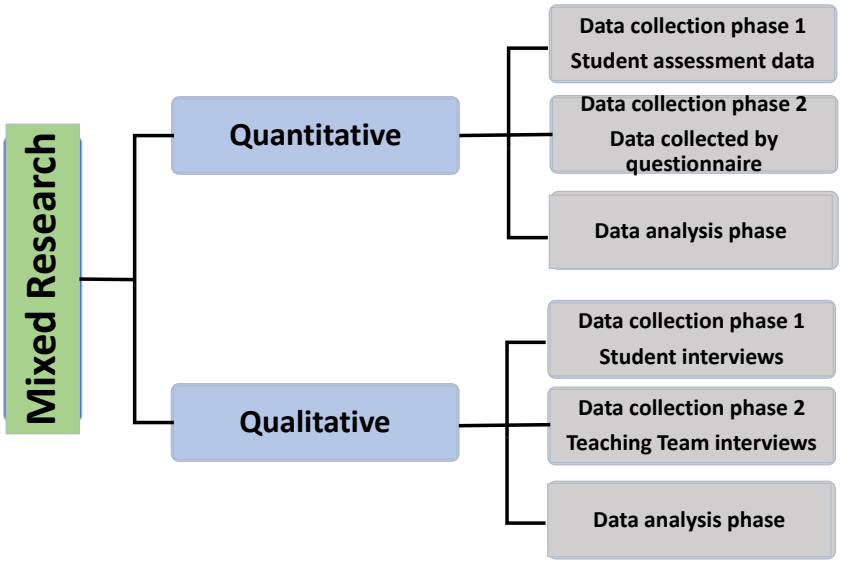

Figure 2. Different phases of mixed research.

technology can disrupt the learning process, jeopardizing the entire learning experience. For instance, limited internet access, computer malfunctioning, or power cuts can cause problems that may be beyond the control of the teacher or the student. E-learning instructional design should consider the Attention, Relevance, Confidence, and Satisfaction (ARCS) motivational model and the Dick and Carey model, which are the most cited models in addition to technology challenges, according to Wilujeng (2021). The ARCS model, which involves four variables, including attention, relevance, confidence, and satisfaction, must be taken into consideration before a lesson starts. The major challenge of E-learning practice is maintaining the student's attention, motivation, interest, and dealing with disruptive technologies while familiarizing them with online learning/teaching pedagogies, as pointed out by García-Morales *et al*. (2021).

Teachers face the challenge of preparing instruction content, while students need help to adapt to the new learning behaviour, as observed by Chang and Fang (2020) and Simamora *et al.* (2020). Among several other critical online learning issues, measuring student performance becomes one of the main concerns, as reported by Bilen and Matros (2021), García-Morales et al. (2021), and Tuah and Naing (2021). Assessment is an integral part of learning; hence the reduced validity and reliability of online assessment (without proctoring) can have a lifelong impact on the overall performance of the learning process, as highlighted by Gikandi et al. (2011).

Method

To consider both quantitative and qualitative data in the study, a mixed research method was employed by Popa, Repanovici *et al.* (2020). The mixed research approach was chosen because it focuses on the ineffectiveness of relying solely on either form of data. By incorporating both qualitative and quantitative data, researchers can support their arguments and provide unique opportunities for advancing understanding (van den Akker, 2013). Cannon (2004) outlined the different phases of data collection and analysis necessary for conducting mixed research methods in detail, which are depicted in Figure 2. The visual model provides a clear representation of the various stages of the research process.

In this study, the quantitative analysis involved a sample of 380 students who were enrolled at the Military Technological College (MTC). To ensure reliable analysis, the qualitative analysis included randomly selected MTC students and faculty members from MTC and other higher education institutes (HEIs) across Oman, such as Sultan Qaboos University (SQU), Buraimi University, and others. Qualitative analysis was conducted through interviews to gather comprehensive description data on the impact of E-learning on both teachers and students. This approach provided valuable insights into the experiences and perspectives of those directly involved in E-learning. Through the use of mixed research methods, the study aimed to provide a well-rounded understanding of the effectiveness of E-learning in higher education institutions in Oman.

Participants (sample description)

According to Bruestle (2009), certain variables such as gender, age, nationality, place of work, and occupation are closely related to the effectiveness of E-learning systems. Thus, these variables were taken into consideration in order to provide valuable insights and recommendations based on the research findings. Figure 3 provides an

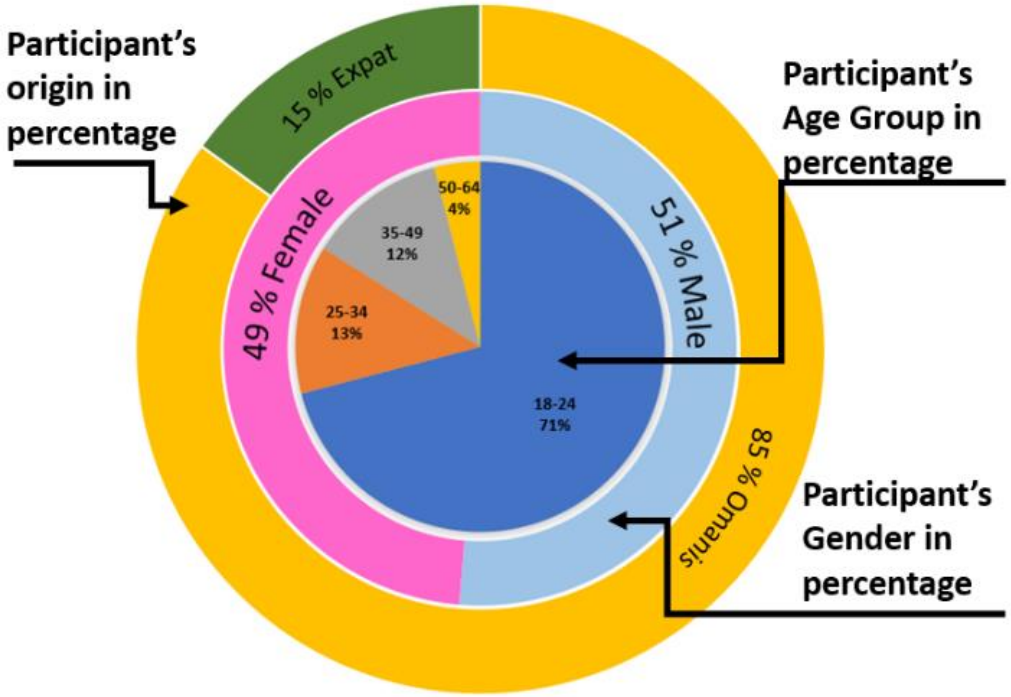

Figure 3. Participant's age group, gender, and origin

Table 1. Participant's age group, gender, and origin data.

	Age Group				Gender		Origin	
	18-24 years	25-34 years	35-49 years	50-64 years	Male	Female	Omani	Expat
Participants in %	71	13	12	4	51	49	85	15

overview of the age group, gender, and origin of the participants involved in both the qualitative and quantitative research phases. Table 1 presents the same information in a tabular format.

The study sample for the quantitative analysis included 380 students enrolled at MTC (Military Technological College), while the qualitative analysis involved randomly selected students and faculty from MTC and other HEIs (higher education institutes) across Oman, including SQU, Buraimi University, and others. These participants were interviewed to generate comprehensive descriptive data on the impact of E-learning on both teachers and students. As can be seen from Figure 3 and Table 1, the study included participants of different ages, genders, and nationalities, which is essential for achieving a diverse and representative sample. The majority of the participants were male, with a total of 234 male participants compared to 146 female participants. In terms of age, the study included participants ranging from 18 to 53 years old, with the majority falling within the 18-25 age group. Additionally, the participants were from various countries, including Oman, India, Pakistan, Bangladesh, and other countries. The inclusion of such demographic data is crucial for ensuring the validity and reliability of the research findings. By considering the impact of various variables on the effectiveness of E-learning systems, the study can provide targeted recommendations for improving the design and implementation of such systems to ensure they are effective for all learners, regardless of their demographic characteristics.

Research Methods of data collection

Ethical considerations are crucial in any research study that involves human subjects. As such, it is important for researchers to take necessary measures to ensure that the participants' rights are not violated during the research process (Berg, 2001). In this study, ethical considerations

were given utmost priority, and all the necessary precautions were taken to ensure that the participants' privacy and confidentiality were maintained. Before the research study began, informed consent was obtained from all the participants, and they were informed about the purpose of the study, their roles, and the nature of their participation. Additionally, the participants were informed that their participation was voluntary, and they were free to withdraw from the study at any time without facing any consequences.

The researcher also ensured that the data collected during the study were kept confidential and were used only for research purposes. All the information collected was stored securely, and access was only granted to the research team members to ensure that the participants' privacy was maintained. Moreover, the study adhered to the ethical guidelines set by the Institutional Review Board (IRB) to ensure that the research study met the necessary ethical standards. The IRB provides oversight on research studies involving human subjects and ensures that the study meets the ethical principles of respect for persons, beneficence, and justice. In conclusion, the ethical considerations of this research study were carefully addressed, and all the necessary measures were taken to ensure that the participants' rights were protected. This ensured that the research findings were reliable, and the recommendations drawn from the study were credible.

Quantitative research

In this study, the authors employed a mixed research method to gather both qualitative and quantitative data. The quantitative data collection process was divided into two phases. The first phase aimed to investigate the impact of online assessment on student performance during the COVID pandemic. To achieve this, a hybrid model was employed, where students took online classes and exams on campus under strict supervision. The results of this hybrid model were then compared with those of the fully online model. In the second phase, the authors used a multiple-choice survey questionnaire to collect data. The questionnaire was designed with caution to gather minimum information in a simple and cost-effective way. The authors followed Creswell's (2002) steps in the data analysis process. The data was transcribed, coded, and then the related codes were combined to develop themes. The third step involved connecting the pieces of information to create a narrative. Finally, thematic articles were gathered into a conceptual matrix.

To analyse the quantitative data, descriptive statistics such as mean, standard deviation, percentage, and correlation were used. The authors' approach to data collection and analysis was carefully designed to ensure reliability and validity of the research findings. Furthermore, the ethical considerations were taken into account to ensure the protection of the human subjects involved in the study.

Qualitative Research

Qualitative research is a valuable method for exploring and understanding complex phenomena by collecting in-depth information from individuals directly involved in the phenomenon. In this research, the central phenomenon of interest was the impact of E-learning on learning and teaching. To gather insights into this phenomenon, interviews were conducted with teachers and students, who were selected using a random sampling method. The interviews were recorded with the interviewees' permission and conducted using MS Teams, a popular video conferencing tool. The collected data was then analysed using thematic analysis, which is a widely used method for identifying, analysing and reporting patterns within raw data. This involved several steps, including becoming familiar with the data set, generating initial codes, searching for themes, reviewing and refining themes, and then reporting the findings. To ensure the accuracy and validity of the results, the thematic analysis was then presented to the participants, who were given the opportunity to provide feedback and make corrections as needed. This process helped to mitigate multiple realities and ensure a better interpretation of the participant's reality and voice. Overall, the qualitative research method was an essential component of this study, allowing for the collection of valuable insights and perspectives that cannot be obtained through quantitative methods alone. The combination of both quantitative and qualitative methods in this study provides a comprehensive understanding of the impact of E-learning on teaching and learning in the context of COVID-19.

Results and Discussion

Assessment and challenges

To investigate the impact of E-learning on students' assessment results, this study selected four different modules from different levels of study: freshman (Level 3), sophomore (Level 4), sophomore senior (Level 5), and final year (Level 6). The rationale for selecting these modules from different levels was to avoid any impact on the study due to the psychomotor skills assessment required in engineering education to develop engineering competencies. The modules selected for Level 3 were theoretical, with no impact on results due to practical omissions. However, the selected Level 4, 5, and 6 modules had different degrees of contribution through practical work on the results.

Figure 4 presents the assessment results for Module A when both classes and exams were online (a) and when classes were online, but the exam was on campus (Hybrid model) (b). The first phase of the quantitative research method involved data obtained from the exam department. The results show that for Level 3 and Level 4, when students took their exams under supervision/proctoring,

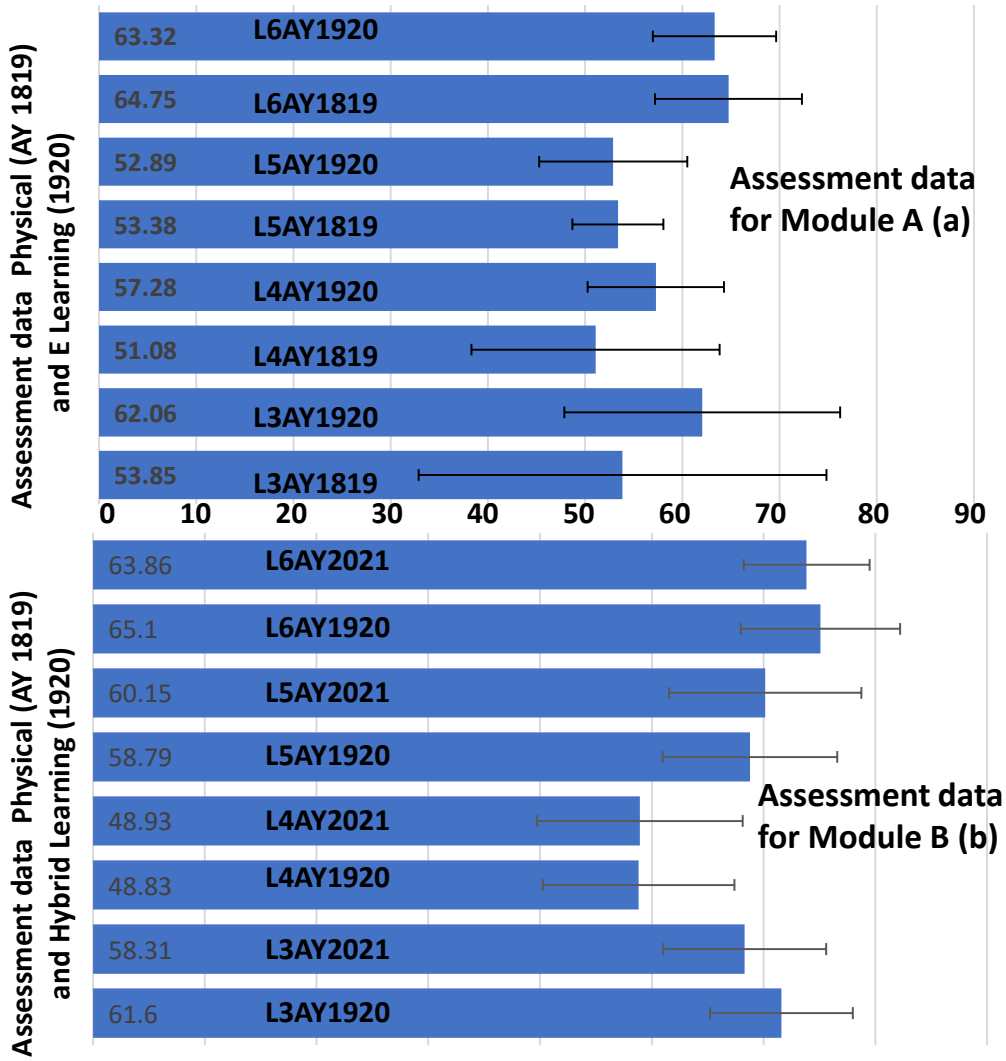

Figure 4. Assessment result **(a)** when both classes and exam were online **(b)** when classes were online, but the exam was on campus (Hybrid model).

their average marks were lower, and the standard deviation was higher. However, in the next academic year, when students took their exams online (without strict invigilation), their average marks increased, and the standard deviation declined. These results indicate that students either attempted the same questions or made the same mistakes. Hence, the validity and reliability of students' assessment results during an online exam were called into question, a finding consistent with Hernan's study (Santos 2021) investigating the effect of lockdown on university engineering education. It was seen that under these conditions for Levels 3 and 4, the overall performance of students increased along with limited discrimination between good and average performers, approximately (5 to 8)% (Ashraf *et al*., 2021; Gamage et al. 2020; Bilen and Matros, 2021).

For Module A, at Levels 5 and 6, where the assessment was mainly based on research and project reports, the performance was reported similarly or had the most negligible impact on student performance compared with conventional delivery and assessment. Furthermore, the performance reported during the second delivery through the online process resulted in better confidence levels due to the collective addressing of lessons learned from the first delivery.

Table 2 presents assessment data for Module A and Module B in tabular form, covering the academic years AY1819, AY1920, and AY2021. The table also shows whether the mode of instruction was physical, e-learning, conventional, or hybrid. Although technologies have evolved rapidly, there is still a long way to go before adapting to E-learning mode with higher confidence, for

Table 2. Assessment data in tabular form.

	Module A		Module B	
Academic Year	AY1819	AY1920	AY1920	AY2021
Semester	Semester 2	Semester 2	Semester 1	Semester 1
Mode	Physical	E-learning	Conventional	Hybrid
L3 Freshman (1st Year)				
Average	53.85	62.06	61.6	58.31
Std Dev	20.97	14.19	6.38	7.31
Pass%	52.89	66.22	93.08	88.85
Fail%	47.11	33.78	6.92	11.15
L4 Sophomore				
Average	51.08	57.28	48.83	48.93
Std Dev	12.76	7.01	8.58	9.2
Pass %	87.18	93.18	63.97	73.39
Fail %	12.82	6.82	36.03	26.61
L5 Sophomore Senior				
Average	53.38	52.89	58.79	60.15
Std Dev	4.69	7.63	7.82	8.6
Pass %	100	91.38	100	95.12
Fail %	0	8.62	0	4.88
L6 Final Year				
Average	64.75	63.32	65.1	63.86
Std Dev	7.55	6.35	7.13	5.65
Pass %	100	100	100	100
Fail %	0	0	0	0

example, mitigating cheating based on experience obtained during COVID-19 (Bilen and Matros, 2021). Assessment is an integral part of learning; therefore, HEIs in Oman implemented a uniform exam policy by adopting a hybrid mode where the classes were conducted online, but students had to take their written exam physically under proctoring.

Figure 4 (Module B) shows the impact on the results, with evidence that the college administration took necessary actions in AY2021 to improve students' assessment validity and reliability. The confidence level for the delivery of Module A to Module B was enhanced due to staff and student familiarisation with the E-learning process (Nafrees, Roshan *et al*., 2020). In the second phase of quantitative data analysis, students were asked to share their experiences with the E-learning model of education. To further expand and improve the results and discussion, we can dive deeper into the academic and technical challenges faced by students during the implementation of the E-learning system in Omani HEIs.

Regarding academic challenges, participants reported various issues, such as difficulty in staying focused during online lectures, lack of interaction and engagement with the instructor and classmates, and lack of practical sessions and hands-on activities. The online mode of instruction limited the ability of teachers to provide hands-on experiences that are necessary for certain courses, such as lab-based experiments and group discussions. Students also faced difficulty in time management and self-discipline due to the unstructured nature of online classes.

On the technical side, participants reported several challenges related to the E-learning system, such as poor audio and video quality, lack of access to necessary software and hardware, slow internet speed, and limited technical support. Many students struggled with technical issues that were beyond their control, such as internet connectivity problems due to their geographic location or lack of technical knowledge and skills to troubleshoot common technical issues.

In addition, students faced challenges related to the physical environment in which they had to attend online classes. Some students reported difficulty in finding a calm and quiet place to study, especially those who live in households with multiple siblings or those who live in noisy and crowded neighborhoods. This highlights the importance of considering the impact of the physical environment on the effectiveness of online learning. Overall, the study shows that the implementation of E-learning during the COVID-19 pandemic has brought about numerous academic and technical challenges for students in Omani HEIs. It is crucial to address these challenges by providing necessary technical and academic support, improving internet connectivity and access to technology, and creating a conducive learning environment. Additionally, it is essential to involve students

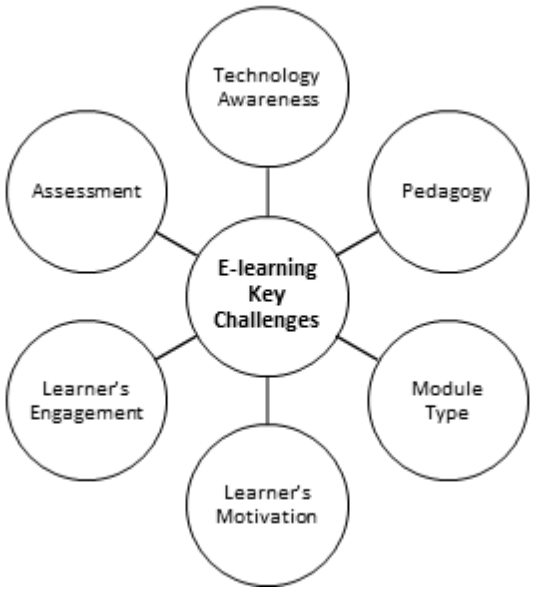

Figure 5. Key Challenges due to E-learning during the Covid period.

in the process of designing and implementing E-learning systems to ensure that their needs and concerns are taken into account.

Teacher and student interviews

Through the process of qualitative data collection, a significant amount of raw data was obtained, which was then organized and structured in a coherent and meaningful manner. The thematic analysis of the data highlighted six academic challenges, including assessment, learning engagement, pedagogy, type of course module (practical), learning motivation, and technology awareness. The findings presented in Figure 5 suggest that technology awareness emerged as a significant challenge during the pandemic. The data revealed that technology-centered learning requires high-level expertise to handle technical issues without wasting time. Furthermore, the participants identified pedagogy as another area of challenge, where teachers' methodological ability to teach online was a significant issue. The modules that involve practical or laboratory classes were also found to be extremely challenging to deliver online for teachers and learners.

The lack of student motivation during online sessions was another area of concern, which might have been caused by the lack of interactivity among students in the virtual classroom. Participants also reported difficulties in keeping students engaged during online sessions, with the reasons being related to lecturer style, approach, and rhythm. Lastly, the data revealed that teachers and learners faced challenges related to evaluation. Finding practical alternative assessment tools that reflect students' performance was a significant challenge. Overall, the findings suggest that the implementation of E-learning during the pandemic has posed various academic challenges for teachers and students in Oman's higher education context. The identified challenges can inform the development of policies and practices that can mitigate the impact of such challenges in the future.

Discussion

The discussion reveals the challenges faced by the education sector in the Sultanate of Oman during the Covid-19 pandemic when institutions were forced to adopt E-learning. The sudden shift from conventional to online teaching posed a challenge to faculty members, learners, and parents who were not adequately prepared for the change. Lack of access to technology and internet connectivity was a significant challenge for many learners, especially those from diverse cultural and financial backgrounds. The data analysis reveals that E-learning supports adult education and mature learners but adversely affects young learners' alertness and concentration levels during online lesson delivery.

Faculty members' major challenge during online teaching was student attendance and attention/concentration. The study highlights the inverse correlation between performance and motivation at early levels of the degree program. E-learning and distance learning scenarios mainly depend on the learner's motivation to accrue better outcomes. The results show that learners' motivation is directly related to their level of maturity and desire to reach higher levels of accomplishment. The discussion further highlights that E-learning has brought many opportunities to the education sector, including convenience and flexibility for learners. However, there is still much to do before fully adopting the E-learning mode of study with higher confidence. A combination of E-learning with

flexibility and face-to-face safety education is a viable future option to accommodate the diverse needs of university education.

Lessons Learned and Way Forward

The COVID-19 crisis has caused unprecedented disruption to academic institutions worldwide, and the higher education sector in Oman was not immune to its effects. The sudden shift to online teaching and learning proved to be the only viable option for many institutions to ensure continuity of education. This research explores the effectiveness of the e-learning system in the Omani higher education context during the pandemic. It uses both quantitative and qualitative data analysis techniques to examine the challenges, complications, and potential solutions to e-learning implementation. One of the significant challenges faced by students during online learning was the lack of access to fast and reliable internet connections. This issue was identified in earlier studies, and the COVID-19 pandemic exacerbated it. Another challenge was finding an appropriate space to study at home, particularly for students sharing a household with other online learners. The research also examined the impact of online assessment on student performance, and while the results showed an increase in scores, it is important to consider the factors that may have contributed to this, including the lack of invigilation and the possibility of cheating.

The study also identified ten academic challenges, including assessment, pedagogy, and course modules, as well as ten technical and other challenges, such as technological awareness and infrastructure, and lack of communication. To address these challenges, the institutions need to build the capacity of both staff and students in e-learning, implement flexible approaches, and prioritise innovative solutions to address the unique context of each institution. The crisis has also highlighted the need for continuous assessment and the use of artificial intelligence-based assessments to provide more confidence in the evaluation process. Additionally, blended learning, combining flexible e-learning and safe face-to-face teaching, is the way forward for future engineering education.

Conclusion

In conclusion, the COVID-19 pandemic had a significant impact on the academic sector, and e-learning emerged as the only viable solution to continue the learning process. This research investigated the effectiveness of the e-learning system during the pandemic in the Omani higher education context. The study found that there were several academic and technical challenges in implementing e-learning, such as assessment, learning engagement, technological awareness, internet connection, and more. The crisis highlighted the need for more flexibility and continuous assessment to bring confidence in online evaluations. The study suggested that institutions should prioritize building the capacity for both staff and students in e-learning and search for state-of-the-art technologies to reach every learner. Blended learning, which combines flexible e-learning and safe face-to-face teaching, is the way forward and a new norm for future engineering education. Overall, the study calls for innovative solutions appropriate to address each context and not leave anyone behind.

Conflict of Interest

The authors have no conflicts of interest to declare.

Ethical approval

The study was held by considering the best ethical principles of social research practices set by the Ministry of Higher Education (MOHE) of the Sultanate of Oman, such as respecting participants and safeguarding their dignity and confidentiality. MOHE guidelines were strictly followed when collecting the data.

Data Availability Statement

The data used in this article can be made available on request; however it is not publicly available because of ethical restrictions.

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