International Journal of Learning, Teaching and Educational Research
Vol. 23, No. 5, pp. 257-283, May 2024
https://doi.org/10.26803/ijlter.23.5.14
Received Feb 26, 2024; Revised Apr 8, 2024; Accepted May 27, 2024

Preparedness, Resilience, and Sustainability for Pedagogical Success at the National University of Science & Technology, Oman during the COVID-19 and Lessons for the Future

Priy Brat Dwivedi*
College of Engineering,
National University of Science & Technology, Oman,

Mohammad Al Ghazali
College of Pharmacy,
National University of Science & Technology, Oman,

Nabila Al Balushi
College of Engineering,
National University of Science & Technology, Oman,

Aliza Batool
School of Foundation Studies,
National University of Science & Technology, Oman,

Jasim Mohammed Sulaiman Al Balushi
College of Engineering,
National University of Science & Technology, Oman,

Charlot Nalankilli
College of Engineering,
National University of Science & Technology, Oman,

Abstract. The COVID-19 pandemic has brought unprecedented challenges to the education sector worldwide, requiring institutions to adapt quickly to ensure pedagogical resilience and sustainability. This case study examines the strategies implemented by the National University of Science and Technology, Oman, to survive and thrive during the pandemic. Using a validated survey instrument, the study collected data from 393 students and 92 teaching staff across four campuses. The survey assessed the challenges, effectiveness, and success

*Corresponding author: Priy Brat Dwivedi; priydwivedi@nu.edu.om

of the digital pedagogy adopted during the pandemic. The results were analyzed using descriptive and inferential statistical methods through SPSS 29 to develop a more comprehensive understanding. The results showed that students were generally satisfied with the pedagogical section of the survey, with higher cumulative grade point assessment level students showing higher satisfaction with online theory classes. The teaching staff were also satisfied with the technical support provided for conducting online classes. However, the study noted that student satisfaction with laboratory activities was lower compared to theoretical classes. To address this, the researchers suggest the use of augmented reality and virtual reality in laboratories to enhance the learning experience of students. The findings of this study contribute to the understanding of pedagogical resilience and sustainability in the face of adversity, providing insights for institutions to develop effective strategies for surviving and thriving in disruption.

Keywords: COVID-19; pedagogy; HELAM; students' satisfaction; online learning; resilient; sustainability; resilient

1. Introduction

The outbreak of the COVID-19 pandemic has significantly impacted teaching and learning in universities worldwide (Korn et al., 2020). With the sudden onset of the virus, universities were compelled to adapt their traditional teaching methods swiftly to remote and online formats. This shift has posed challenges for both educators and students, as they navigate through the new virtual learning environment.

The report published by UNESCO titled "*Higher Education in the Time of COVID-19*" provides an overview of the impact of the pandemic on higher education institutions and emphasizes the need for innovative approaches to teaching and learning. It discusses the challenges faced by educators in delivering effective online instruction and the difficulties encountered by students in adjusting to the new virtual learning environment.

According to the data from the United Nations Educational, Scientific and Cultural Organization (UNESCO), by mid-May 2020, more than 1.2 billion students at all levels of education worldwide had stopped having face-to-face (F2F) classes. Of these, more than 160 million were students in Latin America and the Caribbean (UNESCO et al., 2020). Furthermore, a study conducted by the International Association of Universities (IAU) titled "*COVID-19 and Higher Education: Today and Tomorrow*" offers insights into the experiences of universities worldwide in responding to the pandemic. The study highlighted the rapid shift to online learning and the various obstacles faced by both educators and students. It also discussed the importance of ensuring equitable access to digital resources and support services for all students (Marinoni et al., 2020).

One of the primary effects of COVID-19 on teaching in universities was the sudden transition to online platforms. This shift required universities to develop and implement remote teaching strategies quickly to ensure the continuity of

education. While online learning offers flexibility and access to resources, it also presents challenges such as connectivity issues, limited interaction between students and instructors, and the need for technological literacy (Adnan, 2020).

The pandemic also disrupted the traditional classroom experience. Universities had to cancel or postpone in-person lectures, seminars, and practical sessions, which are crucial for hands-on learning and collaborative activities. The absence of F2F interaction also affected the overall engagement and motivation of students, as they felt disconnected from their peers and instructors.

Moreover, the COVID-19 pandemic highlighted existing inequalities in access to education. Not all students have equal access to reliable internet connections, digital devices, or conducive learning environments. This disparity can negatively impact the learning outcomes of students from disadvantaged backgrounds, widening the educational divide (Ndzinisa & Dlamini, 2022).

The COVID-19 pandemic revealed the longstanding disparities in access to education that exist among students. One of the significant issues that has been highlighted is unequal access to reliable internet connections, digital devices, and conducive learning environments. While some students have the luxury of high-speed internet and well-equipped study spaces, others struggle to connect to online classes or access educational resources.

This disparity in access to technology and learning environments has a significant negative impact on the learning outcomes of students from disadvantaged backgrounds. For example, a student from a low-income family may not have a personal computer or a stable internet connection at home. This can make it challenging for them to fully participate in online classes or complete assignments on time. As a result, they may fall behind their peers (who have better access to technology) and struggle to meet academic expectations.

Furthermore, the lack of access to reliable internet connections and digital devices can widen the educational divide between students from different socioeconomic backgrounds. As education shifts to an increasingly digital format, students without the necessary resources may find it difficult to keep up with their peers. This can lead to decreased motivation, lower academic performance, and limited opportunities for future success (Korkmaz et al., 2022).

These inequalities created opportunities for policymakers and educational institutions to prioritize bridging the digital divide. This may involve providing students from disadvantaged backgrounds with access to necessary technology and internet connectivity, as well as creating safe and supportive learning environments. By ensuring equal access to education, people can work towards a more equitable and inclusive society.

Another impact of the pandemic on students was the disruption of extracurricular activities and social interactions. Students were unable to participate in sports, clubs, and other group activities, which are not only important for personal

development but also contribute to a well-rounded education. Additionally, the lack of social interaction with peers took a toll on students' mental health and well-being.

A study conducted by Loades et al. (2020) examines the effects of social isolation on the mental health and well-being of young people during the pandemic. The lack of social interaction with peers has had an adverse effect on students' mental health, leading to increased feelings of loneliness, anxiety, and depression. Maintaining social connections and engaging in group activities is emphasized for the overall well-being of students (Loades et al., 2020).

Furthermore, the pandemic also affected the prospects of many students. Many students had to postpone or cancel plans to study abroad due to travel restrictions and uncertainties surrounding the pandemic. This limited their opportunities for international exposure and cross-cultural experiences, which are valuable for personal and professional growth (Kanwar & Carr, 2020; Shijian & Agyemang, 2022).

2. Aim of the work:

The focus areas of study were:

- Examining the challenges and effectiveness of online teaching, learning, and assessment during COVID-19 at the National University of Science & Technology, Oman
- Determining resilient and sustainable practices adopted at the National University for sustainable, equitable, and accessible teaching and learning experiences in post-pandemic scenarios.

3. Hypothesis:

This study tested the following five hypotheses:

- Hypothesis 1: The success of pedagogy adopted during Covid-19 is positively related to the learner's perceived satisfaction from the learner's attitude.
- Hypothesis 2: The success of pedagogy adopted during Covid-19 is positively related to the learner's perceived satisfaction from instructor quality.
- Hypothesis 3: The success of pedagogy adopted during Covid-19 is positively related to the learner's perceived satisfaction from supportive issues.
- Hypothesis 4: The success of pedagogy adopted during Covid-19 is positively related to the learner's perceived satisfaction from information quality.
- Hypothesis 5: The success of pedagogy adopted during Covid-19 is positively related to the learner's perceived satisfaction from service quality.

4. HELAM Model

The Hexagonal E-Learning Assessment Model (HELAM) was developed by Ozkar and Koseler (2009). It is a conceptual assessment model to evaluate

learners' satisfaction with online learning and blended model of learning (Ozkan et al., 2009). Since online learning was the norm during the pandemic, the Helam model can be conveniently adapted to assess learners' perspectives about online learning and to study the effectiveness of the measures taken to support online learning. Based on Helam's model, the various aspects of online learning can be classified into human and technical factors which can be further subdivided as follows:

A. Human Issues:
   - Learner's Attitude
   - Instructor Quality
   - Supportive Issues

B. Technical Issues
   - Information Content Quality
   - Service Quality
   - System Quality

Learner's attitude:
Learner's attitude is evaluated by self-productivity, experience, and communication with teachers and classmates. Enthusiasm, confidence, trust, motivation, belief, computer anxiety, apprehension, excitement, and learner's attitude must be recognized first.

Instructor quality:
The quality of an instructor is an important factor for effective learning. This factor includes personal IT competencies, personal innovativeness, teaching style, and time availability to support the learning process of the students. Gilbert (2007) emphasized that it is not the technology itself but the instructional implementation of the technology that determines its effect on learning. Interactive instructional design is an essential tool that impacts learners perceived effectiveness (Gilbert et al., 2007).

Supportive issues:
Ozkan and Koseler (2009) concluded that the wellness of peripherals, emails, discussion boards, chats, and video conferencing are fundamental factors of supportive issues of e-learning. Technical support helps students in the acquisition of knowledge and skills necessary to fulfill curriculum requirements (Ozkan et al., 2009).

Information content quality:
Information content quality depends on how well the learning environment is designed and managed. Learners place a high value on well-organized, interactive, clearly written, and useful content that is of the appropriate length and flexibility and provides an appropriate level of breadth (Shee & Wang, 2008a). Holsapple & Lee-Post, (2006) emphasized the importance of content that is up-to-date and useful.

Service quality:

Service quality is related to users' experience with assessing and interacting with various services provided. Good library access, and necessary and timely feedback, help students in their learning process.

5. Research Design

This research article has focused on examining how COVID-19 restrictions have affected teaching, learning, and assessment activities across the three campuses of the National University of Science and Technology, which are College of Engineering (COE), College of Pharmacy (COP), College of Medicine & Health Sciences (COMHS) and School of Foundation Studies (SOFS) in Oman. To ensure a thorough investigation, a mixed-method design was employed, cohesively incorporating multiple data sources. The use of multiple research methods is crucial for understanding the correlations, among various factors that enhance the credibility and reliability of the findings.

In this study, quantitative results are combined with qualitative findings to develop a comprehensive understanding of the research problem. Correlation between these two types of data allows for a more nuanced analysis, capturing both numerical trends and the personal experiences and perspectives of the research participants.

5.1 Research Samples:

The research team chose two sample categories.
Category 1 students: In this category, a total of 393 responses from students from three campuses were selected. This sample consisted of students of various age groups, genders, grade ranges, nationalities, campuses, programs of study, and levels of study.

Category 2 teaching staff: In this category, a total of 92 responses from teaching staff from three campuses were selected. This sample consisted of teaching staff of various age groups, genders, nationalities, and campuses. This sample consisted of theory and laboratory tutors and instructors.

5.2 Data Collection and Analysis:

Structured surveys for category 1 - students were conducted during October - November 2022 in respective campuses using Google Forms. Students' surveys were conducted in their respective classrooms after briefing and informed consent. This questionnaire consisted of 18 questions (also known as survey items) under the five dimensions HELAM model. These questions were aligned with the focus area of the study. This form was prepared for 5-point Likert scale responses with 5 as strongly agree and 1 as strongly disagree. The mean score of each question is displayed in the respective tables given in the analysis section of this study. A mean score below 3 indicates a negative attitude and a mean score above 3 indicates a positive attitude. The primary language of the form was English with Arabic translation for the question part.

The category 2 - teaching staff survey was also prepared using Google Forms with matching questions like the students' survey for cross verification and

correlations of findings. This survey was conducted during November – December 2022 in the respective campuses. This questionnaire consisted of 16 questions, aligned with the focus area of the study. This form was prepared for 5-point Likert scale responses with 5 as strongly agree and 1 as strongly disagree. The primary language of the form was English.

Both surveys were prepared by the research team and validated by subject experts from different departments. Written permissions were taken from the executives of all campuses before the start of both surveys. The participants were given a proper briefing about the nature of the study, its importance, and the survey process. The surveys were distributed to all eligible students and teaching staff across all campuses. After careful investigation and removing any outliers, 393 and 90 responses were accepted from students and teaching staff respectively.

To examine the data, descriptive and inferential statistical analysis methods were conducted using SPSS 29. To assess the success of pedagogy adopted during Covid 19 in terms of the learner's perceived satisfaction, the HELAM model was adopted and implemented throughout the survey instrument. Several validity and reliability tests were applied to survey items to improve the credibility of the results.

5.3 Implementation of the Helam model in the current study:

In this study, under the pedagogy variable, a total of 18 survey items were constructed and arranged under 5 dimensions (also called factors). System quality dimensions were not taken into consideration, because students were at home and were using their hardware peripherals. Google Cloud services and Blackboard learning management system were provided by the National University to all stakeholders, including students and staff. The other five dimensions were customized as per the requirements of the current study.

In Table 1, all 18 survey items are loaded under 5 dimensions of the Helam model.

Table 1: Loading of survey items under the Helam model.

Factor 1: Learner's Attitude (5 items)	
1	Switching to complete online learning was easy for students.
2	Learning theory in online mode was convenient for students.
3	Learning laboratory in online mode was convenient for students.
4	Students would prefer online delivery of some modules in the future.
5	I believe malpractice in exams is a serious ethical issue.
Factor 2: Instructor Quality (3 items)	
6	Teachers provided good teaching support to students during and after the online classes.
7	Good academic advising support was available.
8	Teachers were able to engage students in online classes.
Factor 3: Supportive Issues (4 items)	
9	Good support was provided for laboratory / practical sessions like access to licensed software.
10	Students were able to contact their teachers through online platforms.

11	Good support and training were provided for online exams (like mock tests and extra time for upload).
12	Mock test and 1 hour extra to upload answers were good practices?
Factor 4: Information Content Quality (3 items)	
13	Teachers provided sufficient and good-quality study material for theory and laboratory sessions.
14	Online presentations were convenient and effective.
15	Extra marks for participation have enhanced student participation in class.
Factor 5: Service Quality (3 items)	
16	Good online access to library facilities was available.
17	Teachers provided timely feedback on formative and summative assessments. (Assignments, reports, presentations, etc.)
18	The university should continue online assessment of final exams.

6. Result and Discussion

6.1 Validity and Reliability of the Survey Items

In this work, explanatory factor analysis was used to develop the model's factor structure. The 18 survey questions were the five dimensions of the HELAM model, which are Learner Attitude (factor 1), Instructor Quality (factor 2), Supportive Issues (factor 3), Information Content Quality (factor 4), and Service Quality (factor 5). The Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy and Bartlett's test of sphericity were used to evaluate the sample's suitability, as shown in Table 2.

Given that the correlations are near 1, the KMO value of 0.848 indicates that the correlations are generally compact, and factor analysis should produce unique and trustworthy factors (Hair, 2009). In addition, a significant test was performed, with a Chi-Square value of 881.945, 10 degrees of freedom, and a significance level of 0.001. It is therefore possible to conclude that factors exist because there are non-zero correlations between the variables (Hair, 2009).

Table 2: KMO and Bartlett's Test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.848
Bartlett's Test of Sphericity	Approx. Chi-Square	881.945
	df	10
	sig.	<0.001

Table 3: Factor Structure of Survey Instrument

Factors factor	**% of Total Variance**	**Reliability**
Factor 1: Learner's attitude	65.037	.856
Factor 2: Instructor Quality	12.759	.837
Factor 3: Supportive issues	8.004	.829
Factor 4: Information Content Quality	7.690	.824
Factor 5: Service Quality	6.509	.830

The factor loadings of the survey instrument are summarized in Table 3. The total explained variance obtained from data analysis was found to be 100%. This

proportion is deemed substantial enough to classify the HELAM survey instrument as successful.

To evaluate the reliability and internal consistency of the factors, Cronbach's alpha was utilized. As shown in Table 3, all the factors exhibited high values of Cronbach's alpha, approximately 0.8, which are near 1. The high value of Cronbach's alpha indicates that the items comprising the factor can measure the same underlying structure, suggesting that they form a reliable factor that is consistent with the other items in the factor (Hair, 2009).

A descriptive statistical analysis of each HELAM dimension is presented in Table 4 in which the data collected from survey instruments are summarized. An overall satisfaction score of 3.4268 indicates that the pedagogy adopted during the Covid-19 pandemic was successful and students were satisfied with their learning. It also indicates that overall students' learning was not affected due to COVID-19 restrictions, and students were satisfied with the actions taken by the teaching staff and the National University.

Table 4: Mean scores of five factors in the student survey

Factor's factor	Mean	Std. Deviation
Factor 1: Learner's attitude	3.2707	.80063
Factor 2: Instructor Quality	3.4203	.79567
Factor 3: Supportive issues	3.5324	.71209
Factor 4: Information Content Quality	3.4864	.75355
Factor 5: Service Quality	3.4241	.78280
Overall satisfaction in pedagogy	3.4268	0.61908

To assess the quantitative results, Pearson correlations were conducted in addition to descriptive statistics. The Pearson Correlation Coefficient was employed at a significant level of 0.001, and all findings were analyzed accordingly. The outcomes of testing Pearson Correlation Coefficient values are presented in Table 5, which reveals a significant relationship between each HELAM dimension and students' perceived overall satisfaction, thereby supporting the five proposed hypotheses in the Research Hypothesis section (Hair, 2009).

Table 5: Pearson Correlation

Factor's factor	Correlation	p-value
Factor 1: Learner's attitude	0.756	<0.001
Factor 2: Instructor Quality	0.805	
Factor 3: Supportive issues	0.817	
Factor 4: Information Content Quality	0.831	
Factor 5: Service Quality	0.820	

Pearson's product-moment coefficient is a parametric measure that indicates the strength and direction of the relationship between two variables. It is a statistical tool commonly used to assess the degree of supposed linear relationships between two variables. According to guidelines by Cohen, (1998) the interpretation of values between 0 and 1 is r=.10 to.29 or r=.-10 to -.29 is considered weak; r=.30 to

.49 or r=-.30 to -.49 is considered moderate; and r=.50 to 1.0 or r=-.50 to -1.0 is classified as strong. The level of significance of each dimension is represented by its Pearson Correlation results as shown in Table 6. The Pearson Correlation results support all five proposed hypotheses, as there is a highly robust relationship between learners' attitudes and overall perceived satisfaction (Hair, 2009).

Table 6: Correlation between the factors in the pedagogy

	Factor 1	**Factor 2**	**Factor 3**	**Factor 4**	**Factor 5**
Factor 1	1				
Factor 2	.411**	1			
Factor 3	.495**	.639**	1		
Factor 4	.531**	.635**	.610**	1	
Factor 5	.585**	.552**	.576**	.582**	1

**** Correlation is significant at the 0.01 level (2-tailed)**

6.2 Response analysis of students under all five factors.

Table 7 consists of the demographic data of all student participants. It shows that a majority of young, Omani female students participated in the survey. The student survey was not conducted at the SoFS, because the students who faced COVID-19 restrictions joined the other three campuses at the time of this study.

Table 7: Demographic data of sample

Items	**Category**	%
Nationality	Omani	85.8
	Expats	14.2
Gender	Female	84.5
	Male	15.5
Age group	18-22	83.4
	23-27	15.8
	28 onwards	0.08
Study Level	2	36.6
	3	24.4
	4	25.7
	5	8.9
	Others	4.4
Mode of study	Full time	90.8
	Part-time	7.4
	Special part-time	1.8
Campus	CoE	65.2
	CoP	11.5
	CoMHS	23.3
Cumulative grade point assessment range	Below 2.0	1
	2.0-2.4	6.6
	2.5-2.9	23.7
	3.0-3.4	37.7
	3.5-4.0	31

6.2.1 Learners Attitude:

Under this factor, a total of five survey items were loaded and the data were presented in Table 8. This dimension is crucial because it directly assesses the satisfaction level of students under a revised pedagogy under COVID-19 restrictions. In this factor the response of students for item 1 'switching over to complete online learning was easy for students' is 2.99. Here 37.4% of students showed agreement and 37.9% of students showed disagreement with this item. This response was quite expected. Though students are tech-savvy, and they enjoy E-learning activities, fully online remote teaching and learning were not expected. Important reasons behind inconvenience and interruption in studies were unreliable internet connections at home; unavailability of devices, and other hardware; lack of quiet place for study; lack of communication with peers; and a lack of excitement of F2F study (Derksen et al., 2022; Henriksen et al., 2022; Malamud et al., 2019).

As expected, the mean score of item 3 'learning laboratory in online mode was convenient for students' is 2.48, well below the mean score of 3. A minority 23.7% of students showed agreement and the majority of 55.7% of students showed disagreement for this item question. Almost all programs that are running in the three campuses of the National University, COMHS, COP, and COE, are laboratory-based and require a great deal of practical experience. It is part of pedagogy in all campuses and courses of the National University that the physical and person-to-person experience were completely missing. Teaching staff provided full support through self-made videos, YouTube videos case studies, and simulations. At COE, access to all necessary laboratory software was provided to students through SplashTop software. However, these efforts could not make for the F2F human interactive experience. These findings were similar to to a study by Hong et al., 2021) which also assessed online learning in experimental courses for high school students in China.

Table 8: Mean score of learner's attitudes (factor 1)

S.No.	Learner's attitude	Mean	Std. Deviation	% Agreement	% Disagreement	% Neutral
1	Switching to complete online learning was easy for students.	2.99	1.282	37.4	37.9	24.7
2	Learning theory in online mode was convenient for students.	3.14	1.203	42	31.8	26.2
3	Learning laboratory in online mode was convenient for students.	2.48	1.254	23.7	55.7	20.6
4	Students would prefer online delivery of some modules in the future.	3.68	1.241	63.1	18.3	18.6
5	I believe malpractice in exams is a serious ethical issue.	4.07	.948	77.3	5.3	17.4

Learning theory online was convenient as revealed by 42% student agreement. The teaching staff were trained and motivated. In addition to this, a majority of 63.1% of students preferred the online delivery of some modules in the future. This data supports item 2 and evinces the technical competencies of the National University teaching staff. In contrast the teaching staff at Hungarian universities were not prepared and skilled enough to handle the move to remote teaching so quickly (Coman et al., 2020).

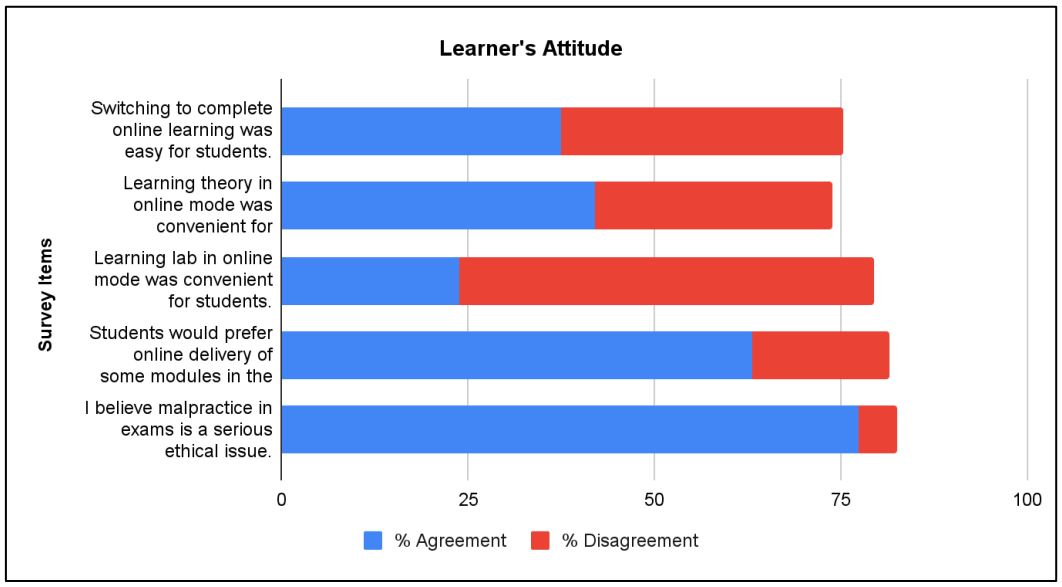

Figure 1: Percentage agreement and disagreement in survey items under factor 1

A huge majority of 77.3% of students believed that malpractice in exams is a serious ethical issue. This data were triangulated by malpractice data obtained from the assessment office.

Malpractice cases have an interesting record at the COE as shown in Figure 2. Before the Covid-19 lockdown, between 2016 and 2019 a total of 93 malpractice cases were recorded. After Covid-19 restrictions were imposed and exams were conducted online during 2020, only 2 malpractice cases were recorded. This was perhaps because all exams were open-book exams and assignment-based assessments were conducted.

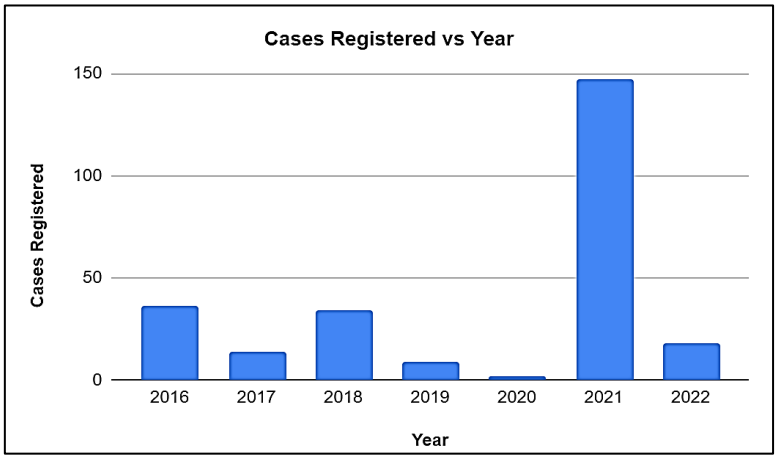

Figure 2: Malpractice cases registration

The National University reopened in Sep 2021 for F2F sessions and exams of the Fall semester 2021-2022 were conducted F2F. This exam recorded a vast 136 cases in the Dec-2021-Jan 2022 exams. The major reasons for this surge were as follows:

1. Students were challenged with the comeback of F2F exams.
2. Students lacked confidence in writing skills to present descriptive answers.
3. Students' anxiety about their performance in the F2F mode (Dey, 2021).

The HA office conducted a thorough analysis and found that smart devices were an aid for students to engage in malpractice. Consequently, smart devices and health bands were not allowed in the examination hall. This strict action resulted in 31 malpractice cases in the June 2022 exam and then 18 cases in the December 2022 exam. Hence, the ban on smart devices controlled the situation.

6.2.2 Instructor Quality:

Under the dimension of instructor quality, a total of three survey items are shown in Table 9. All these items have mean scores above 3. Students were quite satisfied with the quality of instructors. In these items, item 8 has a very high value of 3.65, that 63.9% of students agree with this question. This number shows the competencies of the teaching staff in engaging the students in an online teaching and learning atmosphere.

Table 9: Mean score of Instructor Quality (factor 2)

S.No.	Instructor Quality	Mean	Std. Deviation	% Agreement	% Disagreement	% Neutral
6	Teachers provided good teaching support to students during and after the online classes.	3.48	.963	55.2	13.8	31
7	Good academic advising support was available.	3.13	1.149	40.9	28.2	30.9
8	Teachers were able to engage students in online classes.	3.65	.927	63.9	10.5	25.6

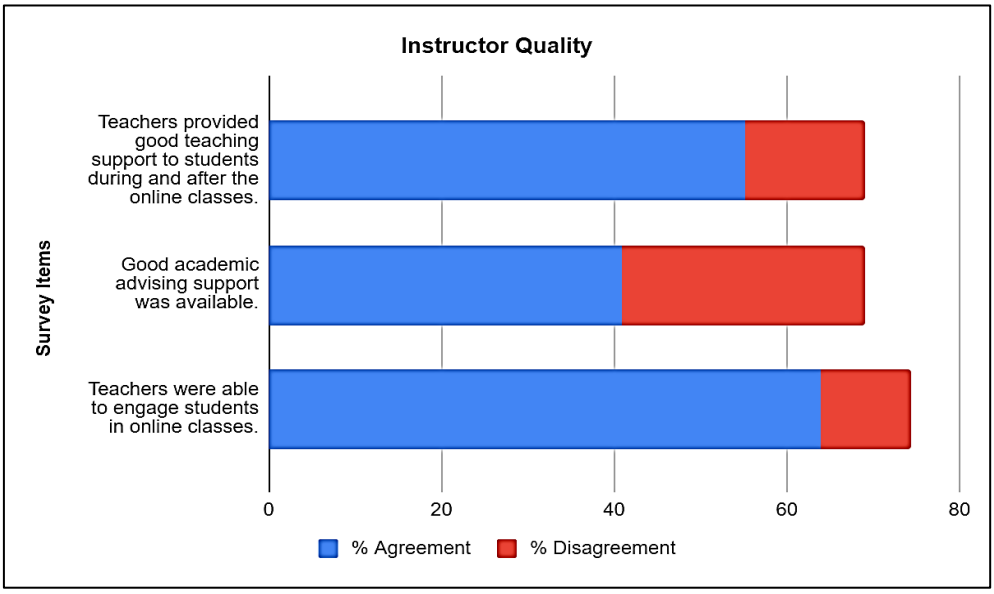

Figure 3: Percentage agreement and disagreement in survey items under factor 2

This success can be traced to two practices at the National University.

1. In each semester the fifth teaching week is observed as an e-learning week. This practice has enabled and empowered the teaching staff with the required IT and technical competencies.
2. Online and offline staff development workshops are held on teaching and learning practices, students' engagement, and various aspects of enhancing the skills of teaching staff. These workshops have empowered the teaching staff with the latest teaching and learning methodologies.

6.2.3 Supportive Issues:

Under this dimension four survey items were loaded. In all four items, students showed a high level of agreement with the questions. It shows a high level of satisfaction among students about teaching support.

Online platforms like Gmail, Chat, and WhatsApp were highly used for communication and 69.7% of students were satisfied with this support. This shows the motivation and professionalism of the National University teaching staff in supporting the learning process of students.

The National University adopted good practices during this stressful time. The teaching staff started providing mock tests before the final exam so that students were familiar with downloading and uploading exercises using Blackboard. Also, an hour of extra time was provided to students to take care of any technical malfunctions in the Blackboard applications; 63.6% of students showed satisfaction with this practice.

Table 10: Mean score of Supportive Issues (factor 3)

S. No.	Supportive issues	Mean	Std. Deviation	% Agreement	% Disagreement	% Neutral
9	Good support was provided for laboratory / practical sessions like access to licensed software.	3.31	1.112	49.6	22.3	28.1
10	Students were able to contact their teachers through online platforms.	3.80	.887	69.7	8.1	22.2
11	Good support and training were provided for online exams (such as mock tests and extra time for upload).	3.24	1.083	44.7	25.2	30.1
12	The mock test and 1 hour extra to upload answers were good practice	3.78	1.069	63.6	10.7	25.7

The following chart demonstrates the satisfaction of the students regarding the support systems provided by the National University. The extent of the agreement stands as evidence for their satisfaction with the support they received.

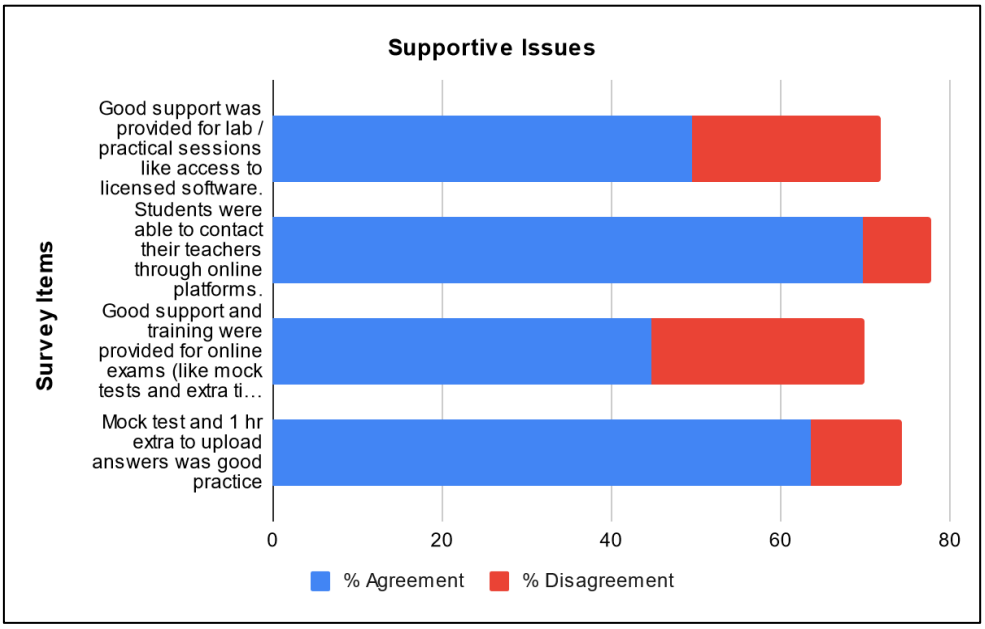

Figure 4: Percentage agreement and disagreement in survey items under factor 3

6.2.4 Information Content Quality:

Under this dimension, a total of three survey items were loaded as shown in Table 11. In all three cases, the mean of students' satisfaction is well above 3, showing their satisfaction with the quality of the content provided to them. According to Shee & Wang, (2008b) learners place a high value on well-organized, interactive, clearly written, and useful content that is of the appropriate length and flexibility and provides an appropriate level of breadth. This satisfaction also proves that the learning atmosphere was well-designed and executed. Survey items 14 and 15 are generally related to the learning atmosphere which helped learners to acquire learning with satisfaction.

Table 11: Mean score of Information Content Quality (factor 4)

S. NO	Information Content Quality	Mean	Std. Deviation	% Agreement	% Disagreement	% Neutral
13	Teachers provided sufficient and good-quality study material for theory and laboratory sessions.	3.43	.935	51.5	14.3	34.2
14	Online presentations were convenient and effective.	3.72	1.079	60.3	11.5	28.2
15	Extra marks for participation have enhanced student participation in class.	3.32	1.130	48.4	24.6	26.8

The following chart represents student' satisfaction. For all three survey items, a high percentage of satisfaction shows a good and effective learning environment that was appreciated by students.

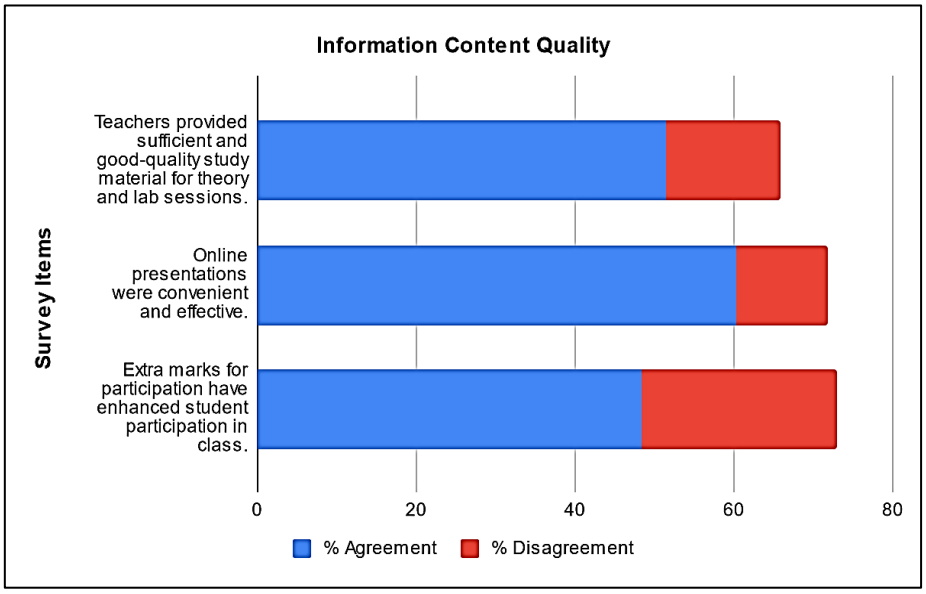

Figure 5: Percentage agreement and disagreement in survey items under factor 4

6.2.5 Service Quality:

Under this dimension, three survey items are presented. The student' responses are well above 3 in all three items. It shows the higher satisfaction perceived by students related to online library access and teacher feedback. Students were very satisfied with online pedagogy and assessment, and they supported the online assessment of final exams as well.

Table 12: Mean score of Information Service Quality (factor 5)

S. No	Service Quality	Mean	Std. Deviation	% Agreement	% Disagreement	% Neutral
16	Good online access to library facilities was available.	3.23	1.111	44.6	24.4	31
17	Teachers provided timely feedback on formative and summative assessments. (Assignments, reports, presentations, etc.)	3.46	1.008	52.6	15.3	32.1
18	The university should continue online assessment of final exams.	3.58	1.353	58.3	23.1	18.6

Figure 6 represents the students' satisfaction. In all three survey items, the majority of students have shown agreement with the action taken by the university.

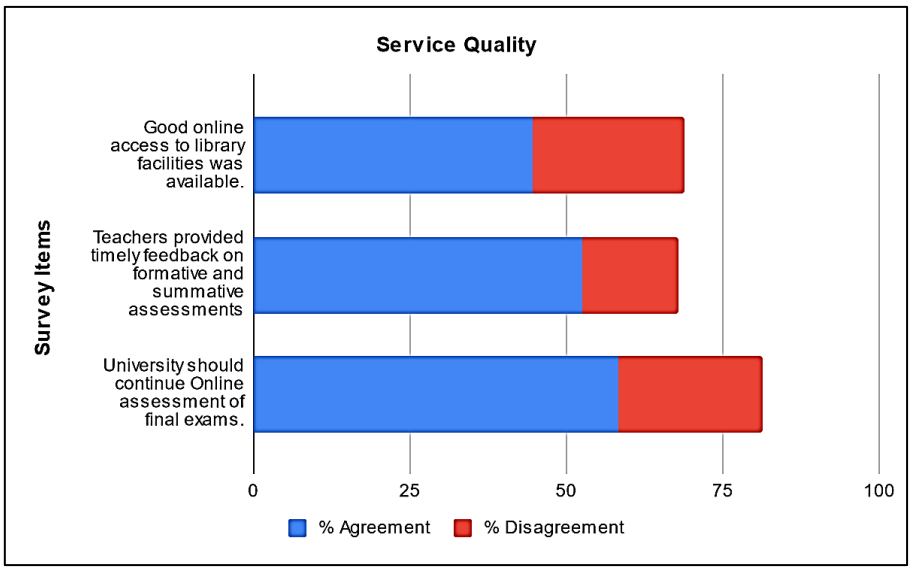

Figure 6: Percentage agreement and disagreement in survey items under factor 5

6.3 Deeper Analysis of Key Survey Items

6.3.1 Ease of Communication

Both students and teaching staff use WhatsApp and Gmail as the main platforms for communication. The striking similarity in the percentage of usage also suggests that tutors responded to the students using a platform that is mostly and easily used by students. Gmail and Google Chat were also used to a good extent. This good communication also reflected in higher satisfaction with the survey item 10 'Students were able to contact their teachers through an online platform' with a high mean value of 3.8. Also, 69.7% of students agreed with this survey question (evident in Table 13). This reflects the motivation and professionalism of the teaching staff of the National University for supporting the learning process and well-being of students.

Table 13: Usage of various communication platforms

Communication Platform	Students	Teachers
WhatsApp	45.3	42.4
Gmail	38.9	38.4
Google Chat	11.2	16.2
Phone	1	0

6.4 Demographic Analysis of five Significant Survey items:

The following five survey items from students' surveys were selected for further analysis based on the demographic data that were collected during the survey. These five survey items are crucial because they are directly related to the change in pedagogy due to COVID-19 restrictions. The National University was also interested in a deeper analysis of these questions.

Table 14: Selected five survey items for demographic analysis.

Sr no	Item no in survey instrument	Survey item
1	4	Students would prefer online delivery of some modules in the future.
2	2	Learning theory in online mode was convenient for students.
3	3	Learning laboratory in online mode was convenient for students.
4	1	Switching to complete online learning was easy for students.
5	18	The university should continue Online assessment of final exams.

6.4.1 Based on Gender:

It is evident in Table 15 that irrespective of gender, male and female students have given similar responses. In all five questions, the p-value is more than 0.05, so there is no evidence of a difference of opinion (Andrade, 2019) for these questions based on gender. In other words, the pedagogy adopted at the National University is highly accessible for both genders and is free from gender discrimination.

Table 15: Survey response based on gender

Survey Item	Female	Male	P-value
Students would prefer online delivery of some modules in the future.	3.68	3.69	0.950
Learning theory in online mode was convenient for students.	3.15	3.07	0.600
Learning laboratory in online mode was convenient for students.	2.48	2.44	0.809
Switching to complete online learning was easy for students.	2.98	3.02	0.860
The university should continue online assessment of final exams.	3.6	3.48	0.501

6.4.2 Based on age group:

Similar to the gender-based analysis, the age group of the participants has no big impact on the students' responses as seen in Table 16. In other words, all students irrespective of their age had almost similar experiences. This observation is supported by p-values more than 0.05 in all five cases.

Table 16: Survey response based on age group.

Survey Items	**18-22**	**23-27**	**28-32**	**33-37**	**> 38**	**P-value**
Students would prefer online delivery of some modules in the future.	3.61	4.03	5	4	4	0.105
Learning theory in online mode was convenient for students.	3.13	3.23	3	3	3	0.937
Learning laboratory in online mode was convenient for students.	2.49	2.44	3	3	2	0.982
Switching to complete online learning was easy for students.	2.95	3.19	2	4	4	0.588
The university should continue online assessment of final exams.	3.62	3.48	1	4	1	0.148

6.4.3 Based on the level of study:

The level of study has a significant difference of opinion on a few survey items. As seen in Table 17, the p-value for three survey questions is less than 0.05, indicating that the level of study is one of the deciding factors in students' satisfaction for three questions, namely, switching to complete online learning was easy for students, students would prefer online delivery of some modules in the future and the university should continue online assessment of final exams. For these three questions, different levels of students gave different opinions.

Table 17 also shows that irrespective of the level of study all students faced inconvenience in learning laboratory in online mode.

Table 17: Survey response based on level of study.

Survey Items	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**p-value**
Students would prefer online delivery of some modules in the future.	**4.25**	**3.38**	**3.93**	**3.83**	**3.71**	**2.6**	**4.33**	**5**	**0.001**
Learning theory in online mode was convenient for students.	3.25	2.94	3.32	3.34	2.89	2.8	4	2.33	0.057
Learning laboratory in online mode was convenient for students.	3.25	2.42	2.54	2.67	2.09	1.6	1.67	2.33	0.112
Switching to complete online learning was easy for students.	**3.75**	**2.78**	**3.21**	**3.22**	**2.54**	**3**	**2.67**	**2.67**	**0.022**
The university should continue online assessment of final exams.	**4**	**3.59**	**3.72**	**3.67**	**3.37**	**1.4**	**3**	**2**	**0.004**

6.4.4 Based on CGPA:
As evident in Table 18, the cumulative grade point assessment (CGPA) of students has no impact on the response in four out of five survey items. This means students of all CGPA ranges have similar learning experiences.

For the survey item 'learning theory in online mode was convenient for students with different CGPA levels', different opinions were expressed. Higher CGPA level students showed greater satisfaction with online theory classes compared with low CGPA students. Table 18 also proves that learning in an online laboratory was inconvenient for all students irrespective of their CGPA level.

Table 18: Survey response based on CGPA level.

Range of CGPA	**<2.00**	**2.0-2.4**	**2.5-2.9**	**3.0-3.4**	**3.5-4.0**	**p-value**
Students would prefer online delivery of some modules in the future.	2.75	3.88	3.85	3.6	3.63	0.243
Learning theory in online mode was convenient for students.	**3**	**2.65**	**3.4**	**3.02**	**3.2**	**0.035**
Learning laboratory in online mode was convenient for students.	3.25	2.35	2.74	2.36	2.42	0.115
Switching to complete online learning was easy for students.	3.25	2.85	3.27	2.95	2.84	0.159
The university should continue online assessment of final exams.	4.25	3.69	3.8	3.59	3.37	0.165

6.5 Pedagogy Survey from Teaching Staff

A survey for pedagogy was done with teaching staff. Observations from tutors' surveys were used to verify students' responses. In this survey, both theory and laboratory tutors were involved. A total of 92 staff responded to the survey. A summary of this survey is presented in Table 19.

Table 19: Pedagogy Survey from Tutors

S. No	**Survey Items**	**% Agreement**	**% Disagreement**	**% Neutral**
1	Adequate technical support was available for conducting online theory classes.	71.7	10.1	18.2
2	Adequate technical support was available for conducting online laboratory classes.	48	19.3	32.7
3	Adequate support was available to prepare quality study materials.	73.8	8	18.2
4	Good online access to library facilities was available.	74.8	6.1	19.1
5	Switching from offline to online classes was convenient.	52.5	22.2	25.3

6	Teaching theory in online mode is effective.	44.5	32.3	23.2
7	**Teaching practical/laboratory in online mode is effective.**	**11.1**	**61.7**	**27.2**
8	Awarding extra marks to students for class participation was a good initiative and enhanced student participation.	57.6	17.2	25.2
9	Teachers would prefer the online delivery of some modules in the future.	52.5	28.3	19.2
10	Adequate support and training were provided to conduct online assessments.	62.6	15.1	22.3
11	I feel empowered to handle online assessments.	62.6	13.2	24.2
12	Conducting an online un-proctored final exam was stressful.	64.7	4	31.3
13	Online assessment of final exams and coursework was stressful.	55.6	16.2	28.2
14	Conducting online presentations and viva was stressful.	32.3	33.3	34.4
15	The assessment of online presentations was convenient and effective.	53.6	19.2	27.2
16	Malpractice cases increased during online un-proctored exams.	66.7	7.1	26.2

In Figure 7, the tabulated data is presented. In Table 19 and Figure 7, a few observations are significant and need explanation.

When considering item 7 in this survey it was found thta 61.7% of teaching staff agreed that teaching laboratory in online mode was ineffective. Similar observations are recorded by Cai et al. (2017). During the student survey, a similar question was asked by students. (student survey item 3). A majority of 55.7% of students agreed that learning laboratory in online mode was not convenient. At COE, SplashTop software was used to provide remote access to course-specific software for laboratory experiments and simulation but nothing was found to fill the gap created by the lack of experiential learning caused by the lockdown during the COVID-19 period.

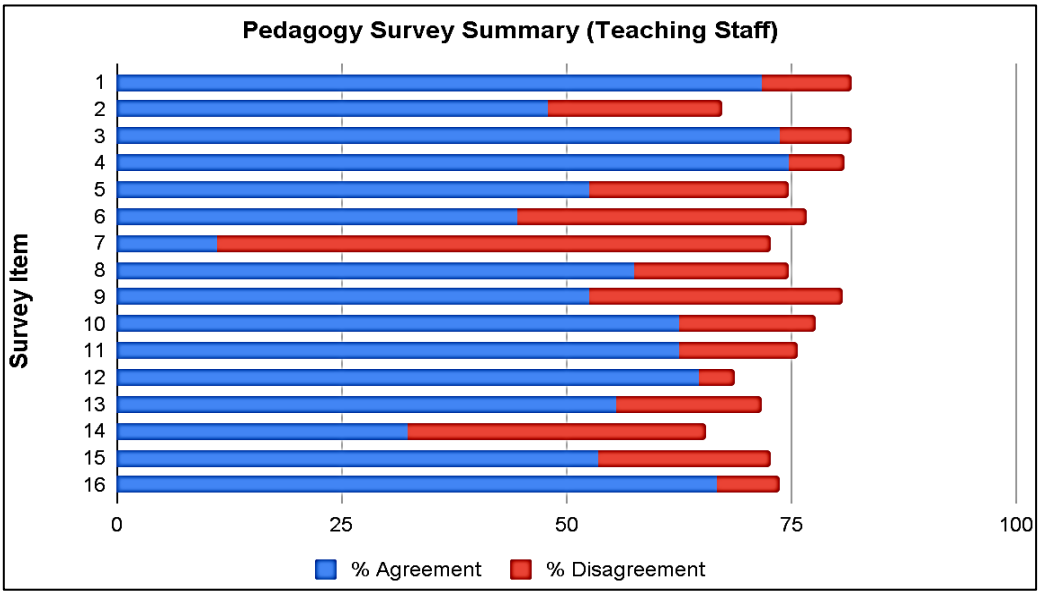

Figure 7: Pedagogy Survey Summary (Teaching staff)

Except for items 2, 6, 7 and 14 in all cases, the agreement is higher than 50% corresponding to the question. Items 12, 13, and 14 are asked in a negative tone. Tutors felt stress in conducting exams and assessments in online mode (Abduh, 2021; Yulianto & Majid Mujtahid, 2021). Teachers are tech-savvy and feel confident in teaching the courses (except the laboratory part). A majority of 71.7% of tutors agreed that adequate technical support was available for conducting online theory classes and 73.8% of tutors said that adequate support was available to prepare quality study materials. When a similar question was asked of students, 51.5% of them agreed that good quality study material was provided.

7. Sustainable Practices at National University Oman

- Teaching staff were using e-learning tools in regular classes before COVID-19. It provided ample opportunity for tutors and learners to learn the tools and get comfortable with them.
- Regular staff development workshops were conducted for skill enhancement for teaching staff. These workshops were majorly focused on teaching methodologies, teaching tools, and platforms. The COE conducted a total of 188 workshops in the last five years. It includes 76 workshops during COVID-19 restrictions in four semesters.
- Regular discussions on best teaching and learning practices through university learning management system Blackboard forums were held. These discussions motivate teaching staff to learn from others and implement them in their classes.

These practices enabled teaching staff and students to handle online teaching and learning during COVID-19 restrictions successfully.

8. Best Practices at National University During COVID-19

Students and teaching staff expressed their satisfaction with the following practices.

- Mock tests and an extra hour to download and upload assessment materials to support students with poor internet connectivity. Students in remote areas and villages especially benefitted from this arrangement. (Abubakar et al., 2022)
- Extra marks were awarded to students who were actively engaged in classroom activities through questions, answers, and discussions. This incentivization enhanced the participation of students in online class discussions.
- Timely feedback was given on students' assignments and activities to keep the morale high and achieve required learning outcomes (Zou et al., 2021).

9. Conclusion

This study is vast and encompasses students and teaching staff of four campuses of the National University of Oman. This study proved a high level of consistency in operations on all campuses. Directives given by the university executives related to pedagogy, student support, and facilities were followed to a high extent. The teaching staff were trained, self-motivated, and enabled to handle remote learning. This led to high satisfaction among students as shown in the survey results and various dimensions of the HELAM model. Similarities in responses of students and teaching staff are not at all easy to achieve. It happens due to indiscriminatory policies and practices at all levels and on all campuses at National University.

There was inconvenience in learning laboratory sessions online and it was expressed by students across all campuses. Notably the learning experience of students was not affected by gender, age group, nationality, level, or mode of study. These findings are noteworthy. The hour extra time to upload assessment components gave relief to students in handling assessments. Extra marks for active engagement in class have kept students active and engaged in classroom activities. The successful switching to online course delivery resulted in the sustainability of teaching practices. The National University has shown a high level of resilience and quickly adopted to an online mode of teaching learning and assessment.

10. Recommendations

Universities must impart training to teaching staff on innovative teaching practices, education technologies, software, and hardware. Students should be given adequate training on online learning tools. This training will prepare and enable all stakeholders to face any future disruptions. In engineering education, the training of tutors and learners a great advantage. A few weeks in a year should be dedicated to online teaching and learning so that new methodologies can evolve. This way tutors and learners can be kept up to date with new education technologies.

Virtual Reality and Augmented Reality enabled laboratories to provide necessary support at times of disruptions of this level. Virtual laboratory sections have

emerged as a cost-effective option for institutions, making them a favorable choice. Moreover, the increasing demand for online formats has propelled the need for effective alternatives to traditional F2F methods in laboratory education. Virtual methods can successfully facilitate the acquisition of laboratory content knowledge, validating their efficacy as substitutes for in-person approaches (Miller et al., 2018).

Universities should extend academic freedom to teaching staff in exercising innovative activities to enhance students' engagement. Better communications, open dialogue, and an empathetic attitude ensure success for the teams and organizations in times of big disruptions.

11. Limitations

This study was conducted with students enrolled in four campuses of the National University of Science and Technology, Oman. In general, Gulf Cooperation Council countries have good technological infrastructure and hence internet access, speed, and availability of devices, such as mobile telephones, personal computers, and tablets were not considered as big limiting factors. It was realized that this data should have been collected just after the COVID-19 restrictions were lifted.

12. Acknowledgment

This study is funded by the Executives of the National University of Science and Technology, Oman. The authors are thankful to Dr Miriam Simon, Associate Professor, College of Medicine and Health Science, National University, Oman for support in the research design. The authors also express heartfelt thanks to the offices of Deans, Assistant Deans, Quality Offices, Academic Assessment offices, and HODs at all campuses for providing necessary permission and logistical support in completing this study.

Conflict of Interest:

The author team declares no conflict of interest with the stakeholders of this study.

Funding:

This study is funded by the executives of the National University of Science and Technology, Oman

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