Research Article

Integrating IoT Technologies with Open Educational Resources (OER) for Enhanced Learning Experiences During the COVID-19 Pandemic

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ABSTRACT

Consequently, this research focuses on the blended application of IoT with OER within college students learning in the context of the COVID-19 outbreak. As more education is moving to the online setting, this study examines if there is an improvement in learning achieved through the integration of open educational resources with Internet of Things-based educational appliances. Two groups of students were surveyed: those studying traditionally in face-to-face classes before the pandemic and those studying online during the pandemic. In the 2019 survey, out of the 912 students who responded, while in the 2021 survey, 1018 students responded. They found that an overwhelming number of students across the two groups felt that OER particularly the open online courses and the open-access textbooks were more advantageous during the pandemic. The current study revealed that distance learners benefited most from OER as supplementary sources of material as opposed to traditional learners where OER was deemed relevant for examinations and tests. Each group, however, mooted some concerns about the nature and range of OER that is available in the market. The findings show that IoT adaptation in combination with OER can solve the challenges students face in different learning conditions while increasing education access and quality during crises.

1. INTRODUCTION

The incorporation of OER in higher education has received much focus in the recent past in particular due to the emergence of covid-19 pandemic that pushed for online learning. That's where OER stepped in; universities and colleges across the globe shifted from online learning during the COVID-19 pandemic, and OER allowed students access to materials that in other cases would be expensive and insufficient in their availability. Therefore, the present study aims to examine college students' OER appreciation and the feasibility of OER usage during the COVID-19 pandemic by comparing the experiences of students who attended face-to-face classes before the pandemic and those who were learning through distance education during the pandemic. Presumably, this study, which analyses how students coming from different learning environments perceive OER, seeks to reveal the purpose of digital resources in improving learning accomplishments during crises [1].

Out of the 912 students who responded to the survey conducted in 2019 before the pandemic, 1,018 students responded to the survey same year 2021 during the pandemic. The comments of these two groups of students were useful for comparison and helped to understand shifts in attitudes towards OER given the development of education during the pandemic. The results show that the students in both groups perceived the OER as handier during the first semester of COVID-19 than in the pre-COVID-19 period. This change strengthens the use of electronic and other freely available media to supplement conventional teaching-learning aids during the COVID-19 pandemic period [2].

Among the OER investigated in the survey, there was an open online course and free access to textbooks. Students ranked these resources highly as they felt that could improve their learning process; most students agreed that they were easy to come by, affordable, and exhaustive. Such advantages were especially useful during the pandemic when the learners' encountered situations like the shutdown of physical learning environments, restricted communication, and extensive use of materials in digital formats. While the use of OER helped keep the cost of learning within students' reach and ensured their efficient access as the environment was changing rapidly [3].

Comparing the results of the current study to another study pointed out differences in the ways distance learners and traditional students enrolled in face-to-face classes used OER. As for distance learners, OER was also effective as an

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ancillary source of the material on the subject which could be integrated into the learning process. On the other hand, the traditional learner who attends face-to-face classes considers OER to be more advantageous in preparing for examinations and tests. Such a situation shows disparities in the expectations of students depending on their learning mode and the kinds of learning materials that can help them excel in their studies [4].

Nonetheless, similar to the OER appreciation both groups shared some reservations about open educational resources quality and availability. These concerns were mainly focused on the originality of the content addressed, as well as on the degree of difficulty experienced in guaranteeing that OER resources matched the courses' curricula. On one hand, OER provides an opportunity to give equal access to materials to learners from different parts of the world and backgrounds, but on the other hand, a large amount of unorganized and uncontrolled material leads to a situation where learners studying in different countries and even in different schools within the same country receive different qualities of the material. To this end, we need to lessen these concerns as a way of enhancing the effectiveness of OER in benefiting student success [5]

The study findings reveal that there should be a push to include OER when designing education systems and during crises like the COVID-19 pandemic. OER thus stands to support students who have different needs… students who are attending face-to-face sessions and those who are undertaking online sessions. In the next sections, we will discuss how universities should fit OER to improve learning effectiveness, to consider the needs of students during disruptions of the educational process [6].

Thus, we see that traditional and distance learning students' attitudes toward OER are different based on the results of perceived usefulness and concerns about the quality of material (Figure 1).
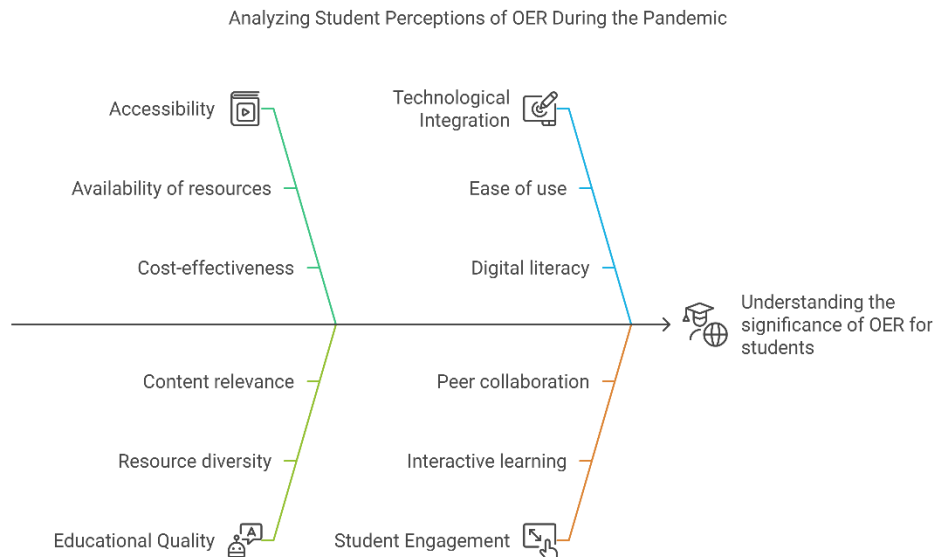

Fig. 1. The Importance of OER During the Pandemic: Student Perceptions.

1.1. Benefits of Open Educational Resources (OER)

Many benefits come with the use of Open Educational Resources (OER) in education, a major being the enhancement of student performance. By using OER, the quality of teaching and learning resources is assured and barriers to students' learning are eliminated by providing both cheaper and locally accessible content. Making these tools open and freely available for everyone, OER improves the way people learn and frees students from the costs of buying books and other teaching materials. The level of improvement of student performance due to OER depends on factors such as; support offered to the learners, the level of the learners in terms of; digital skills, resources to the equipoise of the learners and their learning goals [7].

Of particular importance is the attitude that students have to the utility of the OER resources in terms of how they align their intentions and behaviour concerning the content. Previous studies have also established the importance of students' attitudes toward the effectiveness of OER in the adoption and use of the said resources [8]. This preference suggests that students prefer OERs tools like open courseware, open e-books, and online dictionaries because they find them more useful for practical, project-based learning.

The transition from conventional face-to-face learning to online learning during the outbreak of the COVID-19 pandemic offered a good background for assessing the efficacy of the OER. When educations were relocated online to adhere to social distance policies, OER had more importance added to it. Scholarship and studies indicate that OER is advantageous for contextualized online learning settings instead of the ordinary classroom setting demonstrating how OER has flexibility and openness to distance learners [9]. Nevertheless, an understanding of the effects that different modes of instruction may have on how these students view OER has not been well investigated. COVID initiated the quick transition to online classes forcing the need to undertake more research on how OER is embraced by students, especially those in face-to-face and online learning environments.

2. STUDY OF LITERATURE

The COVID-19 crisis has caused unprecedented changes in educational approaches and practices, concerning classroom relationships most severely. This research outlines several prior works done on the effects of the pandemic on teaching and learning, regarding learning-teaching practices as well as the implementation of new instructional materials. Literature by [10-12], and [13] has reviewed how different educational contexts responded to the crisis, providing insights regarding relationships between the crisis in global health and changes in technology and pedagogy. In their research into the impact of the pandemic on education, [14] said that course modality and student completion rates were all affected. From their data, they noted that courses that were taught online and at different times were more complete before COVID-19 as a result of restrictions and most likely the flexibility of the learning process.

Other subsequent research including the one by [15], examines how the change from traditional face-to-face teaching to the online learning environment affects the students' results, interpersonal interactions, and mental health. These studies identified that most learners who engaged in online learning, enjoyed the convenience and flexibility despite the challenges, especially when Direct contact was missed by learners, which is an important part of the process in traditional education. Therefore, these results show the contextual nature of teaching modes and their impact on learners, which emphasizes the usefulness of variable learning delivery.

[16] In the field of Open Educational Resources (OER), several studies were conducted to explore the application of OER in traditional face-to-face as well as, online teaching-learning environments. These investigations demonstrated that OER is appreciated by students in both types of learning settings, particularly when used as a complement to printed materials, including course textbooks. Students indicated that OER facilitated in enhancing their knowledge, in fulfilling assignments and, indeed in the preparation of tests. The distance learners who responded to the survey supported the use of open education resources like open digital textbooks and open-source software because they come in handy should the learning process go online. The students who take face-to-face courses also benefited from OER, although these learners incorporated such materials as complements rather than primary sources for learning in the context of traditional face-to-face instruction.

Nonetheless, given that COVID-19 has significantly disrupted the learning processes in classroom and distance education, much of the research investigating students' perceptions of OER remains an uncharted area in the literature. Since the shift to online learning from face-to-face instruction caused by the pandemic, there has been limited research regarding the change in the student's perception of the use of OER. This study goes further to fill this gap by exploring the impact of the shift in learning modes during the pandemic on students' use and perception of OER. In this way, it aims to contribute to what can be done to harness the possibilities of OER better in other learning paradigms especially in the new normal educational setting brought about by the COVID-19 pandemic for better learning experiences. Table 1 presents the main conclusions extracted from each study reporting on how the pandemic has impacted education, OER, and students.

TABLE I. SUMMARY OF THE LITERATURE

Study	Focus	Key Findings	Relevance
[10]	Impact of COVID-19 on teaching and learning	Investigated how the pandemic affected teaching methods in various educational settings.	Highlights changes in instructional methods due to the pandemic.
[12]	Pedagogical strategies during the pandemic	Analyzed shifts in teaching methods and the adoption of digital tools.	Explores pedagogical adaptations to online education.
[13]	Changes in educational delivery during COVID-19	Examined the effects of the pandemic on course delivery methods and learning outcomes.	Provides insights into course delivery changes during the pandemic.
[14]	Impact of COVID-19 on completion rates and course delivery methods	Found that asynchronous courses had higher completion rates during the pandemic.	Shows the rise in asynchronous learning due to social distancing.
[15]	Effects of traditional and online learning on students' performance	Studied the effects of learning modes on academic performance, social interactions, and well-being.	Highlights the challenges and benefits of online learning during COVID-19.
[16]	Student perceptions of OER in traditional vs. online learning settings	Found OER highly valued by both traditional and online learners for supplementing course materials.	Demonstrates the value of OER in diverse learning environments.

3. Method of Research

Particularly, this study was designed to understand how the transition to the preference of new forms of teaching by students due to COVID-19 influenced their perceptions about using Open Educational Resources (OER). The study included two groups: those students who had been attending classes physically and other students who had been studying online due to the COVID-19 pandemic. Before the COVID-19 crisis, traditional learners physically went to their classes, while the district or distance and open learning learners almost entirely studied online, but with classroom sessions occasionally. The pandemic hit everyone, and both groups transitioned fully to the online curriculum.

This study was done at the Hong Metropolitan University in Hong Kong which has a traditional face-to-face classroom learning teaching model as well as an online learning teaching model. Data related to the students' perceptions towards OER was obtained using an online self-administered questionnaire. The survey was administered in two phases: the first wave was administered in December 2019 and the second wave was administered in February 2021. The participants comprise university students whether on campus or those attending classes off campus. According to the data collected in the 2019 survey, 489 responses from the traditional classroom students were valid and from the online learners, 423 responses were valid. Theอว of the first group of participants was 21.65 years and the second group had a median age of 32.32 years. From the 2021 survey, the research gathered 624 responses from traditional learners and 394 from online learners. The mean age of these two groups was 31.51 and 21.82 years respectively.

Similar to prior studies regarding students' perceptions of OER, this survey was designed and adapted from earlier surveys Cheung 2017, 2018, and 2019. I fared it into three parts I. The first one was questions posed to the students to get an overall idea about the practice of using OER in teaching. The participants were required to rate their level of perception concerning the effectiveness of OER with a T or D beside questions that were asked. The second section looked at the way the four forms of categorized OER including open courseware, open textbooks, and digital resources were rated by the students in terms of usefulness. The last part was questions on the difficulties that students encountered while using OER with questions asking the level of agreement with criticisms that have been made regarding OER, for example on the aspect of quality and scope.

Each question in the survey was scored on a five-point Likert scale: "strongly agree," "agree," "neutral," "disagree," and "strongly disagree." Responses were assigned numerical values: 2 for "strongly agree," 1 for "agree," 0 for "neutral," -1 for "disagree," and -2 for "strongly disagree." A weighted score formula was used to analyze the responses, as follows:

$$Score = (p.s.a \times 2) + (p.a \times 1) + (p.n \times 0) + (p.d \times -1) + (p.s.d \times -2)$$

Where:

p.s.a represents the percentage of "strongly agree" responses,
p.a represents "agree",
p.n represents "neutral",
p.d represents "disagree", and
p.s.d represents "strongly disagree".

This is because, as indicated before, the use of weighted scores gives a more comprehensive view of the responses given by students. A score between -0.5 and 0.5 means that there is no preference and if a score is greater than 0.5, it carefully means that there is majority preference, the higher the score, the stronger the preference. On the other hand, a score of less than 0.5 indicates clearly that the clients are in the disagreeing category. This method afforded the authors a structure to view perceptions of OER from the learners under various learning environments before and during the pandemic especially concerning the effects of the sudden shift to online learning.

Based on the research strategy used the research aimed at examining the reaction of students to OER disrupted by the COVID-19 pandemic. Data collection started from surveys that were done before and during the current pandemic. After data collection, the above questionnaires were grouped into survey sections based on general perception, type of OER, and decimal challenges facing the students. After completing the collection of responses, the response frequency data was further analyzed using the scale of measures, which includes the use of a Likert scale where responses given were scaled on different levels of agreement as shown below. The last process was data interpretation during which the values assigned to the topics were brought out to view the overall dirge of the students and how it had changed due to the vice shift to online learning. Figure 2 flowchart shows how data is collected, survey responses analyzed, and conclusions made on the outcome. Get more information on the Types of music you prefer at present.

Data
Collection

↓

Survey
Sections

↓

Response
Analysis

↓

Data
Interpretation

Fig. 1. Methodology of data collection, survey sections, response analysis, and data interpretation in the study.

4. RESULTS AND ANALYSIS

The study aimed to understand students' points of view concerning the applicability of OER based on their different purposes and types of learning outcomes. The usefulness of OER for various learning tasks was also assessed from the student perspective as shown in Table 2 and here there was a clear distinction between the traditional students and distance students. The coalescing evidence indicates that OER was perceived as more valuable during the pandemic with a rise in perceived effectiveness particularly for distance learners. This is useful in showing how OER availed itself to provide easy and flexible learning during a time when traditional learning modalities were disrupted. Both of them, though, considered that OER was most helpful when used for course-related purposes, such as readings and assignments, which were critical for further learning in the time of the pandemic.

TABLE II. THE VALUE OF OPEN EDUCATIONAL RESOURCES FOR TEACHING AND LEARNING.

Learning objectives	Traditional students' scores			Distance students' scores		
	2019/2020 (n equal 489)	2020/2021 (n equal 624)	Variance	2019/2020 (n equal 423)	2020/2021 (n equal 394)	**Variance**
Adding course materials and textbooks	1%	1%	0.02%	0.96%	1.02%	**0.11%**
Acquiring New Information for Use in Instruction	83%	1%	0.17%	0.86%	0.97%	**0.11%**
Finding tools to complete homework and projects	0.97%	1%	0.10%	0.95%	1.11%	**0.16%**
Obtaining Study Materials for Examination and Test Preparation	**0.66%**	**0.82%**	**0.16%**	**0.70%**	**0.78%**	**0.08%**

Table 1 presents the data that shows the highest improvement in usefulness by distance learners during the pandemic, which has augmented the perceived value of OER. Meanwhile, traditional students sampled for the study appreciated OER

slightly, by 0.02 points more than before, but the positive value was identified in test preparation more than anything else, influenced probably by the existing 'new normal' learning mode during the COVID-19 pandemic.

In Table 3, the survey analyzed which particular genres of OER, open courseware and materials, were estimated by students. Overall, among the face-to-face students in 2020/2021, these types of resources were considered more useful than in the 2019/2020 academic year and distance learners' ratings slightly changed. On the part of face-to-face students, it was established that they struggled to adapt to the new method of learning online but appreciated the opportunity online gave to access learning resources.

TABLE III. THE VALUE OF SEVERAL KINDS OF FREELY AVAILABLE COURSE MATERIALS AND SOFTWARE.

The value of several kinds of freely available course materials and software	Traditional students' scores			Distance students' scores		
	2019/2020 (n equal 489)	2020/2021 (n equal 624)	Variance	2019/2020 (n equal 423)	2020/2021 (n equal 394)	Variance
distributed entire libraries of study guides	1%	1%	0.12%	1%	1%	**0.08%**
Class notes and lecture notes were freely distributed.	0.99%	1%	0.14%	1.06	1%	**0.01%**
Video recordings of classes and lectures are widely disseminated.	0.95%	1%	0.14%	1%	1.07%	**0.05**
Additional Resources for Distance Education	**0.86%**	**1%**	**0.19%**	**1%**	**0.98%**	**−0.02%**

This information proves that face-to-face students considered other aids like recordings and notes as being of higher value in the 2020/2021 survey. Distance learners, on the other hand, indicated little change, perhaps because they were already familiar with these online tools due to COVID-19.

Table 4, looks at the perceived utility of MOOCs, tutorials, and discussion boards based on the experience of the study. These two groups established that the value associated with such OER forms was higher and face-to-face students especially valued open online courses and tutorials. However, as observed from the score analysis, both the students and teachers considered the small-scale mobile learning courses and applications to be of poor quality since these formats were unable to satisfy the needs of students during the pandemic.

TABLE IV. VALUE OF NUMEROUS MOOCS, TUS, AND DISCUSSION BOARDS.

Value of numerous MOOC, TUs, and discussion boards.	Traditional students' scores			Distance students' scores		
	2019/2020 (n equal 489)	2020/2021 (n equal 624)	Variance	2019/2020 (n equal 423)	2020/2021 (n equal 394)	Variance
Free, publicly available, and self-contained learning opportunities	0.66%	0.98%	0.32%	0.94%	1.05%	0.11%
Tutorials available publicly online, organized by subject	0.56%	0.85%	0.29%	0.70	0.83%	0.13%
Courses and apps for small-scale mobile learning	0.27%	0.35%	0.08%	0.32	0.40%	0.08%
Start live chats and message boards for customers online.	0.23%	0.39%	0.16%	0.44%	0.54%	0.10%

This table also reinforces the fact that due to the COVID-19 pandemic, MOOCs and online tutorials became more relevant to both communities whose classes shifted to online. Compared to that, separate courses on mobile learning and online help desks did not show much usability, so it indicated that such ideas were less useful within the new learning environment.

Finally, Table 5 highlights students 'perception of the amount of usefulness of free e-books, journals and reports accessible through the Internet. The students gave these resources a higher rating in the 2020/2021 survey due to the increased use of digital resources. The perceived usefulness has also risen especially among traditional students learning has shifted to online platforms.

TABLE V. VALUE OF FREE ONLINE RESOURCES LIKE BOOKS, JOURNALS, PAPERS, AND MORE.

Value of free online resources like Ebooks, journals, papers, and more.	Traditional students' scores			Distance students' scores		
	2019/2020 (n equal 489)	2020/2021 (n equal 624)	Variance	2019/2020 (n equal 423)	2020/2021 (n equal 394)	Variance
free online resources like Ebooks (textbooks)	0.79%	1.11%	0.32%	1.10%	1.26	0.16%
free online resources like Ebooks (reference-books)	0.75%	1.04%	0.29%	1.05%	1.19	0.14%
free online resources like journals, papers,	0.58%	0.74%	0.16%	0.64%	0.80	0.16%
free online resources like reports and other	0.78%	0.93%	0.15%	0.78%	0.90%	0.12%

Table 5 shows that in their study, the first group of students as well as the second group of students also felt that e-books, journals and reports were more useful during the pandemic. This can be seen from the fact that face-to-face learning was shifted to online learning indication of the increased use of information resources in learning.
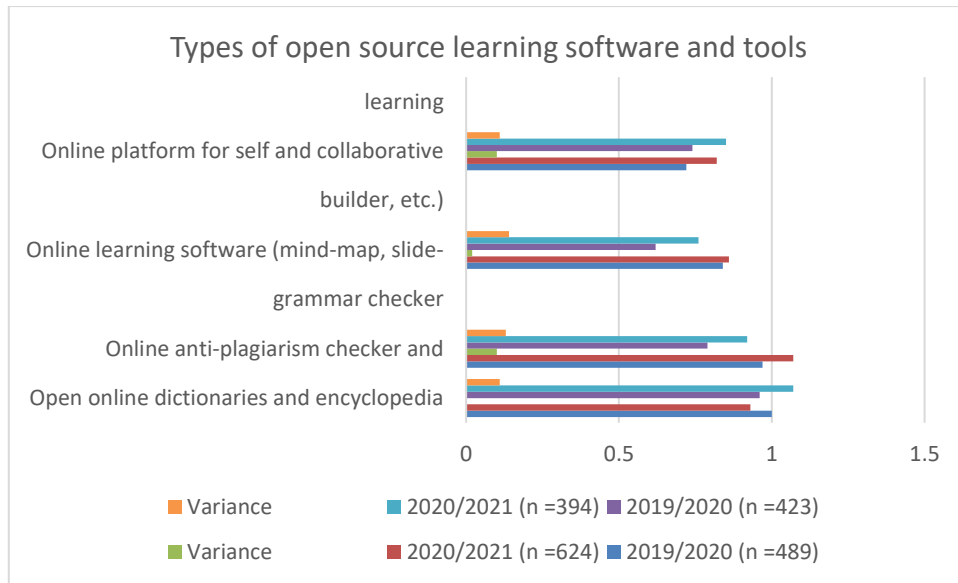

Fig. 3. Open-source software, tools, and platforms for education have a wide range of apps.

The comparison of open-source software and online tools including anti-plagiarism software, grammar checkers and online learning systems revealed that the perceived usefulness of the tools was higher for distance education students. Nevertheless, face-to-face students also identified some of the tools as useful including anti-plagiarism checkers and grammar checkers, yet their value was reduced in comparison to the distance learning students. As shown in Figure 3.
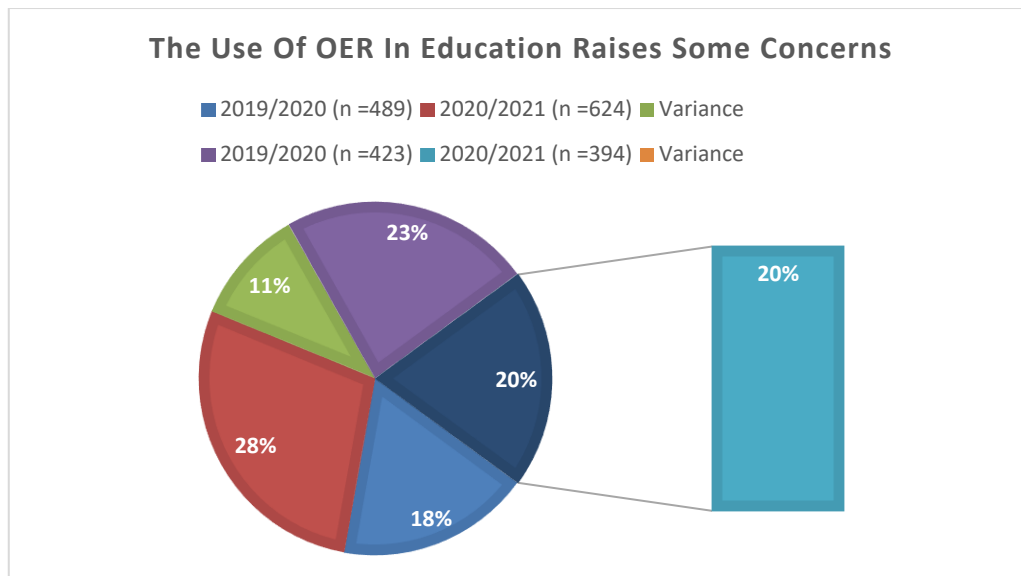
Fig. 4. The use of OER in education raises some concerns.

Concerns that OER is not dependable, out of date, and inadequate were also raised by the students. However, there were negative sentiments on whether the materials were authentic and whether they were current in the set subject area. As for the course materials, face-to-face students complained more than did distance students about the quality and relevance of the course resources. As shown in Figure 4.

These findings reclaim the experience the students had during the pandemic about OER and the change in how students utilized OER as a learning aid. The growth in the use of OER in learning especially during disruptions means that there would be a need to improve on the quality, standard, relevance and variety of OER.

5. DISCUSSION

Table 6 captures the key points discussed concerning the utilization, impact, and perception of OER in different learning contexts, particularly under the influences of the COVID-19 pandemic.

TABLE VI. KEY POINTS ON THE UTILIZATION, IMPACT, AND PERCEPTION OF OER IN VARIOUS LEARNING CONTEXTS DURING THE COVID-19 PANDEMIC.

Aspect	Discussion Summary
Effectiveness of OER	OER is effective in both traditional and online learning environments, enhancing access to learning resources and coursework completion.
Impact of COVID-19	COVID-19 shifted learning from face-to-face to online, elevating the importance and utility of OER in education.
Differences in Use	Distance learners used OER primarily to supplement course materials, while traditional students used it for exam preparation.
Perceived Value	Traditional students found open courseware more beneficial than distance learners during the pandemic due to availability issues.
Student Needs	Different needs between traditional and distance learners highlight the requirement for tailored learning activities.
Quality Concerns	Face-to-face students were more concerned about the accuracy and completeness of OER compared to distance learners.
Online Teaching Adaptation	Universities need to adapt teaching methods to maintain course quality in an online setting, adjusting content delivery as necessary.
Resource Quality	Both student groups emphasized the importance of the quality of textbooks and reference materials for their learning potential.
Integration Concerns	Variations exist in how OER is integrated into conventional and online learning, with a call for better training and resource integration.

6.CONCLUSION

This paper seeks to understand the level of usefulness provided to students during the COVID-19 pandemic in matters concerning Open Educational Resources (OER). The study revealed that OER which includes open online courses, open access e-text books and other free accessible course resources was perceived to be more helpful during online learning as compared to traditional learning. These resources offered additional information and instruments that include open online dictionaries, anti-plagiarism checkers, grammar checkers and so on. Nonetheless, students had doubts over the accuracy,

completeness and authenticity of OER sources, which indicates that the quality and the credibility of OER remain problematic even after their authors have made them available to the public. The study also indicates the potential of students' attitudes to the effectiveness of OER based on their mode of learning whether distance learning or traditional face-to-face classes. The findings of this study would add knowledge on Using OER in Higher Education Institutions, especially during crises such as the COVID–19 Pandemic. Online learners reported frequent use of OER to complement teaching learning materials as part of understanding contextuality in approaches to learning. The study pays more attention to the differences in the needs of learners across learning contexts, especially as in-class discussions showed no increase in the perceived usefulness of resources compared to online learners. Understanding the needs of students especially those learning online, will enable a teacher to fashion how he or she teaches and how to use OER to address those needs. Further researchers should continue the study by performing it in different areas and educational levels including the faculty members and other stakeholders: and examine the changing needs and perceptions of students regarding OER while the institutions slowly shift towards the face-to-face or blended learning environment post-pandemic.

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