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# A COVID-19 Inspired Augment Reality Application for ICT Module: Migration Experiences of Muscat College Computer Science Students

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**Abstract:** The COVID-19 pandemic motivated higher education institutions to become dynamic and provide resilient learning environments which are not solely reliant on physical classrooms and laboratories. During online classes, students have no alternatives for performing lab practical activities that require physical devices. This study aims to explore the benefits of augmented reality in providing simulated environments for students depicting real computer hardware components. Forty-two (42) computer science students were immersed in the AR app for the Information and Communication Technology Workshop module. The students find the app effective as it provides a real-world model, provides useful information, and can be used as a substitute for a real computer which can be accessed within their phones, anytime and anywhere. They strongly suggested that all modules should implement an AR-assisted app. The scores in the classroom assessment have a significantly high positive correlation with the scores obtained in the app's self-assessment feature.

***Keywords****: Augmented Reality, ICT, Computer Science*

## 1. Introduction

Education is essential in human development and driving socio-economic growth (Khadzhalova, Savzikhanova, & Eminova, 2021). The quality of education directly influences the achievement of an individual's overall progress (Ali & Ahmed, 2022). However, the current methodology of education delivery, including to Omani students, has met several challenges. These challenges encompass learners' difficulty comprehending lessons (Vaughn, et al., 2019), and lack of critical thinking, creativity, and communication skills (Xu, 2023), leading to an increasing concern about the effectiveness of education. To make the situation worse, the COVID-19 pandemic caused education to be delivered online (Zhao & Watterston, 2021). In addressing these challenges, technological intervention is always an option (Thaariq & Surahman, 2021). For one, augmented reality (AR) has proven its capacity to translate abstract concepts into forms which learners can comprehend (Sahin & Yilmaz, 2019). By integrating AR into classrooms and laboratory setups (Altınpulluk, 2019), there can be a substantial revolution in the way students learn and interact with educational content. This technology can bridge the gaps in learners' comprehension while offering dynamic visualization (Sahin & Yilmaz, 2019), fostering creativity, and promoting practical application (Garzón & Acevedo, 2019), thus enhancing the overall effectiveness of education. This research aims to explore the integration of AR in education, examining its impact on Omani learners by soliciting their migration experiences.

## 2. Literature Review

Education is an indispensable pillar of human development, serving as a conduit for the transmission of knowledge accumulated by human civilization. In this research endeavour, the quality of education and the efficacy of its delivery are highlighted. Recognizing the need to identify the essential conditions for nurturing the educational potential of learners and increasing the efficiency of delivery is crucial. Such are essential for fostering appropriate socio-economic growth and addressing the prevalent challenges in the modern systems of preschool, school, and university education (Khadzhalova, Savzikhanova, & Eminova, 2021). To achieve these, policies in education must be carefully implemented to enhance the availability of quality education that aligns with the demands of innovative economic development, the evolving needs of society, and the aspirations of each citizen. It is imperative to modernize educational institutions and establish mechanisms for assessing the quality of educational services, ensuring the incorporation of innovation in the educational process. In addition, educational systems must underscore the pressing need for technological integration to improve the standard of education and achieve sustainability. This, in return, will produce quality learners who are not only well-educated but also employable and well-suited for the job market, transcending the confines of traditional textbooks and embracing the advantages of technology (Munna & Kalam, 2021).

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In the year 2019, the COVID-19 pandemic has brought significant changes to the education system, triggering massive experimentation with distance education at an unprecedented scale. Universities were compelled to grapple with the dual challenge of delivering quality distance education while contending with the ongoing pandemic. This unforeseen situation has provided a unique opportunity to gain valuable insights into the effectiveness of large-scale online education and maintaining educational continuity in the face of adversity. To make this system work, teachers have had to invest greater effort in preparing for online courses, employing innovative teaching methods, and designing engaging lessons to captivate students' attention. This shift also demands a patient transition of students from passive recipients to active participants through interactive question-and-answer sessions, tests, presentations, and open discussions (Sun, Tang, & Zuo, 2020). But despite the pandemic's disruptive impact on traditional education, it presented opportunities for universities to identify shortcomings and utilize the platforms for online education. Certainly, the COVID-19 pandemic has sparked discussions about reshaping the educational landscape, pushing us to explore strategies outside traditional school settings. This pandemic's profound and enduring influence on society also motivated the need to reimagine education in unprecedented ways (Zhao & Watterston, 2021).

In the quest to ensure inclusive and equitable quality education for all learners, the integration of digital technologies has become a crucial cornerstone. These digital innovations have brought about a transformative shift within the education system, significantly streamlining the learning process by making it more accessible and efficient. Digital tools like video conferencing systems, online polls, web-based, blended learning and other technology-driven solutions actively engage students, fostering a more interactive and participatory learning experience (Haleem, Javaid, Qadri, & Suman, 2022). In effect, the infusion of technology into education has ushered in a new era of learning, one that is more inclusive, interactive, and responsive to the diverse needs of students, contributing to the pursuit of quality education for all (Mahmud, Freeman, & Abu Bakar, 2021).

The application of AR in the education system is an area that warrants deeper exploration. As the capabilities of AR continue to expand, it introduces new possibilities for reshaping how we learn, perform tasks, and engage with the world around us. Studies suggest that AR technology allows for the seamless integration of real-world objects with information and virtual elements, creating innovative automated applications that can significantly enhance the effectiveness and appeal of teaching and learning. Furthermore, AR's potential extends beyond visual enhancements; it can engage all human senses, including hearing, smell, and touch (Quintero, Baldiris, Rubira, Cerón, & Velez, 2019). In the realm of education, AR emerges as a promising strategy to promote educational inclusion by facilitating a quicker and more profound way for learners to understand complex concepts and offering more engaging and enjoyable learning experiences. This, in turn, positively impacts the overall educational system, boosting confidence levels, commitment, and stakeholders' interest. In recent years, the number of educational AR studies has grown substantially, reflecting the increasing recognition of its value in diverse fields of education particularly in science, engineering, and medical training, where its interactive and immersive nature can significantly enhance the learning process (Sirakaya & Sirakaya, 2018).

The implementation of AR technology has witnessed substantial growth across diverse applications, ushering in new and innovative ways of learning and interaction. In the realm of education, AR has become a prominent tool in the analysis of educational trends and offers immersive and interactive learning experiences for students, revolutionizing the traditional learning paradigm. Additionally, AR has been recognized as a sophisticated technology which is compatible with smartphones, tablets, and other devices (Altınpulluk, 2019).

AR has proven especially effective as a learning medium in fields like chemistry, offering a unique way to explore spatial reasoning skills to chemistry students, and enhancing their understanding and proficiency (Behmke, Kerven, Lutz, Paredes, & Pennington, 2018). AR technology extends its applications to a wide array of educational training domains, including electrical circuit lessons (Baran, Yecan, Kaptan, & Paşayiğit, 2019) and medical training (Dhar, Rocks, Samarasinghe, Stephenson, & Smith, 2021). AR has also assisted with instructions for sports skill drilling, providing athletes with unique training tools (Chang, Zhang, Huang, Liu, & Sung, 2018). AR has also been employed in the vocational skills curriculum, which in effect, shortened the time of realizing a task (Radosavljevic, Radosavljevic, & Grgurovic, 2018).

Additionally, AR has aided novice carpentry learners in comprehending the conceptual visualization of three-dimensional space and indirectly improved their grasp of furniture carpentry skills and the complicated mortise–tenon joint (Lee, 2018). Likewise, corporate training programs (Martins, Jorge, & Zorzal, 2020) and worksheet management (Zhang, Huang, Liu, Sung, & Chang, 2019) are also innovated through the incorporation of AR technology. Vocktail, another AR innovation, enhances the drinking experience through the stimulation of taste

buds and the manipulation of colour and smell (Kerruish, 2019). Furthermore, AR Studio has added an extra dimension to anatomy education by displaying anatomical structures on the body in real-time, thus enriching the learning experience (Kelly, et al., 2018).

AR technology offers distinct advantages and impacts over traditional learning materials, notably through its capacity to enhance learners' spatial skills (Gecu-Parmaksiz & Delialioğlu, 2018). It provides the opportunity to experience object orientation and visualization from multiple perspectives. As an example, the use of AR Sandbox has proven beneficial for children, facilitating exploration and better engagement of students that results in a deeper understanding of spatial concepts (George, Howitt, & Oakley, 2019). Furthermore, AR learning techniques have been found to lead learners to higher levels of achievement and more positive attitudes towards education (Sahin & Yilmaz, 2019). Studies also suggest that the use of AR also benefits the cognitive processes of learners (Kim & Irizarry, 2020). Such benefits highlight AR's potential to revolutionize and optimize the educational experience for students in diverse ways.

Despite the perceived advantages of integrating AR into the learning modules, there are still few studies conducted in Oman, specifically for practical classes. For example, Al Saqria and Al Salmi (2020) reported that 10th-grade female Islamic students who used AR had higher thinking skills. A similar study by Al Shuhaili, Al Musawi, and Muznah (2020) found the same result as the 10th-grade male students scored higher in the achievement and attitudinal tests in Social Studies as compared to those students who did not use AR. Al Buraiki, Abdullah, and Khambari (2022) attempted to apply AR in teaching ICT. However, this effort culminated with an integration model.

Considering the above literature, this research builds its foundation anchored to education's crucial role in human development and societal growth. Studies reveal that traditional educational methods need to be improved to provide sustainable and quality learning experiences to learners. Various technological interventions have already been introduced to address these concerns. The occurrence of the COVID-19 pandemic compelled a shift to online and blended learning approaches, creating research opportunities and motivation to further revolutionize educational strategies. Therefore, this research explores AR capabilities as an educational tool to enhance the learning effectiveness for Omani students, both in lecture and laboratory setups. AR has already been proven to enhance spatial reasoning skills, effectively facilitate educational training, and aid in three-dimensional space visualization, sensory stimulation, and creative concept presentation for learners. These positive impacts manifest through better engagement and comprehension of Omani students. AR demonstrates an innovative solution to address the limitations of traditional education, opening doors to more dynamic and effective learning experiences.

## 3. Methodology

### 3.1 Samples and Context

The study purposely involved 42 first-year Computer Science students of which 21 are from Software Engineering and 21 are from Networking majors respectively. The students are currently taking the Information and Communication Technology (ICT) Workshop module which aims to immerse students in the fundamentals of computer hardware and software. The students are exposed to the internal and external components of a computer system. At the end of the module, the students are expected to assemble a computer.

### 3.2 Data Collection and Analysis

A series of training and orientations were given to students to familiarize themselves with the application.

The students were given two sets of questionnaires. The initial questionnaire aims to gather basic information on the mobile operating systems and awareness of AR of students. The second questionnaire is subdivided into two sections. The first section solicits their experience during the use of the app while the second section collects the scores of the students during the practice exam within the app.

The data were organized and analyzed using Microsoft Excel and PSPP Tool. Outliers were determined using Box Plotting and values were imputed using the median value. The Shapiro-Wilk test is used to determine the normality of the data. Since the data are not normally distributed, the Wilcoxon Test was used to compare the responses of the two majors and the Spearman Correlation to determine relationships between variables. Hypotheses were tested using the p-value of 0.5.

The responses to questions are expressed using a Likert scale of 1 to 5 and can be interpreted as shown in Table 1.

Table 1. Likert Scale of Level of Agreement

| Mean Value | Weight | Verbal interpretation |
|---|---|---|
| 4.20 – 5.00 | 5 | Strongly Agree |
| 3.40 – 4.19 | 4 | Agree |

| Mean Value | Weight | Verbal interpretation |
|---|---|---|
| 2.60 – 3.39 | 3 | Neutral |
| 1.80 – 2.59 | 2 | Disagree |
| 1.00 – 1.79 | 1 | Strongly Disagree |

### 3.3 AR App Overview

Although 71.43% of the students were using Apple IOS, the app's prototype was initially deployed in Android as testing is flexible. The APK file (the installer) of the application can be easily shared and installed on the phone at the users' discretion which is impossible to do on iPhones. Android phones were given to iOS users during the app training and testing.

The app offers both the Learning and Quiz modes with the use of a QR code (Fig. 1) placed on the table as the base of the AR model.

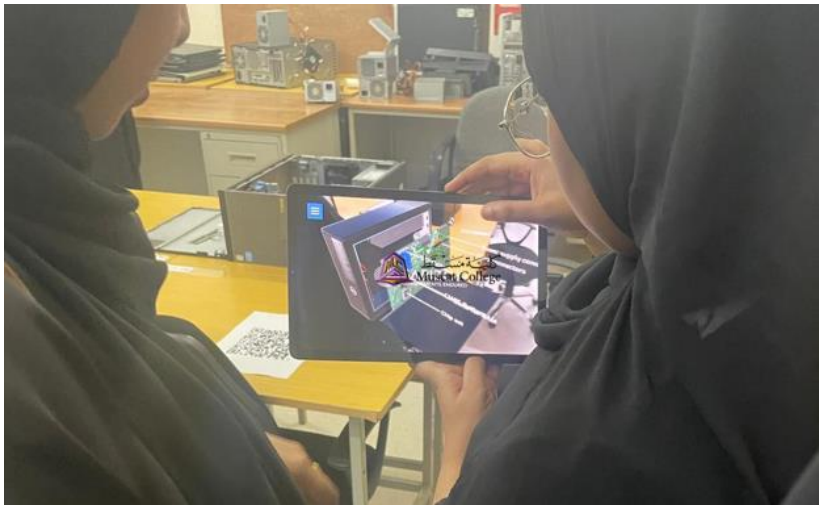

Figure 1. App's QR Code

During the Learning Mode, the students can explore the various parts of the computer using the AR model. The ability to zoom and pan enables them to explore and navigate each component. The students can access learning topics (Fig. 2) related to each component.

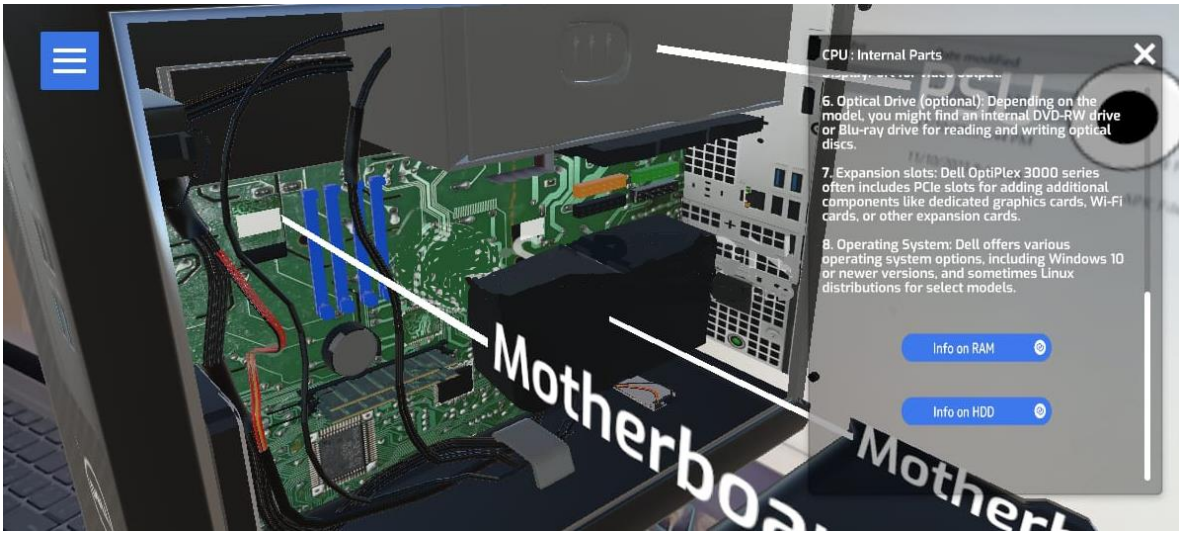


Figure 2. Learning Mode

Aside from the built-in topics, students have options to watch related videos (Fig. 3) within the app. The videos were arranged according to the topics.


Figure 3. Video Discussions

The Quiz Mode enables students to perform self-assessments of their knowledge gained from the topics. The assessment is comprised of eight (8) theoretical questions (Fig. 4) and a simulation of a PC assembly (Fig. 5) to familiarize students with the location of each component on the board. Feedback (Fig. 6) is given at the end of the assessment.

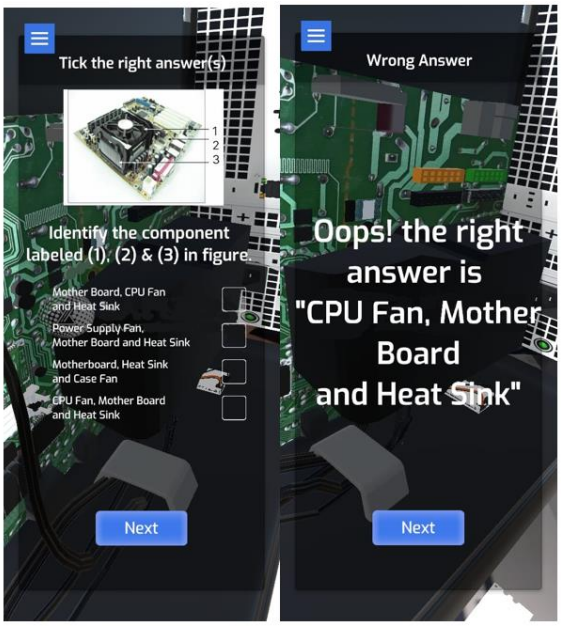


Figure 4. Theoretical Questions

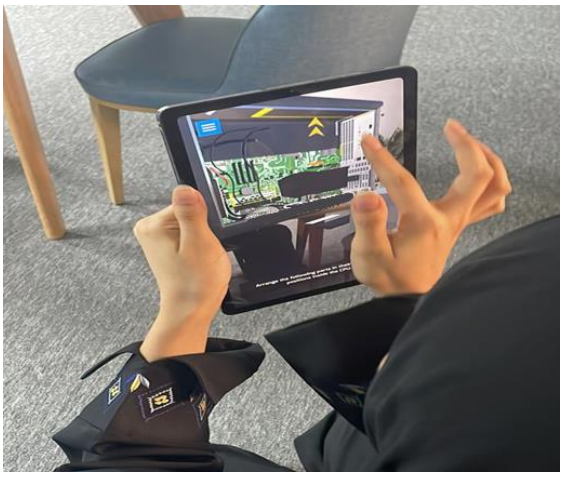

Figure 5. PC Assembly Simulation


Figure 6. Feedback

## 4. Results and Discussion

Most of the students (78.75%) involved in the study have no experience using AR-related applications as they rely on websites for learning. Many students (80.95%) welcome the possibility of integrating AR-related mobile applications in the teaching and learning process. The Wilcoxon test indicates that there is no significant difference (z =-0.03, p=0.978) in the responses between the majors.

The students were asked about the perceived effectiveness of the AR app. Table 2 shows the mean value of the responses in each area and the Wilcoxon test results of the disparity of the responses between the groups.

Table 2. Perceived Effectiveness of the AR App

| Areas | Wilcoxon Test | P value | Significant Difference | Mean | Verbal Interpretation |
|---|---|---|---|---|---|
| The augmented reality app makes the students more interested in learning the topic related to PC Assembly. | -0.86 | 0.391 | No | 3.79 | Agree |
| The augmented reality app helped the students gain more information about PC assembling. | -0.63 | 0.527 | No | 3.59 | Agree |
| The augmented reality app helped me have a better understanding of each PC component. | -0.11 | 0.912 | No | 3.77 | Agree |
| The augmented reality app helped students to get more information about PC assembly quickly. | -0.52 | 0.606 | No | 3.87 | Agree |
| The augmented reality app provides a real-world experience of the inner components of the computer system. | -0.04 | 0.971 | No | 3.92 | Agree |
| The augmented reality helped students to explore the inner components of the computer system. | -0.84 | 0.399 | No | 3.82 | Agree |
| The augmented reality model of the computer can be a substitute for a real PC when studying the parts. | -0.79 | 0.428 | No | 3.82 | Agree |
| The augmented reality app is effective in helping students to prepare for the test. | -0.32 | 0.749 | No | 3.77 | Agree |

The students strongly agree (M=4.31) with the idea that augmented reality should be integrated into applicable modules (z=-0.26, p=0.796). They also agree (M=4) that after using the app, they can be skilled in the use of augmented reality (z=-1.13, p=0.257).

The self-assessment conducted within the app shows very satisfactory results. The class was able to answer 6.44 of 8 or 80.45% of theory questions correctly. All students got perfect marks in the simulated PC assembly. There is no significant difference between the mean scores of the groups (z=-0.80, p=0.422). Table 3 shows the breakdown of the answers.

Table 3. Breakdown of Scores

| Questions | Percentage (%) of Students | |
|---|---|---|
| | Correct Answers | Incorrect Answers |
| 1 | 87.18 | 12.82 |
| 2 | 58.97 | 41.03 |
| 3 | 64.10 | 35.90 |
| 4 | 64.10 | 35.90 |
| 5 | 66.67 | 33.33 |
| 6 | 66.67 | 33.33 |
| 7 | 58.97 | 41.03 |
| 8 | 76.92 | 23.08 |
| Simulated PC Assembly | 100 | 0 |

Furthermore, the score of the students in the actual classroom assessment has a significant, positive high correlation with the app self-assessment results (r(42) = 0.796, p=0.976). The feedback mechanism of the app's self-assessment helped students to focus on the important concepts.

## 5. Conclusion and Future Work

Although the overall scores of the students in the self-assessment conducted within the app are satisfactory, it must be noted that the training duration, exposure time, and familiarity with the app have a great impact on the scores. The students were immersed in the app for a week. Also, due to Apple's restriction on the installation of unverified (apps not uploaded in the App Store) affected the testing experience of the students. The researchers must compare the semestral grade results of the students who have utilized the AR app in their modules with those who underwent the traditional approach.

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