

A Study on Effect of Virtual Reality Learning On Students: Usage on Classrooms

MALIK JAWARNEH¹, AHMAD SHARIAH²

¹ Faculty of Computing Sciences, Gulf College

² Faculty of Business and Management Studies, Gulf College

Abstract- Educational environment has faced and continues to face a lack of personnel, especially in fields of activity difficult to be understood like mathematics or physics. For this reason, schools are required to teach their students in classes with more students, being difficult for teachers to explain and exercise with every student individually. This involves blocking the activity during class of both the teacher and the other students. For a better understanding, in all science courses, the teachers usually spend multiple hours on the same subject, at the same time. After completing the subject, students need practice for memorizing and often need the teacher to help with homework. Because an active individual teacher, even virtual, is easier to be understood than a written instruction, the authors propose the use of virtual environments as a 3D Virtual Reality. The use of 3D Virtual Reality offers a number of advantages, including: the possibility of working at the same time while following the instructions, reviewing the course material or following a teacher resolving an exercise without having to interrupt or taking a long time to resolve the homework. This paper presents the possibilities of using 3D Virtual Reality devices for individual learning.

Indexed Terms- Education, Learning, Digital Content, Virtual Reality.

I. INTRODUCTION

With progressive twenty-first-century 3D virtual technologies, the ability to blur the lines between material reality and digital worlds is proliferating in classrooms across the globe [1-5].

Virtual reality (VR), which can be described as immersive multimedia or computer-simulated reality, replicates an environment that simulates a

physical presence in places in the real world or an imagined world, allowing the user to interact in that world [6-15]. VR has a long history – its technical foundations could be traced back to the early 1950s, even though it has been a concept long ago conceived. A common definition of VR focuses on technology and refers to a collection of software and hardware for creating computer-mediated simulation [16-25]

Nowadays VR is a very deep and effective technology on human perception. The VR technology importance creates a new simulated world. VR technology is becoming a special and cost effective application and its future will have a positive impact on technology [26-30].

VR delivers to us in a real world where humans can have strong and easy interface message communications. Moreover, VR technology is capable of humans as a part of new ideas inventions in the world. VR technology provides us widely concepts, which use the expanded sensory relationship with humans. VR manipulates different kinds of environments, which get special goals and enhance the capabilities in architecture, interior designers, and engineers. With the help of VR, multiusers become and execute collaboration, which highlights the human's creativity, and most people can deliver their opinions. VR technology provides an excellent platform, which can stimulate the dynamically real world. As well as VR increase productivity in different business areas and introduce new real world because it is difficult to imagine a graphics workstation [31-42]. The purpose of this short paper is to discuss types, benefit and effective usage of 3D learning.

II. LITERATURE REVIEW

This section included on the virtual reality and related work of effect of Virtual Reality Learning on students: usage on classrooms as following:

- Virtual Reality

If people look at VR history from 1965 virtual world started. It was the first idea generated which is Real Cool, Sound Real, and delivers good realistic actions to viewers. In different decades of research on VR, research details are as under 1960-1962 decades which one multi-sensor stimulated and prerecorded film, which was colored and stereo. Then in 1965, a second idea was demonstrated in the name of "DISPLAY ULTIMATE " based on construction artificial concept and it is reality graphic interaction sound. Figure 1 shows the VR architecture and their mechanism [43-53].

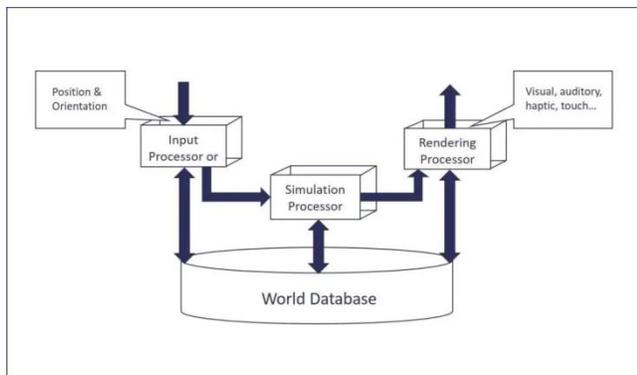


Figure 1: Architecture of Virtual Reality

Virtual reality (VR) is a simulated experience that through hardware and software integration can be like or completely different from the real world. It allows users to interact inside a simulated environment constructed by computer programs. VR technology can create a special region that mimics that of the real world via providing functions such as stereoscopic vision, hearing, touching, and experiencing. VR technology is growing to be intensively popular and widespread as the metaverse ushers in a new era of digital connectivity. It can be effectively used in various subjects, such as education, business, gaming, medicine, new employee training, entertainment, social networking, tour guiding, etc. [54-64]

- Related Work

VR is a very popular technology allowing visualisation of various phenomena and concepts enabling students to better grasp complex terminology definitions. For example, its benefits on learners' attitudes toward mathematics and design activities are investigated in (Simsek, 2016) on 28 secondary school third class students, showing increased positive attitudes and interest in mathematics for the experimental group. Another positive example of VR use, specifically in geometry secondary school teaching, is presented in (Guerrero, Ayala, Mateu, Casades, &Alamán, 2016), where mixed reality technology created by combining tangible interfaces and virtual worlds (Mateu, Lasala, &Alaman, 2014) allowed a more meaningful learning ensuring a higher grade of knowledge retention. VR can also play an important role in VLs (Heradio, et al., 2016), which allow visualising various experiments in subjects such as Physics or Chemistry when certain facilities are not available. It needs to be noted that the use of VL has been shown to provide a similar or increased level on knowledge compared to traditional labs[65-78].

Many studies have shown that virtual reality can be especially useful in education. Virtual reality has already been used in courses such as Biology, Chemistry, Physics, Astronomy, and Medicine [79-82]. Three-dimensional imaging, interactivity, and immersion make virtual reality a useful method that can stimulate motivation to learn and make the learning environment more engaging and effective [83-89].

For example, astronomy is a key issue in science in which students face difficulties. Many children have difficulty understanding concepts such as the size and shape of the Earth, the phenomenon of day and night, the phenomenon of the seasons, and the orbits of the Earth, the Sun and the Moon. Research has shown that many misconceptions of astronomy were found in children from different countries (Parker and Heywood, 1998).

The usual disc-methodical methods of these topics make use of lectures, websites, two-dimensional diagrams, Flash animations, scientifically quality telescopes, and images with NASA space data.

However, Parker and Heywood showed that two-dimensional diagrams that try to represent 3D space are difficult to interpret and do not help to understand these issues.

Also, Pena and Quilez (2001) showed that images and diagrams in textbooks do not always facilitate the understanding of concepts. Misleading 2D diagrams and images can promote misconceptions in children. In contrast, research has shown that the use of virtual reality can pre-emptive spatial perceptions and can provide students with an immersive learning environment.

Virtual and augmented reality technology has also been leveraged in the field of digital, educational applications and games (Pena and Quilez, 2001). At a practical stage, however, the use of virtual and augmented reality in the classroom is at an experimental stage, especially in terms of the extensive use and utilization of corresponding applications in the context of teaching courses and chapters of the curriculum (Huang, et al., 2010) [90-95].

A tool that utilizes virtual and augmented reality applications that are of increasing interest in the educational world, is virtual tours and projections of three-dimensional models and objects. It is a form of virtual tour of open locations, interiors of buildings, works of art and culture, or a virtual processing of objects and models in their three dimensions (Marsh, 2018).

In the case of three-dimensional projection of objects through augmented reality, students have two basic options. One concerns the viewing and processing of the projected models in the three-dimensional imaging environment of smart electronic devices and the second integrates and adapts the objects in real, realistic environments utilizing the camera of the devices and the corresponding augmented reality software (Marsh, 2018).

III. RESEARCH DESIGN

To establish a common ground where applications from two environments can be evaluated fairly, it was important that an educational application that has

same features and visuals. This is very hard to come by, where the VR application market is yet widely open to the public and the fact that we are at the same time looking for an educational application that fulfils these requirements. It made more sense that we would create our own application where we could make sure that both sides are represented fairly in the evaluation. Therefore, we chose Design Research as our research approach. Design research is a problem-solving paradigm that evaluates and identifies problems with an artefact. In this case we would be creating our own artefact (Prototype Application) and evaluate it instead of evaluating an existing one and by doing so we will be able to answer our research questions (von Alan, 2004). For instance, Karagozlu (2018) designed an augmented reality application to improve students' problem-solving skills in science subjects.

- Analysis on Adoption of VR in classrooms

VR has shown great promise in improving teaching and learning methods, particularly in a post-COVID-19 world, where there has been a wide application and acceptance of technology in learning, even in less privileged countries and societies. As was mentioned in previous sections of this paper, many empirical studies have reported VR's positive impact on education across various subjects and at different levels of study, including higher education. However, authoring VR learning content is not an easy task; creating 3D models and providing an immersive learning experience is a complex process.

Currently there are many other mobile HMDs in the market following the Google Cardboard idea. Simple and cheap wireless HMDs that works in combination with an android or iOS devices and uses the stereoscopic display and the head tracking of the device. But Samsung had an idea of improving the wireless HMD experience that utilized mobile devices by introducing their own upgraded version building on top of the Cardboard idea[96-101].



Figure 2: Key Features of Samsung Gear VR

A. Storyboard Design

1) Menu Display

In this main menu, there are two choices of material that can be chosen by the user, the material of the solar system and eclipse material.

2) System design

In this process the author design the Game Design Document that include the main aspects about the game such as the rules, scoring, visual design, and leveling. Also, Collect and make the assets that used in the game likes sound assets and 2D or 3D models. Assets collected from the Unity Assets Store or another resources. Process of making scene in Unity according to the storyboard that already made with arrange all of the 3D assets, text, music, and adding visual effect. Avatar also added to represents the presence of the teacher and the students in virtual world. Adding the control function to the player such as pointer interaction, select, and grab object with processing the input value from controller device. Connecting one device to another so they can interact inside the virtual world. Implement object spawn and also player’s movement synchronization using Photon Unity Networking.

This study aims to design a multiplayer-based learning media applications by utilizing a HMD device and device controller as an input and output device and a server to process data that can be used in multiplayer (Figure 3). Data input received will be displayed in the form of an avatar and interaction

with virtual environments which will then be processed by the server so that it can be received and observed by all players. In order to realize this final project, a system design that describes the concept and work of the system is made [102].

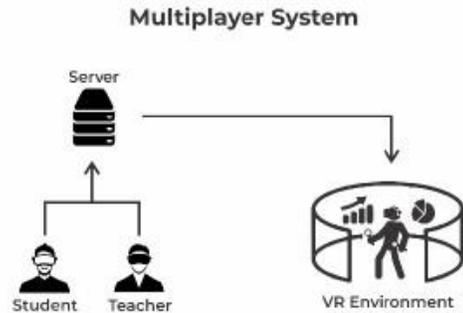


Figure 3: System Design

3) Solar System Material

In the material of the solar system, students will be confronted with spawner where later on this spawner will appear a planet randomly from the eight planets in the solar system. Students are asked to place the eight planets in the appropriate order, then observe the eight planets in the solar system revolving around the sun.

By making it as realistic as possible we made sure to calculate the distance and the rotation speed of the planets. When the user is in a planet scene they are still able to see the other planets orbiting around the sun to get a different point of view of our solar system. Both the VR and non-VR versions of the application have the exact layout, text, models and scenes [103].

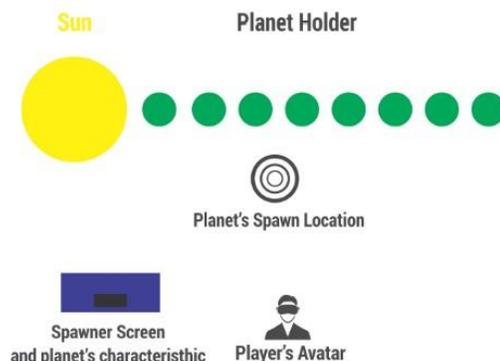


Figure 4: Solar System Scene Plan.

4) Making game design

Inside the VR class for planets learning, for example, there could be game developed as a tutorial. Students have to identify the accurate position of each planet in our solar system relative to the sun and answer a bank of questions about each planet in our solar system [104].



Figure 5: Space – Planets Game

IV. GENERAL FINDINGS

According to the data we collected from the population sample regarding the use of VR technology in classrooms. The majority of people we interviewed have used an educational VR before.

The VR experience was pleasant for the most part, there were no issues for most participants to navigate and explore the application. The issues that did occur were mostly about not being able to locate the touchpad location on the HMD or the blurriness of the text. The majority of the participants found VR to be an interesting and enjoyable experience. One student mentioned:

”I feel really concentrated compared to the mobile app, the main reason is that I don’t get disturbed by the surroundings and just focus on what I’m supposed to do.”

and another student who never tried VR before said: ”I’m amazed, I never used virtual reality before but I would love to learn more about our solar system now.”

Another student compared to VR application with the mobile application and said:

”I didn’t care to read on the mobile app but now when it’s in front of me I just want to read it.”

However, at the same time there were participants who did not find the VR application as appealing, one of them said:

”I don’t know if I learn more on the VR application, because I’m so busy looking at everything else that I don’t read the text.”

and another mentioned that:

”It would be awesome to have an actor reading the text for you, it would be nice for kids to learn. Audio could improve it.”

Regarding the learning aspects of the VR application, a female student told us:

”Since a lot of people learn better with emotions so here when you see the earth you can instantly associate it and might help you learn better, it’s really nice.” It was also pointed out to us by a male student that: ”The VR app presented a different scale, more than what mobile ever could.”

A teacher at Lagman high school also said: ”I would be a happy student if I used this technology, A happy student leads to good results.”

- Challenges of VR adoption on classrooms
An interactive educational content, such as adaptive or intelligent learning systems, has always had its challenges (Obeidat, 2009). Moreover, those systems have interoperability issues (Rey-López, 2008) and, hence, remain an area of active research. As with other rich, interactive, intelligent educational content, XR educational content can be challenging to develop. VR requires intensive graphics capabilities to achieve smooth implementation and worth (Velev&Zlateva, 2017). Many teachers have stated that they face limited availability of instructional designs when it comes to applying VR/AR content in the classroom. This refers to the limited materials offered in VR/AR with no guarantees that these materials would suit the students’ learning goals (Alalwan et al., 2020). Moreover, the interoperability of VR content across platforms is also hard to

achieve, and, hence, VR is often delivered as a proprietary solution (Velev&Zlateva, 2017), that is created or owned by an organisation or an individual [105].

During interviews, it was found that one concern that was raised by a few participants who at the time did not experience anything said that they believed longer exposure with the VR application would result in headaches. There were also a few other participants who experienced motion sickness, disorientation and minor headaches while testing the VR application.

V. IMPLICATIONS FOR FUTURE STUDIES

Based on our findings, we propose several implications for future research to address the limitations of the current literature. First, although researchers have been interested in assessing the learning effect of AR instruction, the literature lacks a systematic and in-depth analysis of different types of learning effects (e.g., cognitive, meta-cognitive, emotional, etc.).

CONCLUSION

This paper believes in the value of XR in education while realising the hurdles blocking these emerging technologies from being part of mainstream educational tools. It recognises that with educational XR, the challenges faced by educators come from multiple perspectives: technical, educational and social. Therefore, it presents varied available solutions that would allow institutions to choose a suitable route, with, hopefully, few technical challenges, in order to focus their attention on both the educational and social aspects of an immersive learning experience. The result should be a learning experience that is an integrated and integral part of the overall learning process. It should have correctly defined learning objectives that can be realised through matching learning activities to produce learning outcomes that can be clearly measured and assessed.

REFERENCES

- [1] Makransky, G., & Petersen, G. B. (2019). Investigating the process of learning with Desktop Virtual Reality: A structural equation modeling approach. *Computers & Education*, 134, 15–30. <https://doi.org/10.1016/j.compedu.2019.02.002>
- [2] Velev, D., & Zlateva, P. (2017). Virtual reality challenges in education and training. *International Journal of Learning and Teaching*, 3(1), 33-37.
- [3] Bazavan, L. C., Roibu, H., Petcu, F. B., Cismaru, S. I., & George, B. N. (2021, September). Virtual Reality and Augmented Reality in Education. In 2021 30th Annual Conference of the European Association for Education in Electrical and Information Engineering (EAEEIE) (pp. 1-4). IEEE.
- [4] Tilhou, R., Taylor, V., & Crompton, H. (2020). 3D virtual reality in K-12 education: A thematic systematic review. *Emerging technologies and pedagogies in the curriculum*, 169-184.
- [5] Simsek, I. (2016). The Effect of 3D Virtual Learning Environment on Secondary School Third Grade Students' Attitudes toward Mathematics. *Turkish Online Journal of Educational Technology (TOJET)*, 15(3), 162 - 168.
- [6] Guerrero, G., Ayala, A., Mateu, J., Casades, L., & Alamán, X. (2016, October). Integrating Virtual Worlds with Tangible User Interfaces for Teaching Mathematics: A Pilot Study. *Sensors*, 16(11).
- [7] Mateu, J., Lasala, M., & Alaman, X. (2014). VirtualTouch: A Tool for Developing Mixed Reality Educational Applications and an Example of Use for Inclusive Education. *International Journal of Human-Computer Interaction*, 30(10), 815-828.
- [8] Heradio, R., de la Torre, L., Galan, D., Cabrerizo, F. J., Herrera-Viedma, E., & Dormido, S. (2016). Virtual and remote labs in education: A bibliometric analysis. *Computers and Education*, 14-38.

- [9] Brinson, J. R. (2015). Learning outcome achievement in non-traditional (virtual and remote) versus traditional (hands-on) laboratories: A review of the empirical research. *Computers & Education*, 218-237.
- [10] Sala, N. (2021). Virtual reality, augmented reality, and mixed reality in education: A brief overview. Current and prospective applications of virtual reality in higher education, 48-73.
- [11] Bazavan, L. C., Roibu, H., Petcu, F. B., Cismaru, S. I., & George, B. N. (2021, September). Virtual Reality and Augmented Reality in Education. In 2021 30th Annual Conference of the European Association for Education in Electrical and Information Engineering (EAEEIE) (pp. 1-4). IEEE.
- [12] Parker, J., & Heywood, D., (1998) The earth and beyond: Developing primary teachers' understanding of basic astronomical events. *International Journal of Science Education*, 20(5), 503-520.
- [13] Pena, B. M., & Gil Quilez, M. J., (2021) The importance of images in astronomy education. *International Journal of Science Education*, 23(11), 1125-1135.
- [14] Huang, H.-M., Rauch, U., & Liaw, S.-S., (2010). Investigating learners' attitudes toward virtual reality learning environments: Based on a constructivist approach. *Computers & Education*, 55, 1171–1182.
- [15] Marsh, J., Plowman, L., Yamada-Rice, D., Bishop, J., Lahmar, J., & Scott, F., (2018) Play and creativity in young children's use of apps. *British Journal of Educational Technology*, 49(5), 870-882.
- [16] Kaminska, D.; Sapinski, T.; Wiak, S.; Tikk, T.; Haamer, R.; Avots, E.; Anbarjafari, G., (2019). Virtual Reality and Its Applications in Education: Survey. *Information*, 10, 318.
- [17] Mandal, S., (2013). Brief introduction of virtual reality & its challenges. *Int. J. Sci. Eng. Res.* 4, 304–309
- [18] Obeidat, H.; Meccawy, M.; Blanchfield, P., (2009). Authoring for Adaptive Web-Based Learning Systems: A Case Study; *International Journal of Emerging Technology in Learning*: Kassel, Germany.
- [19] Rey-López, M.; Brusilovsky, P.; Meccawy, M.; Díaz-Redondo, R.; Fernández-Vilas, A. (2008). Ashman, H. Resolving the problem of intelligent learning content in learning management systems. *Int. J. E-Learn*.
- [20] Velev, D. & Zlateva, P., (2017). Virtual reality challenges in education and training. *Int. J. Learn. Teach.*, 3, 33–37
- [21] Alalwan, N.; Cheng, L.; Al-Samirraie, H.; Yousef, R.; Alzahrani, A.I.; Sarsam, S., (2020). Challenges and prospects of virtual reality and augmented reality utilization among primary school teachers: A developing country perspective. *Stud. Educ. Eval.*, 66, 100876.
- [22] R. H. von Alan, S. T. March, J. Park, and S. Ram, (2004). Design science in information systems research, *MIS quarterly*, vol. 28, no. 1, pp. 75–105.
- [23] JAWARNEH, M. (2022). The Effects of Reducing Food Waste on Increasing the Quality of a Healthy Life.
- [24] Ahad, M. A., Paiva, S., & Zafar, S. (2020). Sustainable and Energy Efficient Computing Paradigms for Society. Springer International Publishing AG.
- [25] Al-Ahmad, A., Ahmaro, I. Y., & Mustafa, M. (2017). E-learning Difficulties in Jordan. *MEDIU publications*, 1(5).
- [26] Al-Ahmad, A., Ahmaro, I. Y., & Mustafa, M. (2017). E-learning Difficulties in Jordan. *MEDIU publications*, 1(5).
- [27] Al-Ahmad, A., Ahmaro, I. Y., & Mustafa, M. (2017). Importance of UML model in the RUP Development lifecycle along with the time and the static aspect of the process. *Al-Madinah Technical Studies*, 1(4).
- [28] Li Yan, MohdWazih Ahmad, Malik Jawarneh, Mohammad Shabaz, R. Raffik, KakarlaHari Kishore, "Single-Input Single-Output System with Multiple Time Delay PID Control Methods for UAV Cluster Multiagent Systems", *Security and Communication Networks*, vol. 2022, Article ID 3935143, 7

- pages, 2022.
<https://doi.org/10.1155/2022/3935143>
- [29] Al-Ahmad, A., Ahmaro, I. Y., & Mustafa, M. Classifying Disease Related Data Sets and Building a System for predicting and diagnosing Such Diseases Us-ing Decision Tree Mining Algorithm.
- [30] Al-Ahmad, A., Ahmaro, I., & Mustafa, M. (2015). Comparison between web accessibility Evaluation tools. *AlMadinah Technical Studies*, 1(4).
- [31] Alkhatib, K., Al-Aiad, A., Mustafa, M., & Alzubi, S. (2021). Impact factors affecting entrepreneurial intention of Jordanian private universities students: a mediation analysis of perception toward entrepreneurship. In *Sustainable and Energy Efficient Computing Paradigms for Society* (pp. 53-65). Springer, Cham.
- [32] Huo, Z., Luo, X., Wang, Q., Jagota, V., Jawarneh, M. and Sharma, M., 2022. Design and simulation of vehicle vibration test based on virtual reality technology. *Nonlinear Engineering*, 11(1), pp.500-506.
- [33] Al-Mushasha, N. F., & Hassan, S. (2009). A model for mobile learning service quality in university environment. *International Journal of Mobile Computing and Multimedia Communications (IJMCMC)*, 1(1), 70- 91.
- [34] Jawarneh, M.M., 2022. Factors affecting the success of VR-learning implementation in institutes of higher learning in Jordan.
- [35] Alshar'e, M., & Mustafa, M. (2021). Evaluation of autistic children's education in Oman: the role of eLearning as a major aid to fill the gap. *Elementary Education Online*, 20(5), 5531-5540.
- [36] Alshar'e, M., & Mustafa, M. (2021). Evaluation of autistic children's education in Oman: the role of eLearning as a major aid to fill the gap. *Elementary Education Online*, 20(5), 5531-5540.
- [37] Alshar'e, M.I., R. Sulaiman, M.R. Mokhtar and A. MohdZin, 2014. Design and implementation of the TPM user authentication model. *J. Comp. Sci.*, 10: 2299-2314. DOI: 10.3844/jcssp.2014.2
- [38] Alshar'e, M.I., R. Sulaiman, M.R. Mukhtar and A.M. Zin, 2014. A user protection model for the trusted computing environment. *J. Comput. Sci.*, 10: 1692-1702. DOI: 10.3844/jcssp.2014.1692.1702.
- [39] Alshar'E, Marwan, Abdullah MohdZin, RossilawatiSulaiman, and MohdRosmadiMokhtar, 2015 "Evaluation of the TPM user authentication model for trusted computers." *Journal of Theoretical and Applied Information Technology* 81(2): 298-309.
- [40] Alzubi, F., & Mustafa, M. (2021). Critical Review of A Recent and Significant Change in the (Primary Health Care Center) in Lights of Thr Contemporary Reserch and Best Practice.
- [41] Arshad, H., Mustafa, M., & BadiozeZaman, H. (2015). Design of Vibratory Haptic Interface Model (VHIM) for Autistic Children's Social Interaction. *Asian Journal of Information Technology*, 14(3), 111-116.
- [42] Arumugam, K., Swathi, Y., Sanchez, D. T., Mustafa, M., Phoemchalard, C., Phasinam, K., & Okoronkwo, E. (2021). Towards applicability of machine learning techniques in agriculture and energy sector. *Materials Today: Proceedings*.
- [43] Bhola, J., Jeet, R., Jawarneh, M. M. M., & Pattekari, S. A. (2021). Machine Learning Techniques for Analysing and Identifying Autism Spectrum Disorder. In *Artificial Intelligence for Accurate Analysis and Detection of Autism Spectrum Disorder* (pp. 69-81). IGI Global.
- [44] BIO-CELL CULTURE PROCESSES IN REAL-TIME MONITORING APPROACH WITH MACHINE LEARNING TECHNIQUES. NAGALAKSHMI.T, MAMTA SHARMA , MALIK MUSTAFA MOHAMMAD , ZATIN GUPTA , ASHISH KUMAR TAMRAKAR , AND BESLIN GEO.V.
- [45] Brahmi, B., & Mustafa, M. (2019). Impact of Knowledge Management Process on Managerial Performance in the High Tech

- Sector. *International Journal of Business and Management*, 14(2).
- [46] Bsoul, Q., Abdul Salam, R., Atwan, J., & Jawarneh, M. (2021). Arabic Text Clustering Methods and Suggested Solutions for Theme-Based Quran Clustering: Analysis of Literature. *Journal of Information Science Theory and Practice*, 9(4), 15-34.
- [47] Chakraborty, C., Banerjee, A., Garg, L., & Rodrigues, J. J. (2020). Internet of Medical Things for Smart Healthcare. *Studies in Big Data*; Springer: Cham, Switzerland, 80.
- [48] Chen, H. J. (2010). Linking employees' e-learning system use to their overall job outcomes: An empirical study based on the IS success model. *Computers & Education*, 55(4), 1628-1639.
- [49] Cordova, R.S., Maata, R.L.R., Epoc, F.J. and Alshar'e, M., 2021. Challenges and Opportunities of Using Blockchain in Supply Chain Management. *Global Business and Management Research: An International Journal*, pp. 204-217, 13(3).
- [50] "Bio-Cell Culture Processes in Real-Time Monitoring Approach with Machine Learning Techniques." *International Journal of Biology, Pharmacy and Allied Sciences*, vol. 10, no. 11 (SPECIAL ISSUE), 2021, <https://doi.org/10.31032/ijbpas/2021/10.11.1044>.
- [51] Zhao, Wei, et al. "Design of Die-Casting Die for Engine Cylinder Head Based on 3D Printing and Genetic Algorithm." *Computer-Aided Design and Applications*, 2022, pp. 190–199., <https://doi.org/10.14733/cadaps.2023.s3.190-199>.
- [52] Mustafa, Malik, et al. "Multitask Learning for Security and Privacy in Iov (Internet of Vehicles)." *Autonomous Vehicles Volume 1*, 2022, pp. 217–233., <https://doi.org/10.1002/9781119871989.ch12>.
- [53] DeLone, W. H., & McLean, E. R. (2003). The DeLone and McLean model of information systems success: a ten-year update. *Journal of management information systems*, 19(4), 9-30.
- [54] Franklin, D. L. (2009). What Kind of Business-Friendly Court-Explaining the Chamber of Commerce's Success at the Roberts Court. *Santa Clara L. Rev.*, 49, 1019.
- [55] Heo, J., & Han, I. (2003). Performance measure of information systems (IS) in evolving computing environments: an empirical investigation. *Information & management*, 40(4), 243-256.
- [56] Jawarneh, M. M. (2008). Web-Based Patient Medical Record History (Doctoral dissertation, Universiti Utara Malaysia).
- [57] Kassanuk, T., Mustafa, M., & Panse, P. (2021). An Internet of Things and Cloud Based Smart Irrigation System. *Annals of the Romanian Society for Cell Biology*, 20010-20016.
- [58] Kollu, P. K. (2021). Blockchain Techniques for Secure Storage of Data in Cloud Environment. *Turkish Journal of Computer and Mathematics Education (TURCOMAT)*, 12(11), 1515-1522.
- [59] Kuthadi, V. M., Selvaraj, R., Rao, Y. V., Kumar, P. S., Mustafa, M., Phasinam, K., & Okoronkwo, E. TOWARDS SECURITY AND PRIVACY CONCERNS IN THE INTERNET OF THINGS IN THE AGRICULTURE SECTOR. *Turkish Journal of Physiotherapy and Rehabilitation*, 32(3).
- [60] McGarry, D., Cashin, A., & Fowler, C. (2011). "Coming ready or not" high fidelity human patient simulation in child and adolescent psychiatric nursing education: Diffusion of innovation. *Nurse Education Today*, 31(7), 655-659.
- [61] Mustafa, M. (2021). Coping with and Analysing Factors Impacting Omani Colleges Students' Entrepreneurial Intent during Covid-19 Pandemic. *Turkish Journal of Computer and Mathematics Education (TURCOMAT)*, 12(11), 7019-7031.
- [62] Mustafa, M. Y., Hassan, S. S., & Ahmad, M. D. (2007). Frequency of occurrence of mastitis in different quarters of udders and its cure-a field study. *Biologia*, 53, 51-57.
- [63] Mustafa, M., & Abbas, A. (2021). comparative analysis of green ict practices among palestinian and malaysian in sme food

- enterprises during covid-19 pandemic. *PalArch's Journal of Archaeology of Egypt/Egyptology*, 18(4), 254-264.
- [64] Mustafa, M., & Al-Badi, A. (2021). Role of Internet of Things (IoT) Increasing Quality Implementation in Oman Hospitals During Covid-19. *SPAST Abstracts*, 1(01).
- [65] Mustafa, M., & Alzubi, S. (2020). Factors affecting the success of internet of things for enhancing quality and efficiency implementation in hospitals sector in Jordan during the crises of Covid-19. In *Internet of Medical Things for Smart Healthcare* (pp. 107-140). Springer, Singapore.
- [66] Mustafa, M., Abbas, A., Bsoul, Q., & Shabbir, A. (2021). Smart Irrigation System Based on the Internet of Things and the Cloud.
- [67] Mustafa, M., Alshare, M., Bhargava, D., Neware, R., Singh, B., & Ngulube, P. (2022). Perceived Security Risk Based on Moderating Factors for Blockchain Technology Applications in Cloud Storage to Achieve Secure Healthcare Systems. *Computational and Mathematical Methods in Medicine*, 2022.
- [68] Mustafa, M., Alshar'e, M., Shariah, A., Al-Alawi, M., & Mohammad, A. (2021). Managing and analyzing factors influencing Saudi college students' entrepreneurial intention during the Covid-19 pandemic. *Turkish Journal of Physiotherapy and Rehabilitation*, 7486-7496.
- [69] Mustafa, M., Alzubi, F. K., & Bashayreh, A. (2021). Factors Affecting Job Performance of Teaching and NonTeaching Staff in Higher Education Levels in Oman. *Ilkogretim Online*, 20(5).
- [70] Mustafa, M., Alzubi, S., & Alshare, M. (2020, April). The Moderating Effect of Demographic Factors Acceptance Virtual Reality Learning in Developing Countries in the Middle East. In *International Conference on Advances in Computing and Data Sciences* (pp. 12-23). Springer, Singapore.
- [71] Mustafa, M., Arshad, H., & Zaman, H. B. (2013, December). Framework Methodology of the Autism Children-- Vibratory Haptic Interface (AC-VHI). In *2013 International Conference on Advanced Computer Science Applications and Technologies* (pp. 201-206). IEEE.
- [72] Mustafa, M., Virmani, D., Kaliyaperumal, K., Phasinam, K., & Santosh, T. (2021). Towards Investigation of Various Security And Privacy Issues In Internet Of Things. *Design Engineering*, 1747-1758.
- [73] Najar, F., Bourouis, S., Alshar'e, M., Alroobaea, R., Bouguila, N., Al Badi, A. H., & Channoufi, I. (2020, September). Efficient Statistical Learning Framework with Applications to Human Activity and Facial Expression Recognition. In *2020 5th International Conference on Advanced Technologies for Signal and Image Processing (ATSIP)* (pp. 1- 6). IEEE.
- [74] Surindar Gopalrao Wawale, Malik Jawarneh, P. Naveen Kumar, Thomas Felix, JyotiBhola, Roop Raj, SathyapriyaEswaran, RajasekharBoddu, "Minimizing the Error Gap in Smart Framing by Forecasting Production and Demand Using ARIMA Model", *Journal of Food Quality*, vol. 2022, Article ID 1139440, 9 pages, 2022. <https://doi.org/10.1155/2022/1139440> [46] MUSTAFA, MALIK. "Impact Factors of Smart Technology in Small and Medium Enterprises." (2021).
- [75] Nielsen, S. E., Johnson, C. J., Heard, D. C., & Boyce, M. S. (2005). Can models of presence-absence be used to scale abundance? Two case studies considering extremes in life history. *Ecography*, 28(2), 197-208.
- [76] Pallathadka, H., Mustafa, M., Sanchez, D. T., Sajja, G. S., Gour, S., & Naved, M. (2021). Impact of machine learning on management, healthcare and agriculture. *Materials Today: Proceedings*.
- [77] Petter, S., DeLone, W., & McLean, E. (2008). Measuring information systems success: models, dimensions, measures, and interrelationships. *European journal of information systems*, 17(3), 236-263.
- [78] Mustafa, M., 2021. Impact of Digital Strategy in Business for Small and Medium Enterprises in Developing Countries. [51] Piercy, N.,

- Phillips, W., & Lewis, M. (2013). Change management in the public sector: the use of cross-functional teams. *Production Planning & Control*, 24(10-11), 976-987.
- [79] Sajja, G. S., Mustafa, M., Ponnusamy, R., & Abdulfattokhov, S. (2021). Machine Learning Algorithms in Intrusion Detection and Classification. *Annals of the Romanian Society for Cell Biology*, 25(6), 12211-12219.
- [80] Seddon, P. B. (1997). A respecification and extension of the DeLone and McLean model of IS success. *Information systems research*, 8(3), 240-253.
- [81] Mustafa, Malik. "Mobile Banking App Development and Implementation." (2021). [57] Shabaz, M., Singla, P., Jawarneh, M. M. M., & Qureshi, H. M. (2021). A Novel Automated Approach for Deep Learning on Stereotypical Autistic Motor Movements. In *Artificial Intelligence for Accurate Analysis and Detection of Autism Spectrum Disorder* (pp. 54-68). IGI Global.
- [82] Mustafa, Malik. "Impact of Information Technology on the Banking Sector in Developing Countries." (2021).
- [83] SINGHAL, MANMOHAN, SATHISH KUMAR PENCHALA, and DHEERAJ RANE. "STUDY ON NETWORK MODEL ON TRANSMISSION OF INFECTIOUS DISEASES IN HOSPITALS."
- [84] Tella, A. (2011). Reliability and factor analysis of a blackboard course management system success: A scale development and validation in an educational context. *Journal of Information Technology Education: Research*, 10(1), 55-80.
- [85] MUSTAFA, MALIK. "The Effect of Using M-Banking System Approach in Small and Medium Enterprises." (2021). [62] Wang, Y. S., Wang, H. Y., & Shee, D. Y. (2007). Measuring e-learning systems success in an organizational context: Scale development and validation. *Computers in Human Behavior*, 23(4), 1792-1808.
- [86] Mustafa, Malik. "The technology of mobile banking and its impact on the financial growth during the covid-19 pandemic in the gulf region." *Turkish Journal of Computer and Mathematics Education (TURCOMAT)* 12, no. 9 (2021): 389-398.
- [87] Gao, Huixian, Ahmed Kareem, Malik Jawarneh, Isaac Ofori, R. Raffik, and KakarlaHari Kishore. "Metaheuristics Based Modeling and Simulation Analysis of New Integrated Mechanized Operation Solution and Position Servo System." *Mathematical Problems in Engineering* 2022 (2022).
- [88] MUSTAFA, M., 2021. Mobile Banking as Technology Adoption and Challenges. [66] Wawale, SurindarGopalrao, Malik Jawarneh, P. Naveen Kumar, Thomas Felix, JyotiBhola, Roop Raj, SathyapriyaEswaran, and RajasekharBoddu. "Minimizing the Error Gap in Smart Framing by Forecasting Production and Demand Using ARIMA Model." *Journal of Food Quality* 2022 (2022).
- [89] Mustafa, M. (2021). Mobile Phone Technology in Banking System.
- [90] Mustafa M. The Adoption of Mobile Banking Services in Jordanian Banks and Factors Affecting the Customers. *ECS Transactions*. 2022 Apr 24;107(1):2483.
- [91] Mustafa, Malik, and O. A. A. J. Aldein. "Examining Perception of Malaysian autistic children social interaction for Virtual Reality." *Zenodo*, Dec-2020.
- [92] Smail, B., Sanchez, D.T., Peconcillo Jr, L.B., De Vera, J.V., Horteza, A.D. and Jawarneh, M., 2022. Investigating different applications of Internet of Things towards identification of vulnerabilities, attacks and threats. *International Journal of Next-Generation Computing*, 13(3).
- [93] Zhao, W., He, C., Gill, R., Jawarneh, M., & Shabaz, M. (2022). Design of die-casting die for engine cylinder head based on 3D printing and genetic algorithm. *Computer-Aided Design and Applications*, 190-199. doi:10.14733/cadaps.2023.s3.190-199
- [94] Alshar'e, M., Albadi, A., Jawarneh, M., Tahir, N. and Al Amri, M., 2022. Usability evaluation of educational games: an analysis of culture as a factor Affecting children's

- educational attainment. *Advances in Human-Computer Interaction*, 2022.
- [95] Nageswaran, S., Arunkumar, G., Bisht, A.K., Mewada, S., Kumar, J.N.V.R., Jawarneh, M. and Asenso, E., 2022. Lung cancer classification and prediction using machine learning and image processing. *BioMed Research International*, 2022.
- [96] Ansari, A.S., Jawarneh, M., Ritonga, M., Jamwal, P., Mohammadi, M.S., Veluri, R.K., Kumar, V. and Shah, M.A., 2022. Improved Support Vector Machine and Image Processing Enabled Methodology for Detection and Classification of Grape Leaf Disease. *Journal of Food Quality*, 2022.
- [97] Olayah, F., Anaam, E. A., Bakhtan, M. A., Shamsan, A., Al Mudawi, N., Alazeb, A., ...&Jawarneh, M. (2022). Online Security on E-CRM System. *Telematique*, 7427-7443.
- [98] Olayah, F., Anaam, E. A., Yahya, A. A., Hamdi, M., Shamsan, A., Ali, Y. A. A., ...& Jawarneh, M. (2022). A Systematic Literature Review for Multiple-Criteria Decision-Making Approaches in E-CRM Software. *Telematique*, 7444-7467.
- [99] JAWARNEH, M. (2022). An Enhanced UTAUT Framework for Students Perception on Acceptance of Educational Games.
- [100] Alshar'e, M., Mustafa, M., &Bsoul, Q. (2022). Evaluation of E-Learning Method as a Mean to Support Autistic Children Learning in Oman. *Journal of Positive School Psychology*, 6(3), 3040-3048.
- [101] Jawarneh, M., Alshare, M., Bsoul, Q., & Kalash, H. S. The Impact of Machine Learning On Educational Institutions: An Empirical Study.
- [102] Bian, L., Chen, J., Soni, M., Bhola, J., Kumar, H., & Jawarneh, M. (2022). Research on computer 3D image encryption processing based on the nonlinear algorithm. *Nonlinear Engineering*, 11(1), 664-671.
- [103] Jawarneh, M. M. (2022). Factors affecting the success of VR-learning implementation in institutes of higher learning in Jordan. *benefits*, 10.
- [104] SINGHAL, M., PENCHALA, S. K., & RANE, D. STUDY ON NETWORK MODEL ON TRANSMISSION OF INFECTIOUS DISEASES IN HOSPITALS.
- [105] Raghuvanshi, A., Singh, U., Sajja, G., Pallathadka, H., Asenso, E., & Kamal, M. et al. (2022). Intrusion Detection Using Machine Learning for Risk Mitigation in IoT-Enabled Smart Irrigation in Smart Farming. *Journal Of Food Quality*, 2022, 1-8.doi: 10.1155/2022/3955514
- [106] Hemamalini, V., Rajarajeswari, S., Nachiyappan, S., Sambath, M., Devi, T., Singh, B., &Raghuvanshi, A. (2022). Food Quality Inspection and Grading Using Efficient Image Segmentation and Machine Learning-Based System. *Journal Of Food Quality*, 2022, 1-6.doi: 10.1155/2022/5262294
- [107] Raghuvanshi, A., Singh, U., & Joshi, C. (2022). A Review of Various Security and Privacy Innovations for IoT Applications in Healthcare. *Advanced Healthcare Systems*, 43-58. doi: 10.1002/9781119769293.ch4
- [108] V. Durga Prasad Jasti, Abu SarwarZamani, K. Arumugam, MohdNaved, HarikumarPallathadka, F. Sammy, AbhishekRaghuvanshi, KarthikeyanKaliyaperumal, "Computational Technique Based on Machine Learning and Image Processing for Medical Image Analysis of Breast Cancer Diagnosis", *Security and Communication Networks*, vol. 2022, Article ID 1918379, 7 pages, 2022. <https://doi.org/10.1155/2022/1918379>
- [109] SushovanChaudhury, Alla Naveen Krishna, Suneet Gupta, K. SakthidasanSankaran, Samiullah Khan, KartikSau, AbhishekRaghuvanshi, F. Sammy, "Effective Image Processing and Segmentation-Based Machine Learning Techniques for Diagnosis of Breast Cancer", *Computational and Mathematical Methods in Medicine*, vol. 2022, Article ID 6841334, 6 pages, 2022. <https://doi.org/10.1155/2022/6841334>
- [110] Abu SarwarZamani, L. Anand, KantilalPitambarRane, P. Prabhu, Ahmed MateenButtar, HarikumarPallathadka,

- Abhishek Raghuvanshi, Betty NokobiDugbakie, "Performance of Machine Learning and Image Processing in Plant Leaf Disease Detection", *Journal of Food Quality*, vol. 2022, Article ID 1598796, 7 pages, 2022. <https://doi.org/10.1155/2022/1598796>
- [111] R. Veluri et al., "Learning analytics using deep learning techniques for efficiently managing educational institutes", *Materials Today: Proceedings*, vol. 51, pp. 2317-2320, 2022. Available: [10.1016/j.matpr.2021.11.416](https://doi.org/10.1016/j.matpr.2021.11.416)
- [112] Abhishek Raghuvanshi, Umesh Kumar Singh, Dr. PrashantPanse, Monika Saxena, "A Taxonomy of Various Building Blocks of Internet of Things", *International Journal of Future Generation Communication and Networking* Vol. 13, No. 4, (2020), pp. 4397–4404
- [113] Abhishek Raghuvanshi, Umesh Kumar Singh, Chetan Bulla, Dr. Monika Saxena, KishoriAbadar, "An Investigation on Detection of Vulnerabilities in Internet of Things", *European Journal of Molecular & Clinical Medicine* Volume 07, Issue 10, 2020, pp. 3289–3299
- [114] Abhishek Raghuvanshi, Dr. Umesh Kumar Singh, PrashantPanse, Monika Saxena, Ravi Kishore Veluri, "Internet of Things: Taxonomy of Various Attacks", *European Journal of Molecular & Clinical Medicine*, 2020, Volume 7, Issue 10, Pages 3853-3864.
- [115] Raghuvanshi, U. Singh, T. Kassanuk and K. Phasinam, "Internet of Things: Security Vulnerabilities and Countermeasures", *ECS Transactions*, vol. 107, no. 1, pp. 15043-15052, 2022. Available: [10.1149/10701.15043ecst](https://doi.org/10.1149/10701.15043ecst)