An-Najah National University

Faculty of Graduate Studies

THE EFFICACY OF INTEGRATING AUGMENTED REALITY IN EDUCATION ON LEARNER'S MOTIVATION AND REFLECTIVE THINKING AMONG UNIVERSITY STUDENTS

By

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Supervisors

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This Dissertation is Submitted in Partial Fulfillment of the Requirements for the Degree of PhD in Teaching and Learning, Faculty of Graduate Studies, An-Najah National University, Nablus- Palestine.

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I

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Dedication

This work is appreciatively dedicated for:

The memory of my dadwho was always proud of me.

My darling husband Yousef, who always supports me.

Mymother, the source of love and tenderness.

My brothers and sisters.

My beautiful stars, Mohammad, Amro and Lujain.

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Finally, I'd like to express my gratitude and appreciation to everyone who made it possible for this dissertation to be accomplished.

Declaration

I, the undersigned, certify that I submitted the Dissertation titled:

THE EFFICACY OF INTEGRATING AUGMENTED REALITY IN EDUCATION ON LEARNER'S MOTIVATION AND REFLECTIVE THINKING AMONG UNIVERSITY STUDENTS

I declare that the work included in this Dissertation, unless otherwise noted, is the researcher's original work and has not been submitted elsewhere for any other degree or qualification.

Student's Name: Kifaya Ahmad Ali

Signature: Kifaya Ali

Date: 2/7/2023

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Abstract

This research presents a new experiment in the context of the Palestinian higher education, which is based on augmented reality (AR) technology. The main objective is to investigate the efficacy of AR-based learning on motivation and reflective thinking as important indicators of students' learning and achievement. The research is based on a combined quantitative-qualitative methodology using motivation and reflective thinking scales for the quantitative approach and semi-structured interviews for the qualitative approach. The experiment was implemented on a purposive sample of 24 students enrolled in Digital Communication and 13 students enrolled in Microwave Engineering courses in the Telecommunication Engineering Department at An-Najah National University.

Results indicated a positive effect of using AR technology for teaching and learning on all dimensions of motivation except forconfidence, such as attention, relevance, satisfaction, and volition. Similarly, AR has a positive effect on all dimensions of reflective thinking except for reflection, such as habitual action, understanding and critical reflection. In addition, the qualitative analysis and the thematic coding yield seven main themes, such as benefits, hope for the future, challenges, reflections, initial impression, attitudes, and prior experience.

However, the research has some limitations such as the small sample size, the short period of the experiment that lasted for one semester, and the novelty of the AR technology that requires the instructors and students to be familiar with this emerging technology and using it for education, which requires provision of training and AR models or learning objects.

The researcher recommends the Palestinian education system to benefit from integrating AR into learning and to provide training programs for students and instructors. In addition, networking with peer institutions is recommended, as well as developing educational policies and strategies to merge AR into education. Finally, further research is needed to identify students' confidence levels using with AR.

Keywords: Augmented Reality, Motivation, Reflective Thinking.

Chapter One
Theoretical Background and Literature Review

1.1 Introduction

Digital Transformation influences all aspects of human life (Wilms et al., 2017).One of these aspects is education, especially when technology has been combined with appropriate pedagogical foundations(Nincarean et al., 2013).This combination offers exciting opportunities to design realistic and authentic increase of student engagement, level of understanding andlearning. In addition, this allows design of highly enjoyable learning environment to improve the quality of teaching and learning(Kirkley & Kirkley, 2005).The Teaching Excellence Framework (TEF)introduces digital technology as a key for enhancing learning, especially in higher education, higher education institutions (HEIs) should guarantee that effective technology use for learning and teaching is integrated into curriculum design, including win-win strategies that provide both improved outcomes and cheaper costs(Davies et al., 2017). Moreover, HEIs should create and use digital educational resources towards the acquisition of the 21stcentury competencies(Curaj et al., 2020).

Learners are expected to acquire the necessary professional and life skills and respond to society's demand for qualified graduates and global citizens (Curaj et al., 2020). Therefore, it is necessary to focus on teachers' practices and provide them with knowledge and skills for using emerging technologies in the educational context(Sabbah et al., 2020). This enables them to design, develop educational activities and exploit the potential of these technologies for learning, teaching, and assessment in either face-to-face or online learning(Darling-Hammond et al., 2020). Previous studies customized the quality of services that learners receive into process and structure factors(Daher et al., 2021). Process factor refers to the quality of interaction and engagement in the class, whereas structure factor refers to the resources that facilitate interaction, which includes teachers' education, experience, and subject matter knowledge, as well as availability of learning material and ICT infrastructure(Molina et al., 2020). Moreover, the Horizon Report 2020identified significant impact of emerging technologies on education, one of which is extended reality (XR) (e.g., augmented reality (AR), virtual reality (VR), mixed reality (MR), and haptic technologies). Haptic technologies refer to using touch sensation and control to engage with computer-generated applications.

Augmented Reality (AR) technology overlays virtual objects into the real world(Akçayır& Akçayır, 2017).AR is defined as “a situation in which a real world context is dynamically overlaid with coherent location or context-sensitive virtual information”(Diegmann et al ., 2015). AR is recognized as a technology with a higher impact on university education(Sáez-López et al., 2020). Karagozlu (2021) indicated that AR promotes improved learning performance, enhances university students' practices, and aids in the development of good attitudes about laboratory work. Moreover, he reported that AR is an emerging technology that can be employed as a new strategy for enhancing teaching and learning.

AR provides new teaching and learning methods at schools or universities to enhance effectiveness and attractiveness with an increasing ability to use ICT and related devices, such as computers, tablets, headsets and smart phones that support AR applications(Safar et al., 2017). In this context, it is necessary to distinguish Virtual Reality (VR), which refers to adding elements of reality to a virtual environment and includes more virtual information compared with AR that contains more real than virtual information(Wu et al., 2013). Both AR and VR conform to the Cognitive Theory of Multimedia Learning (CTML) (Mayer, 2009), which states that a meaningful learning should merge text with graphical resources, such as pictures, videos, animation and simulation, to maximize learning effectiveness.

ICT-based learning requires motivation along with other factors for developing thinking skills(OCED, 2019).In order to ensure student motivation in the learning environment, learners are required to be mentally present and to take active roles in the learning process (Ozdamli & Hursen, 2017).Keller (1987) defined motivation as “those things that explain the direction, magnitude, and persistence of behaviors”. He proposed an application-focused model with four categories, Attention, Relevance, Confidence and Satisfaction (ARCS). Over time, it was shown that these four categories did not adequately account for differences in persistence among learners, neither did they provide a basis for motivational support activities (Kuhl, 1987). Therefore, Keller (2010) added Volition as a fifth category that is similar to self-regulation (Zimmerman, 1990), yielding the ARCS-V model. This design will motivate learners to achieve the learning objectives (Keller, 2016).

Furthermore, reflective thinking plays an important role in technology-based learning(Yilmaz & Keser, 2016). It assists students to understand a course content deeply, and provides an opportunity for comprehensive learning(Chang, 2019).In addition, reflective learning employs learners' prior knowledge to improve life-long learning skills, and enables them to gain better experience (Ozdamli & Hursen, 2017). Instructors can benefit from reflective thinking activities and strategies to develop positive attitudes and to increase their teaching profession and performance. So, reflective thinking activities enhance learner's individual responsibility and awareness of their cognitive processes(Yilmaz & Keser, 2016). Moreover, reflective learning approaches influence students' learning positively if they study co-operatively from the beginning of a course (Tok, 2008).

The current research is one of the first to investigate the integration of Augmented Reality (AR) into teaching and learning among university students in Palestine. It emphasizes that the use of AR in education is so important in preparing professional students. Therefore, university instructors should develop their own digital competencies, especially integrating AR into teaching and course delivery. The Researcher believes that the motivated learners for learning engage more in a task until completion, since motivation empowers individuals to initiate and control their behaviors for particular tasks. That is utilization of AR for enhancing learner motivation improves course material visualization for better understanding. This research contributes to identifying the efficacy of AR-based learning on motivation and reflective thinking of a sample of students enrolled into telecom engineering AR-based classes.

This research consists of four chapters, starting with a theoretical background and literature review in the current chapter, which includes introduction, previous studies, problem statement, and research questions. In chapter two, the methodology is presented, which describes the sample, the research instruments, and data collection and analysis. After that, the results and findings are presented in chapter three, which answers the research questions quantitively and qualitatively. Finally, chapter four discusses the results and the findings and ends with conclusions and future work.

1.2Information and Communication Technology in Higher Education

Digital transformation in education makes a great chance to design realistic and engaging learning environment (Nincarean et al., 2013). Many researchers(Dunn & Kennedy, 2019;Liu et al., 2020; Sailer et al., 2021; Shen & Ho, 2020)focused on integrating technology in education and revealed a positive effect on students' learning process. Currently, Technology Enhanced Learning (TEL) has interesting characteristics in Higher Education institutions (HEIs) (Dunn & Kennedy, 2019), which improves the educational practices (Liu et al., 2020) and employs information and communication technology (ICT) applications to enhance teaching and learning outcomes (Shen & Ho, 2020). Liu et al (2020) derived a framework for learning technologies in higher education, which consists of academic staff, context, and influencing adaption. Moreover, implementing digital teaching in higher education needs infrastructural, institutional and organizational environments for teachers and students to conduct teaching and learning activities (Sailer et al., 2021). Therefore, educators began to integrate ICT in education, in order to improve learners' understanding, Increase the ability to innovate and promote positive attitudes(Bacca, et al., 2014). Horizon report 2020 highlighted six types of technologies that have a high impact on the future of learning and teaching in higher education. In addition to extended reality (XR), these technologies are adaptive learning technologies, Artificial Intelligence (AI) or Machine Learning (ML) education applications, analytics for student success, elevation of instructional design, learning engineering, and user experience (UX) design in pedagogy, open educational resources(OER), and XR (AR/VR/MR/Haptic) Technologies (Brown et al., 2020).

Adaptive learning technologies were developed as effective educational tools that personalize the learning experience for each individual student by utilizing advanced algorithms and data analytics. While ML is founded on the idea that machines may learn and adapt through repetitive operations, AI refers to a larger concept where robots can accomplish tasks intelligently (Brown et al., 2020).Analytics for student success refers to the use of data analysis and predictive modeling techniques to identify factors that contribute to student achievement and to develop strategies for improving student outcomes.

The elevation of instructional design focuses on enhancing the effectiveness and impact of learning experiences by incorporating innovative and research-based strategies. Instructional designers can incorporate learner-centered approach, personalized and differentiated instruction, technology integration, evidence-based design, and continuous improvement to create more engaging and meaningful learning environments. Moreover, OER are educational resources designed for teaching and learning without royalties or license fees, which allow reuse and adaptation without permission from the copyright holder(Morrison et al., 2019).

The advancement in ICT promotes innovative learning tools in education among other fields. Several educational technologies are implemented to enhance teaching and learning methods. One of such technologies with vast potential is Augmented Reality (AR), which offers new pedagogies and psychological aspects such as collaborative learning that serve education(Bistaman et al., 2018).

Virtualization technology is important to provide opportunities for research and education. Moreover, virtualization assists academic institutions in reducing capital and expenditures. Besides, It has the potential to provide an environment for collaboration among learning groups(Sommool et al., 2015). Visualization of teaching material during classes enhances communication with learners while performing their activities, promoting better learning. A comprehensive study is required urgently to check the possibilities of introducing AR for education in that estimates the required financial resources. However, HEIs are encouraged to introduce AR, since it is cost effective and its constructors can be utilized for immediate development of the necessary visualization (Iatsyshyn & Kovach, 2020). Furthermore, technological change, such as AR, influences teaching and learning positively(Fidan & Tuncel, 2019).

ICTis commonly used in the classrooms that assists instructors to elevate and replace outdated pedagogical techniques and enables them to design their curriculum in advance (Francis, 2017). A wide range of specific technologies is being used in the classrooms such as interactive white boards, learning management systems, and online collaboration tools(Haleem et al., 2022).Even though, some technologies were not designed to be aligned with the educational goals. In addition, many teachers are still capable of merging technology into their classrooms (Zimlich, 2015). In a survey on using technology in classrooms, Francis argued that IT increases student’s motivation and showed that using technology could solve many problematic behaviors and increase learners' motivation and engagement by 9% in a technology-supported learning environment.

Future lab (2009) reported several methods to support inclusive practice concepts with technology, such as mobile technologies and audio-visual media that provide authentic and meaningful learning experience, and foster a sense of community as well. Technology also helps teachers to develop more entertaining and interesting literature-based connections such as using online discussion forums, digital libraries, and interactive learning platforms. Moreover, it meets the learners 'individual needs, such as differentiation and inclusion, and supports behavior management and routines(Lin et al., 2016). Chen et al. (2017) used supplementary material and found that students who used ICT have better laboratory skills and engagement than others. Therefore, good teaching should integrate technology tools into the curriculum. Lytras et al (2020) presented the concept of transformative education in higher education, which refers to social-awareness and sensitivity of learners and groupsintegrated with behavioral, convictionaland psychologicalskills. They also put six pillars for transformative education includingbig dataanalytics, sustainability, innovation and technology,social awareness, advanced decision making and teacher as a mentor (Lytras et al., 2020). Yilmaz & Keser(2016)measured the effect of TEL on students motivation and reflective thinking on students' academic success and social presence perception. Their results reveal that there are significant differences between post and pre test on learners' motivation and reflective thinking.

According to a recent evaluation, TEL practice in UK universities utilizes course blogs, course-specific discussion forums, online lecture slides and recordings, additional posted content, and student-created social media groups (SMG) technologies.TEL encompasses a wide range of technologies, including lecture slides, recording repositories, gamification and AR (Dunn & Kennedy, 2019).

It is necessary that HEIs coordinate in developing educational systems and applications such as national e-learning platform that is integrated with a digital repository of OER to host massive open online courses (MOOCs). In addition, the concept of educational services are digital by design is primary when developing new educational applications and services to ensure applications are technology independent (Pulist, 2020).Moreover, virtual laboratories offer an evolving option based on applications, simulations, educational games, artificial intelligence, machine learning, and big data to improve the practical side from a distance. Furthermore, the availability of educational data might encourage data exchange among HEIs(Zawacki-Richter et al., 2019).

Researchers are considering using the learning analytics of large dataset in HEIs to bring modern insights on teaching and learning. This can be done by adopting a Teaching Excellence Framework that focuses on teaching strategies for measuring excellence or identification of the areas of improvement (Anne & Matthew, 2021). Hence, university leaders should be aware of the emerging opportunities given by technology to improve learning. Universities hire staff with good experience and proficiency in educational technology to help graduates enhance their digital skill, and provide them with support when necessary(Haleem et al., 2022). ICT can facilitate developing authentic learning experience relevant to the job market and assist students in demonstrating their abilities to potential employers. On the other hand, HEIs regulations and bylaws need to be up-to-date to cope with the digital transformation requirements, such as the adoption of online educational programs and recognition of online-granted degrees. In addition, the governments can support HEIs, faculty members and students to obtain digital devices and Internet access with lower cost via tax exemption and discounts (Davies et al., 2017).

The large amount of data and processes needed for supporting learners and instructors, designers of learning systems take into consideration better understanding of learners' needs to improve their performance. Accordingly, Ivanović et al. (2018) suggested to expand areas of research to apply AR, VR, Educational Data Mining, Educational Policy, Predictive and Learning Analytics, and Machine Learning. Learners' physiological and cognitive responses should be managed while attending a virtual environment to be engaged in learning productively (Crompton et al., 2020).

1.3 Augmented Reality

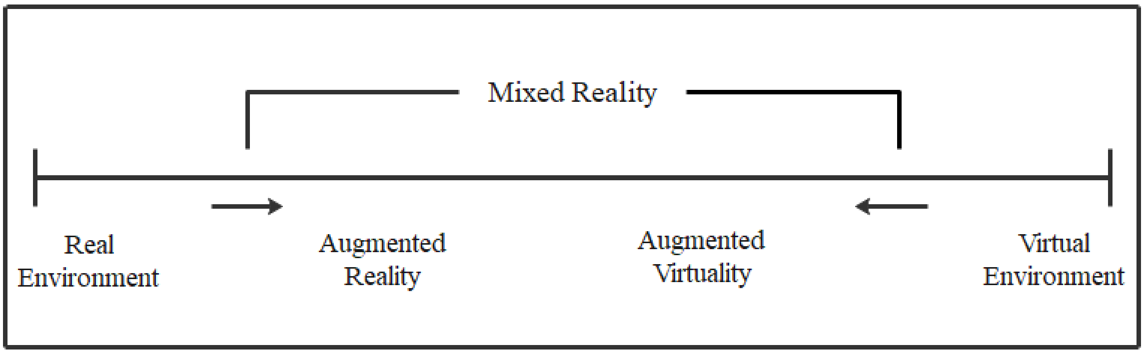
Augmented Reality was first developed in the 1960s by Sutherland (Zhou et al., 2008). Since the 1990s, AR technology was used by some large companies for visualization of their data and training of their employees and researchers at Boeing (Diegmann et al ., 2015; Peng et al., 2016). It has been applied in engineering design, consumer design, military, robotics, manufacturing, maintenance, medicine and psychological therapy

(Azuma, 2001). Although it has been used in other fields for a long time, AR has recently begun to be a good potential in the educational settings. Bujak et al. (2013) mentioned, "AR is just starting to scratch the surface of educational applications."

Milgram et al. (1995) analyzed the basic terms and concepts of AR as "augmenting natural feedback to the operator with simulated cues". The reality-virtuality continuum allows distinguishing between the concept of Virtual Environment, also known as Virtual Reality (VR), and Augmented Virtuality (AV). It is a scale that ranges from a totally actual environment (reality) that may be seen while observing the real world to a wholly virtual environment (virtuality). Mixed reality refers to the distance between the real and virtual environments or the combination of real and virtual entities. While VR deals with total immerse of the users in an imaginary world, AR mixes real and virtual worlds complementing the actual world in real-time(Ozdamli& Hursen, 2017). Figure 1 illustrates a reality-virtuality continuum in which AR is closer to the real-world. AR contains a modest quantity of virtual data, whereas VRcontains more digital data and incorporates real components into a virtual world (Diegmann et al ., 2015;Khan et al., 2019).

Figure 2

Milgram Reality-Virtuality Continuum



Another accepted definition of AR is "a real world context that is dynamically overlaid with coherent location or context sensitive virtual information" (Klopfer & Squire, 2008). According to(Azuma, 1997), AR has three essential requirements: a) integrating actual and virtual items in a real-world setting, b) consistency between these objects, and c) real-time interaction (Khan et al., 2019; Nincarean et al., 2013; Ozdamli & Hursen, 2017). AR enables the seamless integration of virtual and real-world content.(Bacca et al., 2014). In this sense, "AR supplements reality, rather than completely replacing it" (Azuma, 1997). Furthermore, (Chung & Hsiao, 2020).This means that AR is a 3D visualization projected on physical surroundings, as opposed to VR, which is fully immersive in visual impacts of learning(Chung & Hsiao, 2020).

Iatsyshyn & Kovach(2020) referred that AR technology allows a layer of virtual reality to combine with a physical environment in real time utilizing a computer to confront the 3D world. This technology is required for the visualization of objects. Three-dimensional objects, videos, sounds, photos and Text are all examples of supplementary information. Furthermore, specific browsers on tablets or smart phones read labels to obtain augmented content.

There was a blurring in AR terminology in theoretical studies such as "mixed reality", "hybrid reality", "virtual reality with immersive VR", "programmed reality" and they are often synonymous (Iatsyshyn & Kovach, 2020). There are five significant educational applications of AR (Diegmann et al ., 2015; Iatsyshyn, 2020), which include:

1. AR books, where printed books transfer to 3D animated objects to offer learners interactive experiences to become digitally native learners.
2. AR gaming, in which learners promote using an effective tool to gain their interest and attention while teaching a variety of competences.
3. Discovery-based learning, which transfers information about a place in the real world to discovery-based learning, such that learning activities allow independent investigation of scenarios such as exploring 3D geometric shapes.
4. Object modeling, where learners can create, manipulate, and rotate graphic objects to make their idea and design visualized learning objects.
5. Skills training, where learners can use AR as a tool to train individuals and develop their professional skills.

These AR applications in education have the potential to change traditional learning methodologies by making them more immersive, interactive, and successful at engaging learners and facilitating knowledge acquisition.

1.4 Augmented Reality in the Educational Environment

AR encourages student-centered exploration and enables for data collection and observation when fieldwork is impossible(Shea, 2014). AR allows the visualization and manipulation of abstract phenomena and hazardous or far places to be visited. It also permits contact with students or instructors and enables online access to research material instantly(Templin et al., 2022). The study of (Azuma, 2001) aimed to determine the benefits of AR and its features as a visualization tool of teaching science over traditional methods. Instead, AR is a supplemental tool that provides an alternate method of displaying visual pictures in order to make abstract topics more real and accessible to learners. He argued that with better learning infrastructure, technology can increase the reach of pedagogy by allowing teachers or instructors to teach more effectively, resulting into better learners' understanding and learning. For instance, in 2001, Wu et al created an animation to assist students grasp abstract ideas in Chemistry, while Stith (2004) utilized software to produce an animation for cell biology showing enzyme-substrate binding.

Many studies have been conducted related to higher education environment, such as(Sáez-López et al., 2020) which investigated the impact of AR training on instructors' attitudes and practices using qualitative and quantitative methods. Results showed significant benefits to the participants in different domains, such as creativity, innovation, participation, and motivation. Similarly, Iatsyshyn & Kovach(2020) applied AR technologies to educate students on Ukraine universities, which revealed a positive impact on learning outcomes, increased learners' interest for subjects and learners' motivation for independent educational activities (Iatsyshyn & Kovach, 2020). Another research was conducted at Technology University in Malaysia, which investigated the variations in learners' visualizing skills after adopting mobile AR. In terms of mental rotation, the results revealed a substantial degree of visualizing competences. In the experiment group rather than the control group (Omar et al., 2019). A similar research for Herrera revealed a positive impact on developing spatial mathematical skills (Medina Herrera et al., 2019). Furthermore, another research aimed at measuring students' engagement while using an AR sandbox by measuring skin conductance as a proxy for student engagement, which recommended the instructors to focus on developing collaborative activities when incorporating AR sandbox to increase students' engagement (Soltis et al., 2020).

However, the most significant advantage of AR is the integration of the virtual environment's contribution with the reality of the classroom.(Bai et al., 2013). Lin et al. (2016) implemented games to enhance learners' self-confidence in an elementary school for learners with different disabilities enrolled into classrooms with Wi-Fi connectivity. Findings showed that using AR introduced better learners' participation and motivation. Another study underlined that AR has the capacity to build today's learners' required abilities, such as varied evaluation, collaborative learning, problem solving and comprehending hard concepts. Moreover, the use of AR presented helpful opportunities to learners and revealed positive outcomes, especially in science (Zimmerman et al., 2016). They can take part in high-budget, risky, and intricate studies that would be impossible to carry out otherwise. In Science class, learners don't use their skills to observe and assimilate book subjects, where the provision of AR components helped them to acquire better skills and raised their achievement (Sirakaya & Cakmak, 2018) . They could watch events that could not be observed in a real world (Wu et al., 2013b). Another related study employed semi-structured interviews with students and instructors to examine the attitudes of learners and teachers regarding AR material in scientific education. The researchers reported that AR had a favorable influence on teachers' practices and learners' understanding of science concepts(Karagozlu, 2021).

In addition, AR educational environment can support student-centered learning process by increasing the classroom interaction, cooperation, retention of knowledge, and design of learning tasks, which are aligned with thinking skills. In order to achieve creativity, we need to train and motivate teachers who have positive roles in developing the educational system (Khan et al., 2019).

Furthermore, AR can assist teachers in updating teaching techniques to better support inclusionary education as well as enhancing student motivation (Sirakaya & Cakmak, 2018). In addition to the importance of using AR, it helps in developing student curiosity, observation and experimentation. AR technology is a way to combine playing and learning, in which learners develop their mental and cognitive abilities. It helps to develop learners' memories, thinking skills, imagination and abilities (Safar et al., 2017). Moreover, Badilla-Quintana et al. discussed the advantages of AR, which can improve the academic achievement of learners with and without special educational needs (Badilla-Quintana et al., 2020). Finally, using AR is effective in deeper student engagement, perceived enjoyment and positive attitudes (Chen et al., 2017).

Several studies related to using AR in education were conducted in a systematic literature review. Papakostas reviewed 32 related studies on using AR in engineering education and student's spatial ability training, which have been published since 2010. The researcher classified them into three categories, learning outcomes, pedagogical affordances, and technical perspectives. He revealed many advantages and some limitations of using AR, such as the need for more learning content and the lack of personalization in the developed applications(Papakostas et al., 2021). Nesenbergs, also, conducted a systematic review for 30 articles from the Web of Science database, which describe the use of VR and/or AR technologies in distance learning for higher education, and their impact on learning outcomes. He investigated 24 articles with interventions related to the effect on the learners' performance, and the results revealed 11 positive, seven negative and six interventions with no impact. The last six articles with interventions related to the effect on the learners' engagement, and all of them showed a positive impact (Nesenbergs et al., 2021).

Furthermore, Ajit et al. (2021) conducted a review related to the advantages and difficulties that faced using AR in teaching Science, Technology, Engineering, and Mathematics (STEM). He classified the advantages into several categories, such as class engagement, visualization, fun learning, collaborative learning, concretizing abstract concepts, increasing conceptual knowledge, student-centered learning, increased student interaction, and ease of use. The study classified the challenges into marker detection problem, technical problems, device usability, cost, nonrealistic features of AR and less animation elements (Ajit et al., 2021). These results were similar with other reviews conducted by (Akçayır & Akçayır, 2017).

Another important systematic literature review conducted by (Sommerauer & Müller, 2018) focused on theoretical and empirical foundations for using AR in teaching and learning. They extracted the design elements that can be traced back to abstract learning theories (cognitive theory of multimedia learning, situated learning, mobile learning, experiential learning, game-based learning and simulation) and concrete system features by analyzing the design elements, content development and learning-activities evaluation. Moreover, Diegmann et al. (2015) identified 14 distinct benefits in six categories: state of mind, presentation, teaching ideas, content understanding, learning style, and reduced expenses. Moreover, the author categorized these benefits into five areas of AR in the educational setting: AR gaming, AR books, object modeling, discovery-based learning, and skills training. In conclusion, previous research demonstrated several benefits of adopting AR in education, but as with any new technology, it has significant drawbacks, which are described in Table 1 using similar categories (Ajit et al., 2021).

Table 1

Advantages and limitations of integrating AR in education.

Advantages	Reference
Increased motivation.	(Kaur et al., 2020)
Increased academic achievement.	(Ibáñez et al., 2020)
Developed positive attitudes.	(Huang et al., 2016)
Enhanced spatial abilities.	(Roca-González et al., 2017)
Content understanding.	(Karagozlu, 2021)
Enhanced students' spatial visualization.	(Medina Herrera et al., 2019)
Reduced cognitive load.	(Lee et al., 2019)
Enhanced satisfaction.	(Martin-Gutiérrez et al., 2013)
Increased engagement.	(Alzahrani, 2020)
Student-centered learning.	(Akçayır & Akçayır, 2017)
Increased creativity.	(Vate-U-Lan, 2012)
Increased information accessibility.	(Hou et al., 2013)
Improved learning curve.	(Liu, 2009)
Increased student interaction.	(Safar et al., 2017)
Improved memory.	(Chang et al., 2014)
Personalized learning.	(Tumkor, 2018)
Collaborative learning.	(Soltis et al., 2020)
Fun learning.	(Chang & Hwang, 2018)
Low cost.	(Diegmann et al ., 2015)
Ease of use.	(Omar et al., 2019)
Increased students' attention.	(Alzahrani, 2020)
Enjoyment in learning.	(Ozdamli & Hursen, 2017)
Increased students' interest.	(Medina Herrera et al., 2019)
Increased self-confidence.	(Tuker & Fine, 2018)
Increased concentration.	(Yen et al., 2013)
Limitations	Reference
Non-realistic features of AR.	(Cai et al., 2014)
High cost of the devices.	(Echeverría et al., 2012)
Long time of training.	(Lee et al., 2019)
Needs special pedagogical design instructions.	(Kaur et al., 2020)
Technical problems.	(Kamarainen et al., 2013)
Not recognized marker.	(Ibáñez et al., 2020)
Uncomfortable use for a long time.	(Fidan & Tuncel, 2019)
Designed for specific knowledge fields.	(Bacca et al., 2014)
Takes long to recognize the indicator.	(Karagozlu, 2021)
Low quality for the final product.	(Omar et al., 2019)

The above studies show that AR in higher education has significant benefits, including creativity, innovation, participation, and motivation to increase learners' interest in learning subjects and performing independent educational activities. Moreover, they show that integration of virtual environment into the classroom improve learners' participation and motivation. AR offers opportunities for science students to participate in high-budget, risky, and intricate studies, enhancing their skills and achievement as well. It isalso found that AR positively influences teachers' practices and learners' understanding of concepts in scientific education.

1.5 Motivation in Education

Several researchers investigated motivation as an important psychology concept in education(Darling-Hammond et al., 2020; Francis, 2017; Keller, 2016; Khan et al., 2019; Utvær & Haugan, 2016). Most of them agreed that it is related to other educational concepts like curiosity, persistence and performance (Vallerand et al., 1992). Motivation is defined as the energy that drive students to learn and work hard on his school assignments (Martin, 2001), or students' desire to learn and engage in an educational environment (Keller, 2008). It has an impact on self-regulated and academic performance (Zimmerman, 1990). There are two types of motivation: intrinsic motivation (IM) that refers to engaging in a behavior that is satisfying or pleasurable in nature, and extrinsic motivation (EM) that arises from external action or socially creates a reason to do an action. IM is non-automated in nature, that is, a motive-driven action does not depend on any consequence action separated from the behavior itself. On the contrary, EM is instrumental in nature (Legault, 2016).

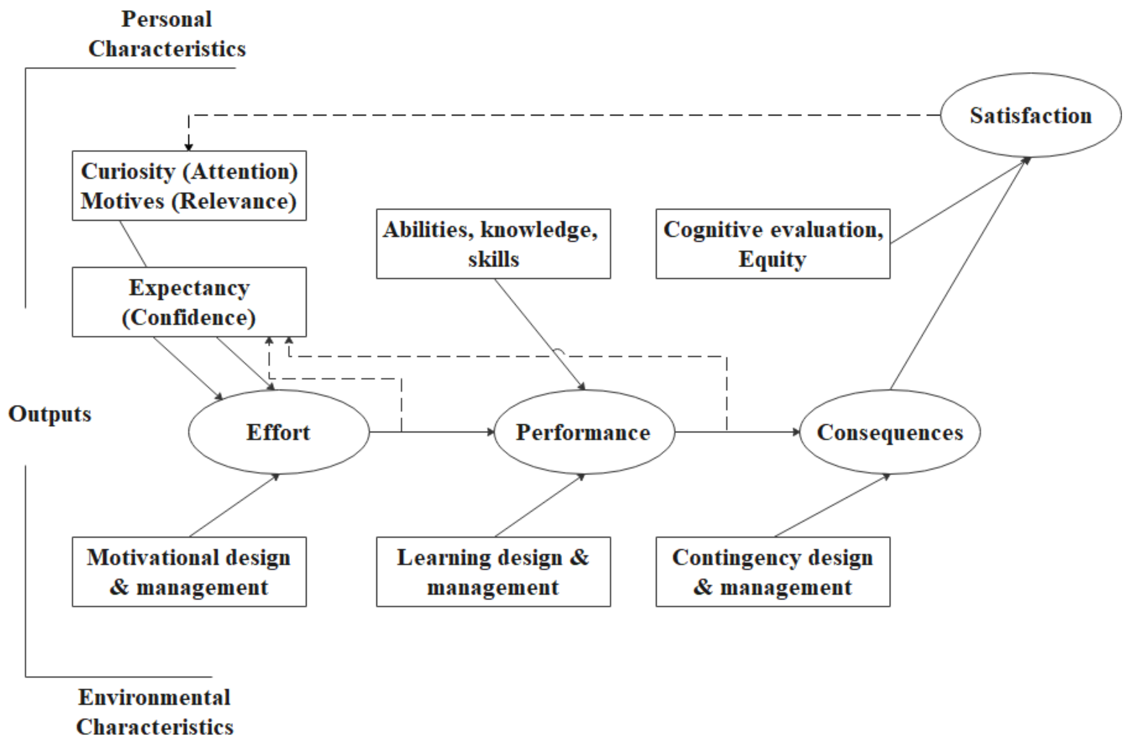
Many theories had been used in measuring the learners' motivation. For example, Theall (1999) conducted a study about different factors of motivation using an Author-by-Factor Matrix with thirteen studies. Moreover, Pint rich worked on self-regulation (*Motivational and Self-Regulated Learning Components of Classroom Academic Performance*, 1990) and used intrinsic motivation, and Perry worked on perceived control and attributional issues(Perry, 2003). One big challenge facing the learning process success is the lack of motivation, so it is important for creating and sustaining motivation(Khan et al., 2019b). Another study describing how motivation levels predict engagement across different types of Technology Enhanced Learning (TEL) showed that intrinsic motivation predicts engagement, whilst extrinsic motivation predicts usage (Dunn & Kennedy, 2019).

It can be stated that "motivation provides a source of energy that is responsible for why learners decide to make an effort, how long they are willing to sustain an activity, how hard they are going to pursue it, and how connected they feel to the activity" (Di Serio et al., 2013). Moreover, learners are, sometimes, excited by new technologies, but their interest is frequently short-lived.

Keller (2008) proposed a problem-solving approach to apply motivation in instructional design based on (Attention, Relevance, Confidence, and Satisfaction) ARCS model (Di Serio et al., 2013). The mentioned four categories influence effectively learning and performance as a process or a model that consists of motivation, performance, and learning. ARCS is based on the macro theory of motivation and instructional design theory. It is grounded on expectancy-value theory, which considers that when a student performs activities that meet his personal needs, he will be motivated to engage with them (Keller, 2008). This model explains how learners' attention or curiosity, his relevance or motives are combined together with learners' confidence, or his expectancy to success to assign the most valuable goals and make his effort to achieve it, as shown in figure 2. Environmental characteristics such as availability of resources, teachers' eagerness, and social values affect directed goals. In addition, learners' skills and knowledge lead to achieve performance. An individual's performance along with the way reinforcement contingencies are managed determines the consequences of achievement in relation to an expected outcome. These consequences, along with cognitive assessment and reflections, determine levels of satisfaction with the process and the results. The dot lines present the feedback loops; one between effort and performance, and another between performance and consequences. In addition, there is feedback from satisfaction to attention and relevance to either weakening or strengthening the value associated with a specific goal. Finally, this model describes how internal environment and conditions effects behavior over time (Keller, 2008).

Figure 3

A macro model of motivation, learning, and performance (Keller, 2008).



ARCS instrument has been validated and used in many motivation studies and technology strategies (Keller et al., 2020), such as Khan et al who examined the student learning motivation through augmented reality mobile application for undergraduate health science learners at the University of Cape Town. The results showed that attention, satisfaction, and confidence factors of motivation were increased, other hood the relevance factor was decreased (Khan et al., 2019). Similarly, Kaur investigated learners' motivation for Engineering Education using AR concepts, and showed a significant impact on learners' motivation while performing a particular task in the four types of ARCS model (Kaur et al., 2020).

In the Arab context, there are many studies that examined the efficacy of AR on students' motivation. For example, (Al-Hujaili, 2019)used quasi-experimental approach to reveal the efficacy of AR on a sample of 64 students from Saudi Arabia who studied the cloud computing unit. The results showed statistically significant differences in favor of the experimental group of the motivation scale. The researcher recommended to support the curricula with modern technologies.

In similar research in Palestine, (Mashharawi, 2018) investigated the effectiveness of employing AR in developing motivation towards learning and academic achievement for tenth graders. The most important result was the existence of correlation between academic achievement and motivation.

Another study (Shehata, 2016) investigated motivation and achievement variables using AR. The sample consisted of 65 Egyptian students in a Geography course. Several educational activities were implemented using Google Earth connected to a global positioning system (GPS). The design of the activities was based on five stages: planning, design, implementation, development and review and evaluation. Their results revealed a positive impact on students' motivation and achievement. Similarly, Sayed et al. (2019) designed a program using Gimp 2.8 based on AR to develop digital image processing skills for 60 Egyptian students enrolled in Computer and ICT course. The quasi-experimental approach was used, and the results showed statistically significant differences in achievement motivation.

Furthermore, the influence of enhanced impact on developing creative thinking skills and motivation on a sample of 68 Omani students studying AR-based Arabic Language course (Alhanai & Almanthari, 2019). The results showed statistically significant differences in favor of the experimental group. Another study revealed an effect of the different forms of feedback in the AR environment on both cognitive achievement and motivation to learn for undergraduate students(Al-Mulhim, 2021).

Another study in Jordan (Abu_Abss & Al_Elwan, 2021) revealed the relation between motivation and distance learning in the Corona pandemic. The sample consisted of 160 high-school students chosen randomly using the descriptive approach. The researchers used Keller's motivation scale, and their results indicated a positive relation between motivation and distance learning, and statistically significant differences in favor of the scientific branch.

In summary, the researcher reviewed the studies that examined the impact of AR on students' motivation in the Arab context. Some of these studies resulted into significant differences in motivation and achievement for the experimental group, while others found a correlation between academic achievement and motivation. Additionally, the use of AI in developing digital image processing skills and creative thinking skills was found to be positively correlated with motivation.

In the learning process, sometimes, a learner has a motivation, but he/she is confused or tiered, so he/she needs another factor to take the action or convert intentions into actions, which is Volition or self-regulated(Keller, 2008). Volition is mainly based on different theories: Kuhl's theory of volitional control (Kuhl, 1987), Zimmerman's theory of self-regulatory learning (Zimmerman, 1990) and Gollwitzer's theory of implementation intentions (Deimann & Bastiaens, 2010; Gollwitzer, 1993). Therefore, Keller (2008)added a fifth factor to ARCS model to be ARCS-V model. Recently, Keller et al. (2020)established a reliable and valid scale to assess volition for learning to be utilized in the context of ARCS-V model in online and face to face learning settings. Their confirmatory factor analysis validated the scale's structure. Therefore, we will use this scale in our research. In summary, attention of ARCS-V model includes attention seeking curiosity, excitement, boredom, interest, and other related domains, such as perception search, are all examples of emotion. Relevance relates to learners' judgments that training matches with their learning styles needs and objectives. and pre-experiences. Confidence refers to the effects of positive expectations for success and attributes successes to one's abilities and efforts not for luck or the level of difficulties the task. Satisfaction is defined as the mix of internally satisfying and extrinsically rewarding outcomes that maintain intended learning while discouraging undesirable behavior. Finally, volition or self- regulated refers to conscious efforts backed by determination or external requirements to transform intentions to work (Keller, 2016).

1.6 Reflective Thinking

With widely used the latest technology in learning environment, the instructors and instructional design should decide which technology effectively supports learners' motivation and reflective thinking activities (Yilmaz & Keser, 2016). Reflection plays an important role in the learning process, and it is very useful for enhancing learning performance (Tok, 2008) and for better understanding of the learning content, when learners reflect during the learning process (Chen et al., 2011). There is no clear definition of reflection and this makes it difficult to assess teacher practices and learners' learning(Rodgers, 2002). Dewey (1933) defined reflective thinking as "active, persistent, and careful consideration of any belief or supposed form of knowledge in the light of the grounds that support it and the further conclusion to which it tends”. From Dewey’s writings on how to think, reflection is a process of producing meanings that allow the learners to move from one experience to the next with greater knowledge and by sharing their experiences with others. He should interact with others systematically, and needs a valued attitude to intercultural development (Rodgers, 2002). So, Dewey assume that reflection includes a combination of attitudes and skills (Boud et al, 1985). According to Boyd & Fales (1983), internal analysis and study of an issue produced by an experience, establishing and clarifying a meaning in terms of self, and resulting in changes in conceptual viewpoint are examples of reflective learning.(Boud et al., 2013) defined reflection as “an active process of exploration and discovery, which often leads to much-unexpected outcomes.”

Different approaches involved reflection, such as journals, logs and portfolios (Moon, 2004), but the most important issue is how to make learners reflect effectively. Some reflection skills assist learners in collaborative reflection through information sharing to evaluate others’ ideas and improve the reflection effectively. Kolb argues that active learners need four kinds of abilities, which match the four stages of his learning cycle, concrete experience, reflective observation, abstract conceptualization and active experimentation. These stages form the concrete/abstract and the active/reflective dimensions of cognitive learning (Kolb & Fry, 1974). According to Kolb, knowledge creation through the transformation of experience and the learning cannot happen without reflection. In his theory of self-regulated learning, Zimmerman (1990)proposed three phases: planning, performance or volitional control, and self-reflection. He classified self-reflection into attributions, self-evaluation, adaptive behaviors, and self-reactions, as cyclical loops. Montgomery also proposed five phases for reflective learning: look, think, do, plan and evaluate. At each phase, learners reflect on what they performed in the previous phase (Kember et al., 2000).

In 1983, Schön described reflective practice as an integration between thinking and doing, and between thought and action, through which the learner becomes more skilled (Colomer et al., 2013). Furthermore, he divided the learners’ reflection into three processes: reflection-for-action, which means that reflection happens before the action, reflection-in-action, which means that reflection happens in the midst of the action, and reflection-on-action, which means that reflection happens after the action (Chen et al., 2011).

In this regard, Jack Mezirow developed a comprehensive, logical framework of reflective thinking which includes six action levels: habitual, thoughtful, introspection actions, content, process and premise reflections (Mezirow, 1992). According to Mezirow, premise reflection is a high level of reflective thinking similar to critical thinking, in which learners are aware of his think, felling and perceive (Başol & Gencel, 2013). Reflection is also a metacognitive ability, which concerns the observation and control of individual cognitive processes(Chen et al., 2011). (Kember et al., 2000) derived from literature, specially from Mezirow framework, and developed a reliable scale for reflective thinking, which consists of four levels, habitual action, understanding, reflection and critical reflection (Kember et al., 2000). These levels are described as follows:

- Habitual action refers to activities that are learned through repeated use when the learner deals with the same action or problem many times as a routine. This behavior is similar to “knowing-in-action” process for Schön (1983)(Kember et al., 2000).
- Understanding refers to thoughtful activity of individuals, where the learners use their existing knowledge and comprehension of different subjects or phenomena (Ozdamli & Hursen, 2017). At this level, learners try to take notes attempting to understand with or without personal reflecting.
- Reflecting refers to the critique and appraisal of assumptions about a content or a process of problem solving (Mezirow, 1992). At this level, learners do not only understand the concept, but also, they make a personal reflection.
- Critical or premise reflection is a high level of reflective thinking. At this level, learners are aware about what they think, feel, perceive, and then require critical review of assumptions from prior conscious and unconscious learning and results. So, learners here develop their reflective skills and recognize their belief phenomena (Ozdamli & Hursen, 2017).

Chen et al. (2011)did research to explore if learners' levels of reflection can enhance teaching tactics (e.g., constructive, guided, and inductive) that are customized to meet learners' thinking styles (e.g., legislative, executive, and judicial) in an online learning environment. The study included 223 graduate and undergraduate students who were divided into fit and non-fit groups. Fit group's reflection levels were superior to the non-fit group. Another research examined the impact of AR applications on reflective thinking skills using pre-test, posttest design for a computer hardware course, which reveals that reflective and critical reflective skills for the experimental group were significantly higher (Ozdamli & Hursen, 2017). Similarly, Colomer et al. (2013) applied reflective learning methodology in higher education for individuals majoring in four disciplines (social education, environmental sciences, nursing, and psychology). They demonstrated that reflective learning approach assists students in being more aware of the learning process and their own requirements. It also promotes critical thinking and analysis, as well as the development of general abilities such as autonomous learning.(Colomer et al., 2013). The same result was revealed by Chang (2019) who explored reflective learning in an online learning environment, and showed that reflective learning provides a comparative reference in learning and builds structural links and social connections in knowledge between learners.

However, many challenges came up, including implementation issues and a lack of social support, particularly in e-learning and self-directed environments where students are not actively involved with instructors and other students. Poorly designed materials that lack well-written text and suitable graphic components might lead to implementation issues (Keller, 2016). In addition, managing the learning and motivating components of the learning environment, particularly when combining technology and novel delivery techniques, is one of the challenges. Nevertheless, integrating the ARCS-V model with instructional design can lead to instructionally rich and motivating learning activities that are appropriate for a given setting (Keller, 2016). Such situations encourage the use of AR technology into education for interactive learning that involves student interaction in order to increase students' motivation to study(Kaur et al., 2020).Up to the researcher’s knowledge, the ARCS-V model have not yet been used in AR-based research. In addition, a few researchers measured the influence of AR-based learning on students’ reflective thinking, such as (Ozdamli & Hursen, 2017). Therefore, this research will add a new and important contribution in the mentioned aspects and relevant domains and variables.

1.7 EON-XR Application

The researcher used EON-XR Platform to create 3D objects and animation, it is built on making Immersive Learning as Effortless, Affordable, Self-service, and Interconnected (EASI concept) (EON,2022). XR stands for eXtended Reality, and it refers to real and virtual worlds that are merged, such as AR, VR, and mixed reality (MR). EON-XR Application was used since it operates on both Windows and Mac Operating Systems with easy development, deployment, and adoption of AR/VR. It has also such features as faster learning with real-time feedback and task-oriented contextual knowledge, safety through simulation, greater engagement, and performance-based assessment. From technical viewpoint, EON-XR is cloud based, CAD/Model and data import, user-generated interaction, global publishing, and data management, content integration, as well as training and support. It has several 3D models and 360 images learning objects as shown in Figure 3 (EON,2022).

Instructors are able to create and edit 3D lessons from the 3D lesson page by following the conceptual map shown in Figure 4, which provides the main functions of the EON-XR platform (EON,2022). More details about these functions are listed in Appendix IX.

Figure 4

Sample learning objects provided in EON-XR platform.

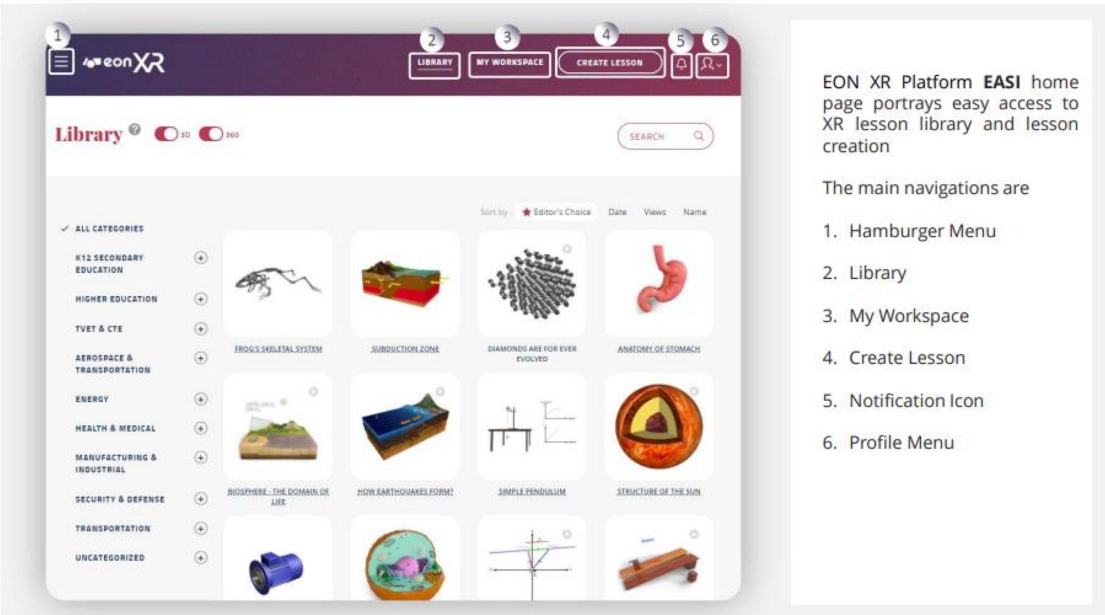
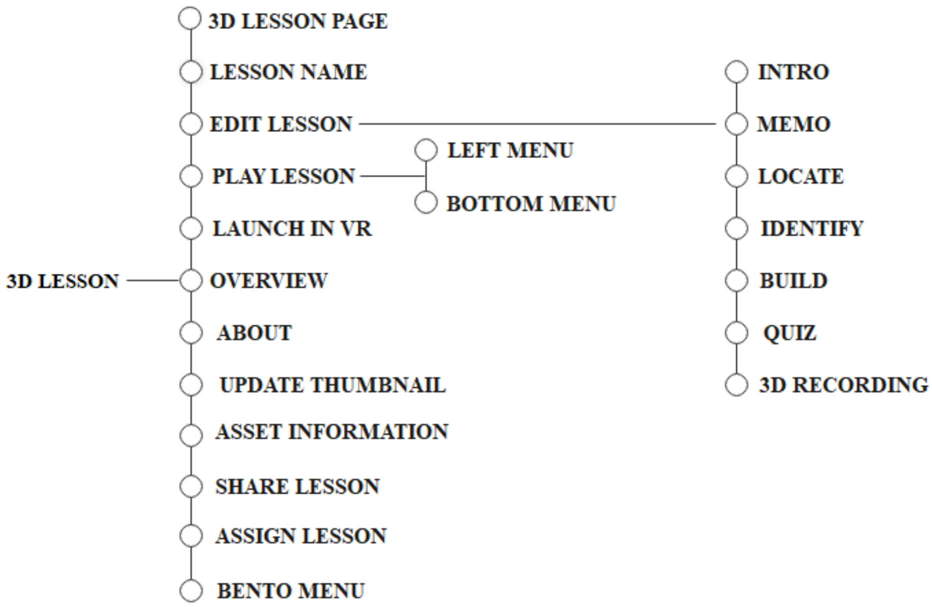


Figure 5

Conceptual map of 3D-lesson development.



The EON-XR platform, a service provided by EON Reality for sharing 3D models and developing lessons from them, is used to deliver topics. The student has access to texts, movies, and audios created to support him or her in learning as well as in the day-to-day academic environment, in addition to being able to construct 3D models with his own hands. The desire to make the developed material readily accessible on any already-existing device leads to the choice to use this platform. Although sophisticated technology is not necessary for students to enjoy the classes, they can consult a complete course with an Internet connection that provides chances for interaction and collaboration. In fact, the platform allows users to share lessons with one another, making the experience more enjoyable when taking a course with a friend.

Figures 5 and 6 illustrate sample lessons and related AR-based models as examples developed by one of the target students using EON-XR application. (Detailed steps are shown in Appendix IX).

Figure 6

Developing a sample model using EON-XR platform.

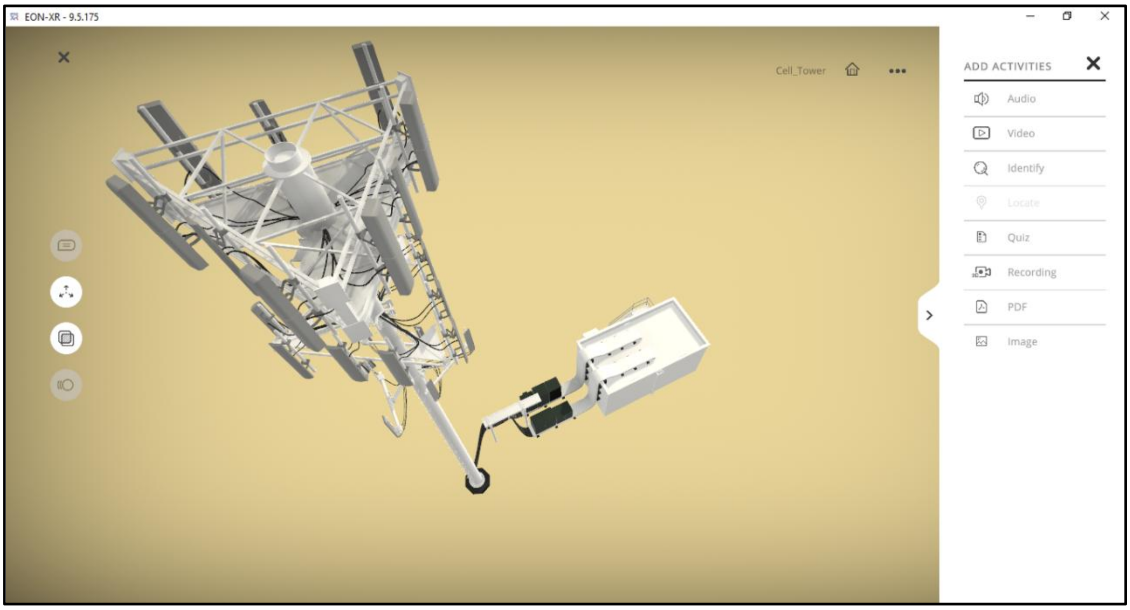
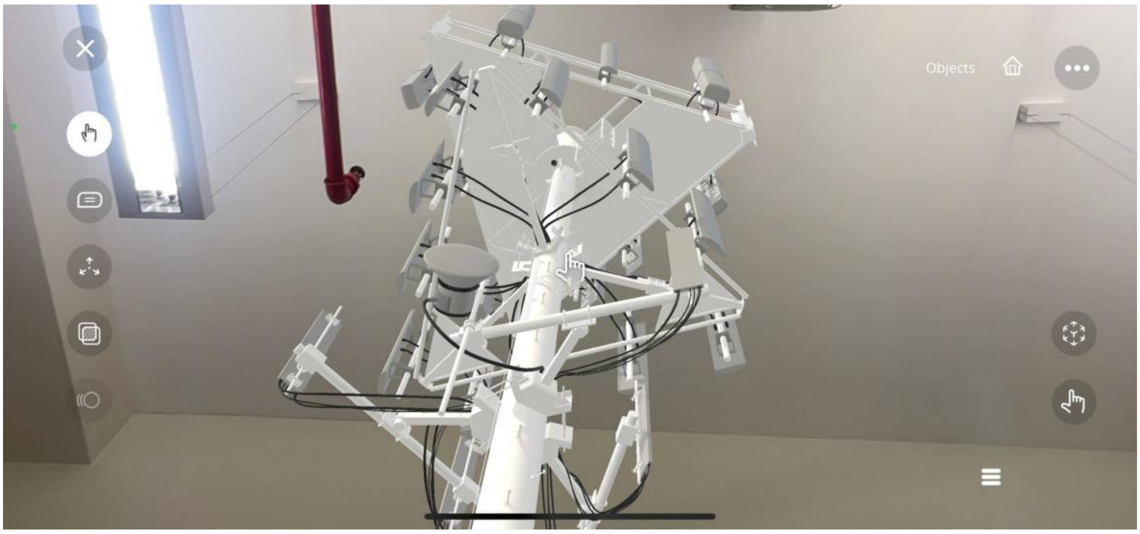


Figure 7

Cellular tower, an AR view



Students must incorporate information and understanding into the lesson when they are engaged in self-directed learning by developing a 3D or a 360-degrees lesson. Let's imagine they were tasked with creating a lesson from a lifelike 3D hospital ward. They must be able to utilize the model to demonstrate how a nurse might do routine patient checks. Importantly, this necessitates considering physical movement, using prior knowledge to the lesson, and designing the lesson in a way that the user can understand it (perhaps one of their peers). If they don't know something, they'll have to conduct some investigation, which is an essential component of active learning. All colleges want to assign more research-intensive assignments to their students. Therefore, finding appropriate videos, whose selection is based on critical evaluation, may fall under this category. It is argued that the platform's learning-focused design makes it possible to carry out significant actions, i.e., it does much more than just allowing users to do experiments with AR.

1.8 Problem Statement

The 21st-century skills include a range of competencies, such as creativity, critical thinking, meta-cognition, problem solving, digital literacy, communication, global awareness, andcivic responsibility (Dede, 2009). These competencies are important for the developing countries, where improving the learning outcomes and the instructional quality is urgent. Unfortunately, these countries do not have a context-specific knowledge of teaching techniques, nor do they have significant ways of supporting teachers' professional development(Kim et al., 2019). In addition, many problems and challenges face universities, such as low level of student interest, teaching methods and techniques, teacher characteristics and lack of equipment and tools. On the other hand, Karagozlu (2021)states that students have negative attitudes toward education because the delivered lessons do not support learning by doing or through experience, and there is a gap in the level of instructors' qualifications. Besides, the practical aspect for certain activities in instructional methods and teaching practices are impractical due to high costs, time constraints, or health risks(Darling-Hammond et al., 2020).

The above drawbacks in the educational system should be resolved to improve the pedagogical, technological, and methodological process in conformity with current realities (Iatsyshyn & Kovach, 2020). For instance, it is necessary to conduct specialized professional development programs to improve knowledge and proficiency of instructors in order to enable modern learners to focus on global trends when addressing issues of innovation in the educational process. Moreover, it is advisable to adapt advanced teaching methods and techniques to specific needs of a country. This will stimulate learners' activities and motivate them to self-study, which will eventually contribute to raising the national level of higher education(OECD, 2019).

It is believed that AR is one of the most effective strategies that help learners to study, think and shift their learning into the real world. It introduces emerging technologies that can be employed to enhance teaching and learning methods, but unfortunately, it is still ambiguous due to the shortage of studies in the literature that strongly relate to AR learning-theory or that describe how AR applications are designed and applied to improve learning outcomes and practices. AR provides better learning performance, learning motivation, improved perceived enjoyment, decreased cost of education, positive attitudes and engagement(Alzahrani, 2020). Besides, using modern learning methods, such as AR, help to keep pace with technological development and to achieve satisfactory results(Lee et al., 2019). This encourages the use of technology to better prepare learners, instructors, teaching techniques, and curriculum in an effort to improve the educational process and deliver better teaching practices.

In the Palestinian context, AR/VR-based education has appeared recently within the last four years at schools and universities as well. At universities, many external projects have been implemented to establish centers for AR/VR aiming at training of instructors and students to promote AR technology in education in various courses. Some of these projects targeted tourism sector and utilized AR/VR to develop virtual tours to the archaeological sites (Techno Park, 2023). For instance, An-Najah National University established the AR Unit in 2022 by the Artificial Intelligence and VR Research Center. The unit intends to deliver cutting-edge technology and essential AR skills to the interested instructors, students, workers, researchers and developers within and beyond the university (An-Najah National University, 2023).

At school level, teachers have made individual initiatives through mobile applications for primary and secondary students. They focused on transformation of static images and forms in the Palestinian curriculum into dynamic and animated material by directing the smart phone's camera to the textbook and programming the pages to show three-dimensional scenes to attract students. For example, they designed 3D models for human devices or any shape depending on the images (Aqel, 2017; Mashharawi, 2018). Moreover, teachers and students were provided with training to deal with AR/VR applications and to use them for education.

Fortunately, during this research, An-Najah National University implemented a project that aims at enhancing education with AR. Instructors were trained to utilize AR in their teaching strategies using EON-XR application, which has a library of ready-made learning objects in various categories. After training, each instructor designed his own AR-based course modules that were delivered to their students. This research targets a sample of those students who enrolled in an AR-based telecom engineering course for intervention. In this disciplinary, AR offers numerous functions that can help with perception or technical representations in the classroom (EON,2022). For instance, it supports increased perception of 3D shapes, designation of a specific point of a mechanism, analysis of a system functioning, implementation of work instructions, visualization of invisible characteristics, and remote expertise (e.g., synchronous collaboration between the operator and an expert)(Dominique Scaravetti & Rémy Françoi, 2021).

1.9 Research Questions

This research tries to answer the following main questions:

1. Are there differences in learners’ motivation dimensions between pretest and posttest for microwave engineering course experimental group?
2. Are there differences in reflective thinking dimensions between pre-test and post-test for the microwave engineering course experimental group?
3. Are there differences in learners’ motivation dimensions between experimental and control groups on pre-test and post-test for digital communication course?
4. Are there differences in learners’ reflective thinking dimensions between experimental and control groups on pre-test and post-test for digital communication course?
5. Are there significant differences on motivation between pre-test and post-test for the digital communication course experimental group?
6. Are there significant differences on reflective thinking between pre-test and post-test among the experimental group for digital communication course?
7. Is there any significant relationship between motivation and reflective thinking for the students of the digital communication course?
8. Are there differences on students’ achievement scores between experimental and control groups for the digital communication course?
9. What are the learners’ viewpoints towards integrating AR technology in the learning environment?

Chapter Two

Methodology

This chapter introduces the research methodology, which includes the research design in section 2.1, the sample and the instruments in sections 2.2 and 2.3 respectively. After that, the researcher identifies the research procedures in section 2.4, in addition to data collection and analysis in sections 2.5 and 2.6. Both validity and reliability are covered in section 2.7. Finally, the chapter ends with our research ethics in section 2.8

2.1 Research Design

The researcher used a mixed-methods research design, which includes data collection and analysis from multiple sources to approach complex research issues in one single study (Creswell and Plano Clark 2011). A mixed-methods design integrates both qualitative and quantitative data to explain research issues significantly (Dawadi et al. ,2021). She employed quantitative experimental study based on relevant scales and semi-structured interviews.

The quantitative experimental study aims at revealing the influence of using AR technology in learners' motivation and reflective thinking using ARCS motivation scale (Keller, 2010), Validation for learning scale (VFLS) (Keller et al., 2020) and reflective thinking scale (Kember et al. ,2000). Moreover, semi-structured interviews were conducted with students from the experimental group, which helps in deep understanding when it is necessary to comprehend the meaning and preferences behind important patterns(Karagozlu, 2021).

2.2 The Sample

The sample consists of 24 students in telecom engineering department who enrolled in digital communication course and 13 students who enrolled in microwave engineering course during the second semester of the academic year 2021-2022 at An-Najah National University using EON-XR platform for AR-based learning. This sample was selected using purposive sampling method that enabled the researchers to use their special knowledge or expertise about the sample proficiency with AR as a phenomenon of interest. The students who enrolled in the experiment are third and fourth years, and their age is between 20-21 years old. The sample is halved between experimental and control groups, and between males and females as well. The socioeconomic status of the sample is moderate for 66.7%, very good for 30.6% and low for 2.8 %. All of the students have smart phones and laptops. Their ICT skills are good for 36.1%, moderate for 55.6%, and low for 8.3%. Table 2 illustrates the demographic characteristics of the sample.

Table 2

Demographic characteristics of the sample

Group	Male	Female	Percentage
Experimental	12	12	50%
Control	12	12	50%
Total	24	24	100%

2.3 Instrument Design

The researcher used three scales as research instruments in order to collect the data and investigate the research variables, as follows:

1. Reflective Thinking Scale (RTS): This scale was developed by Kember et al (2000) to assess the level of reflective thinking. Pre-usage and post-usage questionnaires were developed in this research as data collection instruments based on this scale. The scale consists of four dimensions: (1) habitual action, (2) understanding, (3) reflection, and (4) critical reflection with 16 items. These item feature on five-point Likert response scale (1 = not true; 5 = very true).
2. Motivation Scale (ARCS): Instructional Materials Motivation Survey (IMMS) has been developed by (Keller, 2010). This research employed the ARCS scale for motivation based on pre-usage and post-usage questionnaires to compare student learning motivation and to determine if there was a statistically significant difference in motivation, with 5-point Likert-scale (1) = not true, (2) = slightly true, (3) = moderately true, (4) = mostly true (5) = very true. The IMMS survey comprises 12 items to measure Attention; 9 items to measure Relevance; 9 items to measure Confidence and 6 items to measure Satisfaction. IMMS was chosen based on the successful use in the previous studies to determine the influence of AR technology on student motivation (Kaur et al., 2020; Khan et al., 2019).
3. Volition for learning scale (VFLS) was developed recently by (Keller et al., 2020), which consists of 13 items, where Volition was added as a fifth component to the

ARCS model. The instrument is valid, reliable, and used in the context of motivation modeling successfully as for Keller (2020) results. The scale was comprised of two factors: action planning with 5 items, and action control with 8 items. 5-point Likert's scale was used, where (1) = not true, (2) = slightly true, (3) = moderately true, (4) = mostly true (5) = very true.

2.4 Research Procedure

Both motivation and reflective thinking scales (i.e., quantitative research instruments) were translated from English into Arabic and were reviewed by five Arab arbitrators who have experience in psychology, Arabic language, and education. They reviewed the clarity and comprehensiveness of the scales to ensure content validity. Accordingly, the researcher made minor modifications based on the feedback of the arbitrators. After completion, the scales' translated draft was back-translated into English by an independent translator according to the guidelines developed by Sousa and Rojjanasrirat (2010).

To examine scales' validity and reliability, 77undergraduate students (57.9% females and 42.1% males)at the An-Najah National University(i.e., pilot testing sample) independent from the study sample were asked to answer the Arabic-translated version of the scales to validate them in the Palestinian context. Participants were provided with descriptions of the scales and the purpose of the research, and those who agreed to participate in the research signed informed consent. In addition, factor exploratory and confirmatory analyses were performed to develop the final version of both motivation and reflective thinking scales. The final version of the scales shown in Appendix V and Appendix VIwere distributed to the study sample for data collection and further data analysis.

2.5 Data Collection

The researcher follows Denzin's (2012) triangulation approach, which includes multiple theoretical perspectives, multiple data-collection procedures and multiple analysis techniques. The use of multiple research design strategies and theories increases the depth of understanding and investigation. This research combines both quantitative experimental and qualitative descriptive research approaches, quasi-experimental pre-/post-test (Campbell and Stanley, 1963) and content analysis. While the experimental group employs AR in learning, the control group uses the traditional learning method as shown in Table 3. Content and thematic analysis are qualitative techniques where the transcribed documents are loaded into MAXQDA for analysis of the textual data and extract themes. They include systematic coding, meaning extraction and description of a phenomenon (Vaismoradi et al., 2016).

Table 3

Quasi-experimental pre-test/post-test control group design.

Group	Pretest	Treatment	Posttest
Experimental	Pre-survey	Learning method supported by AR	Post-survey Achievement test
Control	Pre-survey	Traditional Learning method	Post-survey Achievement test

The textual data was collected through semi-structured interviews with participants who enrolled AR-based courses. This qualitative instrument is preferred to investigate learners' perspectives regarding the integration of AR in their courses. The researcher obtained the data using open-ended questions that require some thought, some back and forth with interviewers to extract in-depth responses.

The protocol consisted of 45–60 minutes interviews with participants who agreed to record their responses and signed a consent form. The interviewer sometimes repeated or reworded questions, when necessary, until the participant fully expressed and clearly shared their thoughts. To ensure the participants understand the wording and perceive the relevant meanings of the questions, they were encouraged to ask questions during the interviews. In addition, the researcher designed a reflexive journal to obtain precise data and results. The interview questions are:

1. Explain your previous experiences on the subject of using augmented and virtual reality in education?
2. What was your initial impression when using the XR application?
3. What change did you feel after using the XR application for learning?
4. In your opinion, what are the main advantages of using the XR application in the learning process?
5. In your opinion, what obstacles did you encounter while using the XR application in education?

6. How do you think using the XR application will improve your educational and professional future?
7. Through your experience, do you advise your fellow students to use the application for learning? why?
8. Which student's skills are prerequisites for using XR application in learning?

Moreover, a reflection card was developed as a confirmatory instrument after the experiment, which consists of five questions, as follows:

1. After completing the assignments for this course, what did you learn? concepts? skills?
2. How do you think virtual and augmented reality may help you understand the topics of this course?
3. What is the difference between the design of this course and other previous courses? What are the similarities and differences between the course and other courses?
4. What are the obstacles that you encountered during the performance of the tasks of this course?
5. What can be added to improve the course using augmented reality?

2.6 Data Analysis

Descriptive statistics were calculated to test the statistical reliability of the instruments and study variables included in the research design. In order to evaluate the psychometric properties of ARCS-V and RT, we assessed: content validity (content validity index), internal consistency (Cronbach's alpha), theoretical relevance (exploratory and confirmative factor analysis) Pearson correlation analysis was conducted to assess the associations among the variables. The researcher also used Paired samples T-test to calculate the differences between pretest/posttest among experimental and control groups.

The Mann-Whitney U test was used to check the differences in the dependent variable for two independent groups, while Wilcox on signed-rank test was used to conduct a paired difference test of repeated measurements to assess whether their population mean ranks differ.

2.7 Validity and Reliability

Field (2005) defines the scales' validity as measuring "what is intended to be measured". It can be also defined as the accuracy of measuring a concept (Heale& Twycross ,2015). The researcher examined construct validity for both motivation and reflective thinking scales using Pearson's correlation between items and total dimensions. In addition, she conducted factor exploratory and confirmatory analysis to develop the final versions of those scales.

2.7.1 Scales' Validity

Pearson correlation analysis of the Motivation scale (ARCS-V) was conducted. Table 4 illustrates the correlation coefficients between all dimensions and the total score. Results indicate statistically significant positive correlations between all dimensions and the total score, with correlation coefficients range between (.487-.901), which are acceptable. Therefore, the construct validity is satisfied (John, et. al., 1991).

Table 4

Pearson Correlation Coefficients between the dimensions of ARCS-V and total Score (n = 77)

Measure	1	2	3	4	5	6
Total		901**	.875**	.757**	.859**	.703**
Attention			.741**	.594**	.693**	.600**
Relevance				.487**	.648**	.576**
Confidence					.619**	.628**
Satisfaction						.612**
Volition						

**p < 0.01

Table 5shows Pearson's correlation coefficients of all items of the attention dimension with their dimension and the total score.

Table 5

Pearson Correlation Coefficients of Attention items with Attention dimension and total score (n = 77)

Items	Attention	Total
There was something interesting at the beginning of this lesson that got my attention.	.373**	.492**
These materials are eye-catching.	.317**	.430**
The quality of the writing helped to hold my attention.	.452**	.473**
This lesson is so abstract that it was hard to keep my attention on it.	.351**	.151
The pages of this lesson look dry and unappealing.	.437**	.091
The way the information is arranged on the pages helped keep my attention.	.503**	.516**
This lesson has things that stimulated my curiosity.	.400**	.499**
The amount of repetition in this lesson caused me to get bored sometimes.	.584**	.275*
I learned some things that were surprising or unexpected.	.539**	.619**
The variety of reading passages, exercises, illustrations, etc., helped keep my attention on the lesson.	.454**	.532**
The style of writing is boring.	.487**	.145
There are so many words on each page that it is irritating.	.357**	-.003

**p < 0.01

Results of table 5 report acceptable significantly positive correlation in all items, except four items with total score. This might be due to misunderstanding of the respondents to these items. Therefore, the researcher remodified them.

Pearson correlation coefficients of the relevance items with their dimension and the total score, shown in Table 6, indicate acceptable significantly positive correlation in all items, except one item with the total score. The researcher remodified this item due to the same reason mentioned above.

Table 6

Pearson Correlation Coefficients of Relevance items with Relevance dimension and total score (n = 77)

Items	Relevance	Total
It is clear to me how the content of this material is related to things I already know.	.459**	.245*
There were stories, pictures, or examples that showed me how this material could be important to some people	.520**	.347**
Completing this lesson successfully was important to me.	.501**	.580**
The content of this material is relevant to my interests.	.752**	.490**
There are explanations or examples of how people use the knowledge in this lesson.	.698**	.531**
The content and style of writing in this lesson convey the impression that its content is worth knowing.	.612**	.566**
This lesson was not relevant to my needs because I already knew most of it.	.248*	.218
I could relate the content of this lesson to things I have seen, done, or thought about in my own life.	.596**	.417**
The content of this lesson will be useful to me.	.738**	.628**

**p < 0.01

Pearson correlation coefficients of the confidence items with their dimension and the total score, shown in Table 7.

Table 7

Pearson Correlation Coefficients of Confidence items with Confidence dimension and total score (n = 77)

Items	Confidence	Total
When I first looked at this lesson, I had the impression that it would beeasy for me.	.283*	.256*
This material was more difficult to understand than I would like for it to be.	.453**	.129
After reading the introductory information, I felt confident that I knew what I was supposed to learn from this lesson.	.316**	.464**
Many of the pages had so much information that it was hard to pick out and remember the important points.	.617**	.251*
As I worked on this lesson, I was confident that I could learn the content.	.310**	.302**
The exercises in this lesson were too difficult.	.603**	.350**
After working on this lesson for awhile, I was confident that I would beable to pass a test on it.	.529**	.594**
I could not really understand quite a bit of the material in this lesson.	.415**	-.008
The good organization of the content helped me be confident that I would learn this material.	.499**	.602**

*p < 0.05. **p < 0.01

Table 7 indicates acceptable significantly positive correlation in all items, except two items with the total score. The researcher remodified them due to the same reason mentioned above.

Pearson correlation coefficients of the satisfaction items with their dimension and the total score, shown in Table 8, indicate acceptable significantly positive correlation in all items.

Table 8

Pearson Correlation Coefficients of Satisfaction items with Satisfaction dimension and total score (n = 77)

Items	Satisfaction	Total
Completing the exercises in this lesson gave me a satisfying feeling of accomplishment.	.557**	.543**
I enjoyed this lesson so much that I would like to know more about this topic.	.685**	.536**
I really enjoyed studying this lesson.	.696**	.576**
The wording of feedback after the exercises, or of other comments in this lesson, helped me feel rewarded for my effort.	.660**	.579**
It felt good to successfully complete this lesson.	.623**	.317**
It was a pleasure to work on such a well-designed lesson.	.646**	.521**

**p < 0.01

Since volition for learning scale (VFLS) was recently developed and validated by (Keller, 2020), and the researcher is using it for the first time with the motivation scale (ARCS) in Arabic in the Palestinian context up to the researcher’s knowledge, the characteristics of the VFLS were tested on a pilot sample to examine construct validity and reliability. First, the researcher examined the descriptive statistics of the scale as shown in Table 9.

Table 9

Descriptive statistics of the Volition items

Items	M	SD	Skewness	Kurtosis	Corrected item-to-total correlation
My commitment to achieve the goals in this class was strong relative to the goals in my other classes.	3.32	.933	-.197	.223	.606**
I set up goals for my learning.	3.17	1.074	-.148	-.575	.630**
I was confident that I could avoid obstacles while doing my work.	3.71	.899	-.587	.713	.687**
I was prepared to work hard to achieve my goals no matter what my other classes required.	3.44	.920	-.782	.848	.660**
I was able to prepare a study plan that listed concrete tasks.	3.17	1.110	-.398	-.452	.676**
I kept my feelings under control while working to complete this class.	3.10	1.088	-.395	-.538	.667**
I added more effort to stay on task if my focus on my goal in this class began to decline.	3.26	1.074	-.534	-.195	.623**
I was able to avoid being distracted by competing goals.	3.27	.963	-.570	.259	.671**
I was able to create a setting free of uncontrollable distractions.	3.00	.853	-.129	-.041	.647**
I was able to know when to stop looking for more information to prepare for an exam.	3.44	1.014	-.665	.007	.773**
I didn't let social pressure affect my performance.	3.14	1.102	-.227	-.712	.646**
I anticipated personal or social events that might cause me to get behind.	2.95	1.115	-.012	-.524	.204
When my motivation decreased, I was able to think of things to do to build it back up again.	3.73	.935	-.604	.465	.595**

$*p < 0.05$. $**p < 0.01$

Table 9 shows that the measured values of skewness and kurtosis were between -1 and +1. Therefore, normal distribution is acceptable (Huck, 2012). To refine the measurement, the researcher conducted corrected item-total correlations, where items with the correlation of (<.4) are deleted in the initial evaluation and purification (Chen et.al, 2014). Accordingly, the researcher deleted the 12th item from the original VFLS that states, “I anticipated personal or social events that might cause me to get behind”. Then, the researcher conducted confirmatory factor analysis on the 12 items of volition for construct validity.

The researcher used the factor analysis with the principal component method and varimax rotation, where the factor loadings were calculated as shown in Table 10.

Table 10

Exploratory factor analysis results for the VFLS scale

Items	Volition
V1	0.790
V2	0.711
V3	0.703
V4	0.694
V5	0.656
V6	0.656
V7	0.654
V8	0.649
V9	0.648
V10	0.622
V11	0.586
V12	0.577
Total variance (%)	40.798

The factor loadings of the VFLS scale appear to be stable on one factor, which means that the scale is appropriate in the Palestinian context. After that, the researcher performed the Kaiser-Meyer Olkin (KMO) test to determine the sampling adequacy, with a KMO value of 0.827, which is (> 0.5) and considered validated(Taherdoost, 2018). In addition, the Bartlett’s Test of Sphericity was 393.089 and the degree of freedom was 66.

Pearson correlation coefficients of the volition items with their dimension and the total score, shown in Table 10, indicate acceptable significantly positive correlation in all items, except two items with the total score. The researcher remodified them due to the same reason mentioned above.

On the other hand, the researcher examined the validity of the reflective thinking scale using construct validity. Pearson's correlation analysis was conducted between each dimension's item, the total score of the dimension and the total score of the scale, shown in Table 11Appendix L.

Pearson correlation coefficients of the Habitual Action items with their dimension and the total score, shown in Table 12Appendix L, indicate acceptable significantly positive correlation in all items with a range of (.243** -. 655**).

Pearson correlation coefficients of the Understanding items with their dimension and the total score, shown in Table 13Appendix L, indicate acceptable significantly positive correlation in all items with a range of (.279** -. 697**).

Pearson correlation coefficients of the Reflection items with their dimension and the total score, shown in Table 14Appendix L,indicate acceptable significantly positive correlation in all items with a range of (.368** -.761**).

Pearson correlation coefficients of the Critical Reflection items with their dimension and the total score, shown in Table 15Appendix L, indicate acceptable significantly positive correlation in all items with a range of (.506** _. 791**).

Finally, Person correlation coefficients between the four dimensions of reflective thinking and total score indicate statistically significant positive correlations between all dimensions and total score. Habitual Action ($r = .508^{**}$, $p < .01$),Understanding($r = .611^{**}$, $p < .01$), Reflection ($r = .754^{**}$, $p < .01$), Critical thinking ($r = .757^{**}$, $p < .01$).

For construct validity, confirmatory factor analysis was conducted on 16 items of reflective thinking scale. The factor analysis with the principal component method and varimax rotation was used, where the factor loadings shown in Table 16Appendix L appear to be stable on four factors. This means that the scale is appropriate in the Palestinian context.

2.7.2 Scales' Reliability

Reliability is the degree of consistency or dependency of a construct's measure(Varni et al., 2001). It concerns the result stability of a measurement or a phenomenon (Taherdoost, 2018). The Motivation scale's reliability was validated in many studies like(Ibáñez et al., 2020;Keller, 1987; Khan et al., 2019). It had also been translated into several languages like Arabic (Al-Hujaili, 2019). The researcher used Cronbach's alpha to test the Motivation and Reflective Thinking scale's reliability, as shown in Tables 16 and 17 Appendix L.

Table 16 shows that all values of Cronbach's alpha are above 0.70. According to Nunnally& Bernstein (1994), a value of .70 or higher for Cronbach's alpha indicates acceptable reliability. In addition, the Guttman Split-half coefficient was calculated to be 0.864 in the split-half reliability analysis. shown in Table 18Appendix L.

Table 17 shows that all values of Cronbach's alpha are above 0.60. Ozdamli & Hursen (2017).Straub & Gefen (2004) suggested that the reliability with Cronbach's alpha equal to or above 0.60 is acceptable. Moreover, the Guttman Split-half coefficient was calculated to be 0.657 in the split-half reliability analysis. Hence, our results are in line with the previous studies.

2.8 Research Ethics

This research was conducted in line with the ethical guidelines of the American Psychological Association (APA, 2010) and the Declaration of Helsinki (2013). The researcher completed the Institutional Review Board (IRB) form, which was approved by the An-Najah National University IRB (Protocol number 11 Jun). Informed consent was obtained before data collection from the participants. All participants were provided with information that enabled them to decide whether they want to participate in this study, where their identification was hidden and the collected data were used only for the research purposes.

2.9 Experiment Design

The researcher conducted the experiment on digital communication compulsory course in telecommunication engineering program, which has been accredited by ABET in 2014. At the time when this research started, the digital communication course was being evaluated for the second cycle, including the course syllabus, assessment criteria, course objectives and learning outcomes, and the related feedback was provided to the department. The course prerequisite is communication principles.

2.9.1 Experiment Setup (Preparation and Requirements)

During the experiment, the students need to have a smart phone connected to the Internet, an account on the EON-XR platform, and a headset (magic leap or oculus quest). To get the best experience on using EON-XR app on a mobile device or a tablet, the following requirements are recommended:

1. IOS 10 device with 2GB memory or higher (iPhone 7 and iPad Air 2 or higher).
2. Android device with 3GB memory and 32GB storage or higher, with Lollipop OS (API21) supported with OpenGL ES 3.

To prepare the targeted students for the experiment, a training was conducted to them on EON-XR platform, and they were provided with some pedagogical knowledge.

2.9.2 Experiment Procedure

The researcher followed the five stages of ADDIE model (Rooij, 2013) to conduct the experiment, as follows:

1. **Analyze:** this is the first phase that is essential to develop the next phases. It includes analysis of the learning goals and the content of the course material. In addition, it identifies the targeted students' characteristics and the learning environment.
   - Analyze the learning goals: the extent to which the learning goals are achieved when integrating augmented reality into the learning process.
   - Analyze the content of the course material, where the digital communication course was used in this experiment with the following description:

   This course covers digital communication concepts including sampling, quantization, pulse code modulation, Time Division Multiplexing (TDM), digital multiplexer, quantization noise in PCM systems. In addition, it covers delta-sigma modulation, linear-predictive coding, differential pulse-code modulation, baseband digital transmission and communication model, matched filter, error rate due to noise detection of baseband signals in additive white Gaussian noise (AWGN) and Inter-Symbol Interference (ISI). Moreover, it discusses Nyquist criteria for distortion less channel, M-ary baseband transmission, correlative level coding, pass band digital transmission model, coherent phase shift keying, M-ary phase-shift keying (QPSK and M-ary PSK), hybrid amplitude/phase modulation schemes (M-ary-QAM), coherent frequency-shift keying, no coherent orthogonal modulation, no coherent binary FSK, differential phase-shift keying, M-ary FSK, effect of noise on various modulation schemes, and average probability of error versus increased bandwidth transmission.

In addition, the following items list the intended learning outcomes of the digital communication course:

1. Ability to apply knowledge of mathematics, science and engineering to study noise effect, average probability of error, spectral efficiency of baseband and pass band communication system.
2. Ability to design digital communication system that meets spectral efficiency, noise effect and average probability of error.
3. Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice (i.e., course project).

- Identify participants' characteristics: the students who enrolled in the experiment are third and fourth years in telecommunication engineering. Refer to section 2.2 for the detailed sample characteristics.
- Identify the learning environment: learning enticement with the learning environment, which is described here, is very important for educational issues. This course is based on face-to-face mode, where the lectures are delivered in classroom or in the computer laboratory equipped with a projector and Internet service. In addition, the lecturer designs the learning assessment activities.

2. **Design:** this stage is essential to design the scales and identify the lesson objectives, the learning styles and the teaching strategies, as follows:

- Design a scale for pre-test and post-test.
- Identifies lesson objectives: Students should be able to:
  - Convert analog signal into digital signal and vice versa.
  - Identify the multiplexing technique in the time domain and the E1 system.
  - Discuss the concept of matched filter and its applications in a communication system.
  - Discuss the Inter-Symbol Interference (ISI) and the Additive White Gaussian Noise (AWGN) concepts in communication systems.
- Describe learning style for the learners: Group work on projects and learning by doing. Each group consists of 2-3 students who work on XR activities and XR presentation.

- Identify the educational resources (images, video, audio, assessment): During the class, the instructor uses textbook, PowerPoint presentation, lecture notes. In addition, they provide students with self-learning material on Moodle, such as links, videos, and recorded lectures. The XR activity includes videos, images, 3D recordings, audio recordings, assignments and quizzes.

- Identify learning strategy: The students rely on learning by doing, cooperative learning and presentation skills.

3. **Develop:** in this stage, the educational resources are developed using EON-XR platform through several assignments to the targeted students. The instructor role is to create accounts for the students on the EON-XR platform and provide training them on using the EON-XR platform and application on their mobile devices, to develop learning resources such as uploading images and recording audio and video. The student's role is to develop the learning resources in four assignments including XR projects to evaluate their learning progress.
4. **Implement:** this stage is concerned with the integration of AR into learning, where the instructor assigned four learning activities to the target students with clear goals that covered the content to extend students' learning rather than testing their existing knowledge. These assignments are:
   - Assignment 1 (Project): Students need to prepare a comprehensive project on A/D and D/A conversion using both Hardware and software.
   - Assignment 2 (Project): Students need to develop the concept of Time Division Multiplexing (TDM) system in general, then they need to discuss the E1 system.
   - Assignment 3: Students need to discuss the concept of Matched Filter and its applications in a communication system.
   - Assignment 4 (Project): Students need to discuss the concept of Inter-Symbol Interference (ISI) and the Additive White Gaussian Noise (AWGN) in a communication system.
5. **Evaluate:** this stage was based on XR projects, midterm and final exams. In the projects, each group developed one 3Dlesson satisfying one of the evaluations of the following criteria: annotations or labels, memos with audio narrations, videos, 3D recordings, activities with locate and identify, images, PDFs and quizzes "change default answers".

Tables 19 and 20 Appendix Show two-sample lessons developed by students in both courses, based on the stages described above.

Figures 7 and 8 illustrate some documentary photos of the students while designing and implementation of the lessons and experiments using EON-XR platform in learning digital communication course.

Figure 8

Students' activities while performing their assignment son AR.

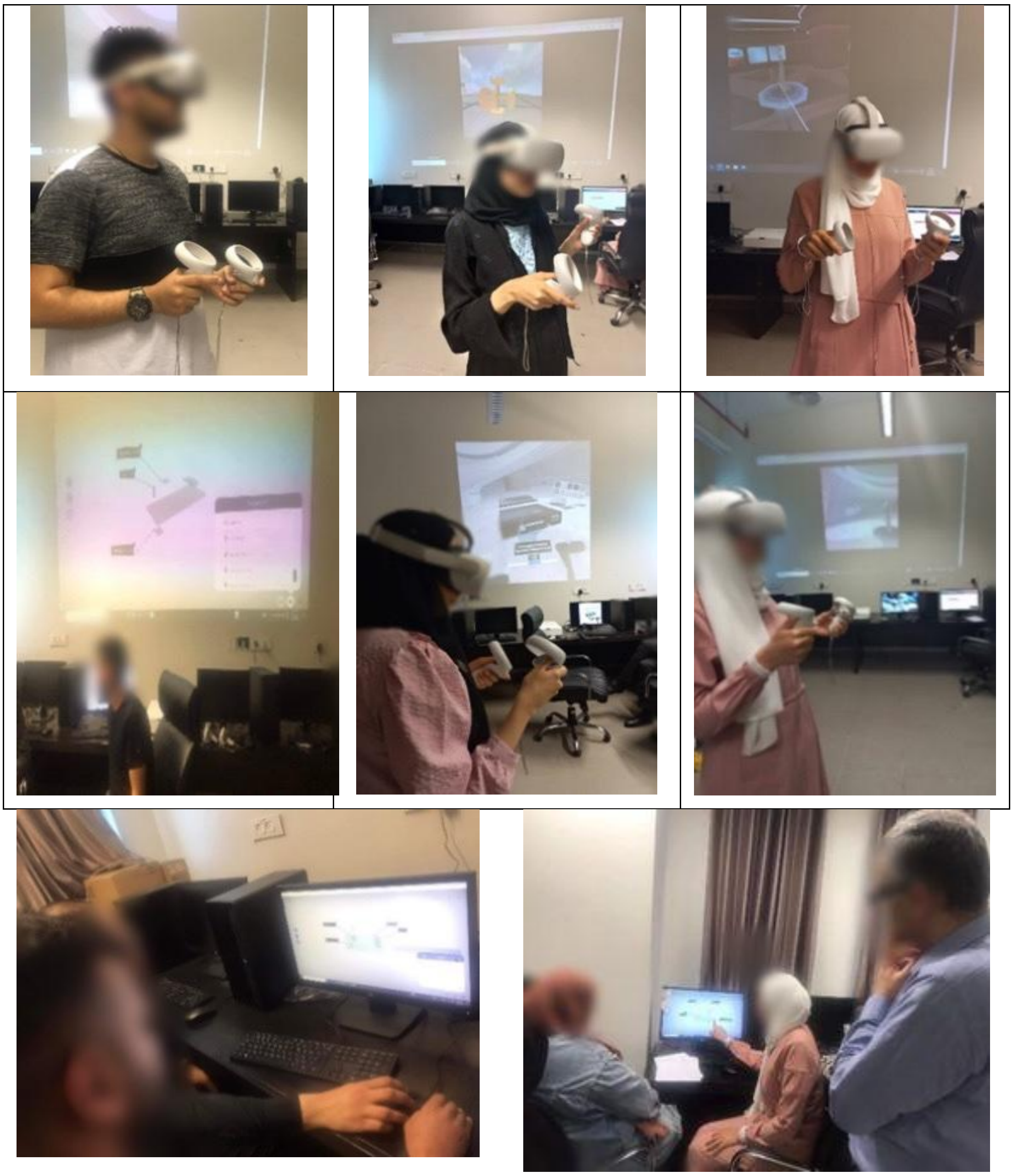
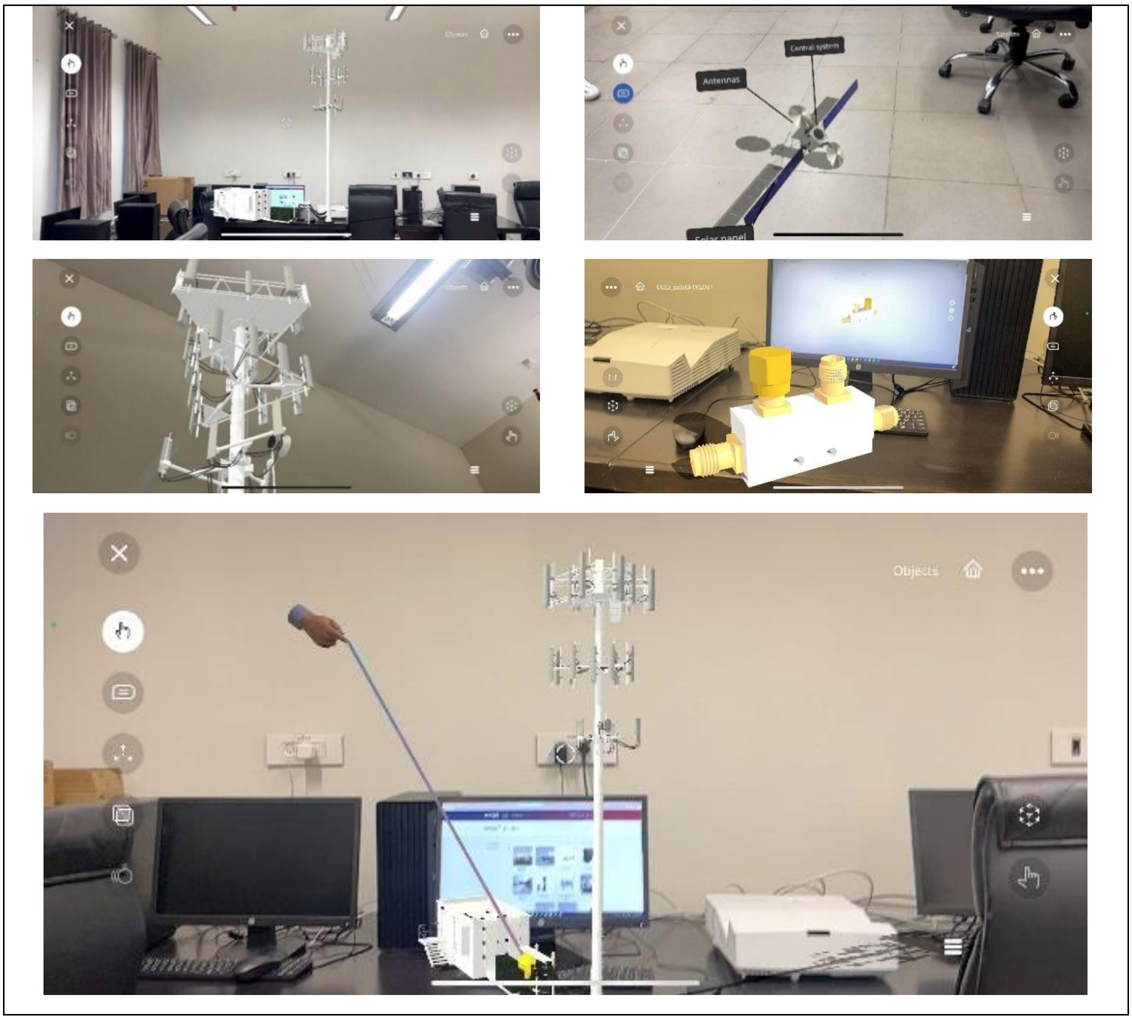


Figure 9

Students' activities while implementing their assignments on AR (e.g., what they see).



Chapter Three

Results and Findings

This chapter introduces the manipulation and analysis of the collected data from the samples using both motivation and reflective thinking scales. This includes the required statistical analysis and tests using the statistical package SPSS that constitute the quantitative results of this research. Two experiments have been conducted on two courses (e.g., Microwave Engineering and Digital Communication Courses) at the faculty of engineering at the An-Najah National University. In addition, the chapter covers the content analysis of the qualitative data collected through semi-structured interviews with the same samples. The chapter consists of three sections. The first section covers the quantitative results. The qualitative results are presented in the second section. Finally, the chapter ends with a summary of the findings.

3.1 Quantitative Results

For Microwave Engineering course, the sample size was less than 50. Therefore, we used Shapiro-Wilk test to investigate the normality assumption, because it is more appropriate for small sample sizes (< 50 participants) (Laerd, 2018). Moreover, Dwivedi et al. (2017) suggests using nonparametric tests for comparing paired or unpaired means and for validating the one way analysis of variance test results for non-normal data in small sample size studies. The normality assumption was not satisfied as the significance was less than 0.05 for motivation scale with ($p= 0.019$) for pretest and ($p=0.02$) for posttest, and for reflective thinking scale with ($p= 0.029$) for pretest and ($p= 0.026$) for posttest. Therefore, the researcher used non-parametric tests for this course. The following sections present the findings and tests to answer the research questions for both courses. All quantitative results are listed in Tables (21-39) of Appendix L.

3.1.1 Research Question 1

Are there differences in learners' motivation dimensions between pretest and posttest for microwave engineering course experimental group?

To answer this question, the researcher followed three steps. At the first step, the means, standard deviations and medians for the experimental group on pre and post tests were calculated for the motivation scale as shown in Table 21.

Table 21 compared the means and medians of pre-test and post-test for the experiment group on all dimensions of the motivation scale. The results show apparent differences between means and medians on total score of the motivation scale and all its dimensions in favor of the post-test.

At the second step, the researcher used Mann-Whitney to examine the statistical differences in the students' responses to the motivation scale pre-test and post-test for males and females (Pre-treatment Measure of Equivalence), as shown in Table 22.

Results in Table 22 show no significant differences in motivation pre-test mean ranks due to gender (U=5.00, P=0.235), implying that the groups have comparable characteristics, and therefore suitable for the research. Moreover, results show no significant differences in motivation post-test mean ranks due to gender (U=10.00, P=0.843) after using AR technology in teaching the Microwave Engineering course.

At the third step, Wilcox on test was conducted to examine the differences in the motivation scale and all of its dimensions between the pre-test and the post-test for the experimental group, as shown in Table 23.

Table 23 shows indicates that the median total post-test ranks for the motivation scale (M_{dn} = 3.6458) were significantly higher than the median total pre-test ranks (M_{dn} = 3.3333, Z= -2.343, P= .019). In addition, results show statically significant differences for Attention, Relevance, Confidence, Satisfaction, and Volition dimensions (Z= -2.0904, P=.037), (Z= -2.077, P=.038), (Z= -2.238, P= .025), (Z= -2.357, P= .018), (Z= -1.959, P= .050) respectively. Therefore, the results indicate that AR-based teaching has an impact on all dimensions of the motivation scale.

3.1.2 Research Question 2

Are there differences in reflective thinking dimensions between pre-test and post-test for the microwave engineering course experimental group?

To answer this research question, the researcher followed the same steps above, where themeans, standard deviations and medians were calculated for the experimental group on pre-test and post-test for the reflective thinking scale, as shown in Table 24.

Table 24 shows apparent differences between means and medians on total score of the reflective thinking scale and all its dimensions in favor of the post-test.

At the second step, the researcher used Mann-Whitney U test to examine the statistical differences in the reflective thinking scale pre-test and post-test for males and females (Pre-treatment Measure of Equivalence), as illustrated in Table 25.

Results show no significant differences in the reflective thinking scale pre-test mean ranks due to gender (U=7.00, P=0.430), implying that the groups had comparable characteristics, and therefore are suitable for the research. In addition, results show no significant differences in the reflective thinking scale post-test mean ranks due to gender (U=6.5, P=0.373) after using AR technology in teaching the Microwave Engineering course.

At the third step, Wilcox on test was conducted to examine the statistical differences in the reflective thinking scale between pre-test and post-test for the experimental group and all its dimensions, as shown in Table 26.

Wilicoxon’s signed-ranks of Table 26 indicate that the median total post-test ranks for the reflective thinking scale (Mdn =4.1875) are significantly higher than the median total pre-test ranks (Mdn = 3.5000), (Z= -2.623, P< .009). Also, results show statically significant differences in Habitual Action, Understanding, and Critical Reflection dimensions (Z= -2.254, P< .024), (Z= -2.590, P< .01), (Z= -2.520, P< .012) respectively, but no statically significant differences for Reflection (Z= -.985, P< .324). Therefore, results indicate AR-based teaching has an impact on reflective thinking and all its dimensions except for reflection.

For Digital Communication course, the sample size was less than 50. Therefore, we used Shapiro-Wilk test to investigate the normality assumption, because it is more appropriate for small sample sizes (< 50 participants) (Laerd, 2018). The normality assumption was satisfied as the significance was more than .05. For motivation scale, the significance was (p= 0.533) for pretest and (p=0.414) for posttest. In addition, the significance for reflective thinking scale was (p= 0.11) for pretest and (p=0.538) for posttest. Therefore, we used parametric tests in our analysis.

3.1.3 Research Question 3

Are there differences in learners' motivation dimensions between experimental and control groups on pre-test and post-test for digital communication course?

To answer this question, the researcher started with the independent t-test to examine the statistical differences in the student's motivation pre-test due to gender and group (Pre-treatment Measure of Equivalence), as illustrated by Table 27.

According to the t-test results for independent groups in Table 27, there were no significant differences (p<=0.05) between experiment and control groups (t-value = -2.280, p = .334). Similarly, Table 27 shows no significant differences between males and females (t-value = 1.331, p = .442). This result indicates that the previous motivation level of both gender and group is equal, which means they are suitable for the research.

Then, the researcher calculated the means and standard deviations for the experimental group on pre-test and post-test for the motivation scale, as shown in Table 28.

Results of Table 28 show apparent differences between means on total score of the motivation scale and all its dimensions due to group and gender in favor of the post-test.

After that, the researcher used the one-way Analysis of Co-variance (ANCOVA) test to determine statistically significant differences between groups on post-test scores controlling for pre-test scores. Before the test, the researcher examined the assumption of homogeneity of regression, where no violation was found (F = 4.196808, p > .05). Results of the ANCOVA test are depicted in Table 29.

Results of Table 29 show significant differences between experimental and control groups on the total score of the motivation scale in favor of the experimental group. In contrast, results show no significant differences due to gender, pre-test and interaction between group and gender.

In order to measure the effect size for comparing the efficacy of AR intervention (i.e., experimental group) on the dependent variables (i.e., motivation and reflective thinking), the researcher used Partial Eta Squared(η^2). According to Cohen (1988), the effect size is indicated byf= $\sqrt{\eta^2(1-\eta^2)}$, such that f = 0.1 indicates a small effect, f = 0.25, indicates a medium effect, and f = 0.40 indicates a large effect.

Results in Table 29 show that the corresponding effect sizewas (η^2= 0.393), which explained that 39.3% of the variance in the groups' mean scores on the posttest was due to the AR intervention, with (f = 0.427), which indicates a large effect of AR-based learning on the motivation.

In order to test the significance of these differences on the motivation dimensions, multiple analysis of covariance (MANCOVA) was employed, as shown in Table 30.

Results show significant differences between experimental and control groups on the motivation dimensions in favor of the experimental group except for Confidence dimension. In contrast, results show no significant differences due to gender, pre-test and interaction between group and gender on the motivation dimensions except for Volition.

Accordingly, results indicate that the integration of AR technology into the learning environment of digital communication course can enhance students' motivation, especially in terms of Attention, Relevance, Satisfaction and Volition.

The partial eta squared (η^2) explained 24.3%, 33.2%, 49.8%, 46.6% of the variance in the groups' mean scores on the posttest due to the AR intervention on Attention, Relevance, Satisfaction, and Volition respectively. All the values of η^2 above are greater than 0.134, and according to Cohen's (1988) classification, these values indicate large effects.

3.1.4 Research Question 4

Are there differences in learners' reflective thinking dimensions between experimental and control groups on pre-test and post-test for digital communication course?

To answer this question, the researcher first used independent t-test to examine the statistical differences in the student's reflective thinking pre-test due to gender and group (Pre-treatment Measure of Equivalence), as illustrated by Table 31.

Results in Table 31 show no significant differences between experimental and control groups (t-value = -.195, p = .587). Similarly, results show no significant differences (p<=0.05) between male and female students (t-value = 1.316, p = .94). This indicates that the previous reflective thinking level due to gender and group is equivalent, which means they are suitable for the research.

After that, the researcher calculated the means, standard deviations and medians for the experimental groups on pre-test and post-test for reflective thinking scale, as shown in Table 32.

Results of Table 32 show apparent differences between means on the total score of reflective thinking and all its dimensions due to gender and group in favor of the post-test.

In order to examine the significant differences between groups on post-test scores controlling for pre-test scores, and after examining the assumption of homogeneity of regression with no violation (F = 2.467, p > .05), the researcher conducted one-way Analysis of Co-variance (ANCOVA), as shown in Table 33.

Results of Table 33 show significant differences between experimental and control group on total score of Reflective thinking scale in favor of the experimental group. In contrast, results indicate no significant differences due to gender, pre-test and interaction between group and gender. Results in Table 33 show that the corresponding effect size was (η^2 = 0.512), which explained that 51.2% of the variance in the groups' mean scores on the posttest was due to the AR intervention, with (f = 0.499), which indicates a large effect of AR-based learning on the Reflective thinking.

In the last step, and to examine the significance of these differences on the reflective thinking dimensions, a multiple analysis of covariance (MANCOVA) was used, as shown in Table 34.

Results of Table 34 show significant differences between experimental and control groups on Reflective Thinking dimensions in favor of the experimental group except for Reflection. In contrast, results show no significant differences due to gender, pre-test and interaction between group and gender on Reflective thinking dimensions.

The partial eta squared (η^2) explained 51.2%, 64%, 49%. of the variance in the groups' mean scores on the posttest due to the AR intervention on habitual action, understanding, and critical thinking respectively. All the values of η^2 above are greater than 0.134, and according to Cohen's (1988) classification, these values indicate large effects.

3.1.5 Research Question 5

Are there significant differences on motivation between pre-test and post-test for the digital communication course experimental group?

To find the differences between pre-test and post-test on the experimental group, the researcher calculated the means, standard deviations, and paired samples t-test was conducted to test the differences between pre-test and post-test for the experimental

Results of Table 35 show significant differences between pre-test and post-test on motivation in favor of the post-test, where the means of the pre-test and post-test are (3.2847, 3.8229) respectively.

3.1.6 Research Question 6

Are there significant differences on reflective thinking between pre-test and post-test among the experimental group for digital communication course?

To find the differences between pre-test and post-test among the experimental group, the researcher calculated the means, standard deviations, and the paired samples t-test was conducted to examine the differences for reflective thinking and its dimensions between pre-test and post-test for the experimental group, as shown in Table 36.

Results show significant differences between pre-test and post-test on reflective thinking in favor of the post-test, where the means of the pre-test and post-test are (3.1667, 4.1823) respectively.

3.1.7 Research Question 7

Is there any significant relationship between motivation and reflective thinking for the students of the digital communication course?

In order to answer this question, the researcher computed Pearson Product Moment Correlation Coefficient to investigate any significant relationship between the independent variable (reflective thinking) and the dependent variable (motivation) for the students of the digital communication course, as shown in Table 37.

Results of Table 37 show a significant positive correlation at 0.05 level ($r = 0.619$, $p<=0.032$) between motivation and reflective thinking. The regression analysis for predicting motivation in Table 38 found

that reflective thinking contributed in a way that was statistically significant toward explaining 38.3 % of variance in motivation ($B = 0\ 0.500$, $SE = 0.201$, $\beta = 0.619$).

3.1.8 Research Question 8

Are there differences on students' achievement scores between experimental and control groups for the digital communication course?

To answer this question, the researcher used the independent t-test to examine the statistical differences in the students' scores between the control group (i.e., students who received traditional assignments) and the experimental group (students who received AR assignments), as shown in Table 39.

Results in Table 39 indicate significant differences between the experimental group and the control group on the students' achievement scores with (t-value = -1.368, $p = .017$).

3.2 Qualitative Results (Research Question 9)

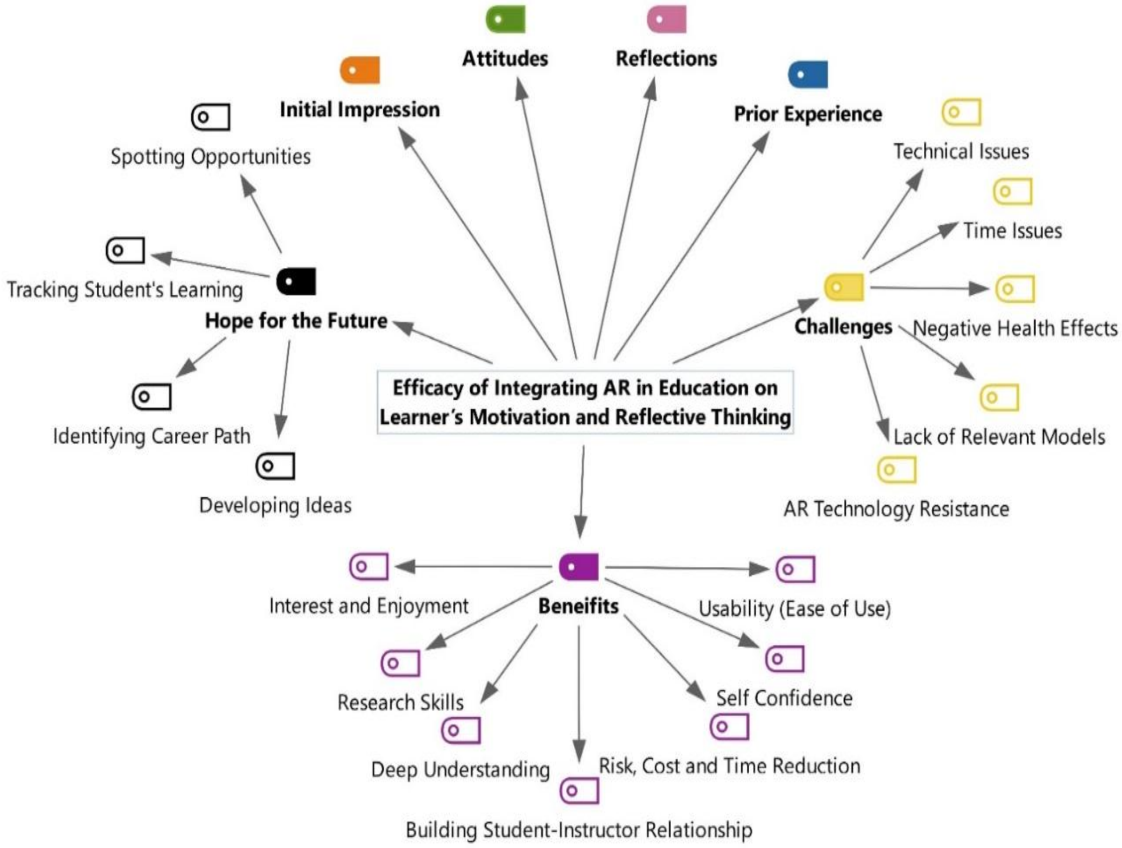
Many studies used AR in education based on qualitative design (Cavilla, 2017; K. E. Chang et al., 2014; Delello, 2014; Fidan & Tuncel, 2019; Ozdamli & Hursen, 2017;

Safar et al., 2017a; Sahin & Yilmaz, 2020; Ziden et al., 2022; Zimlich, 2015). In this section we used inductive analysis process of the interviews using MAXQDA20 to introduce the results. The interviews were analyzed following thematic coding and content analysis methodology (Parker, 2005) to identify the codebook that consists of the main themes emerging from the written material based on bottom-up data driven text analysis to extract codes. After reading the responses of each participant carefully, the concepts and statements containing similar words were identified, and the analysis process continued as follows: (a) open coding from the participants' narratives to generate the main themes; (b) the codes and sub codes were organized into structured text; and (c) the codes and sub codes were discussed and elaborated with evidences of the extracted segments (Mahamid, 2020).

A codebook was generated that constitutes of seven main themes: Reflection, Prior Experience, Initial Impression, Benefits, Challenges, Attitudes, Hope for Future. Hope for future theme yielded four subthemes, developing ideas, identifying career path, spotting opportunities, and tracking learning. Challenge's theme yielded five subthemes: AR Technology Resistance, Lack of Relevant Models, Technical Issues, Time Issues, Negative Health Effects, benefits theme yielded four subthemes: Deep Understanding, Interest and Enjoyment, Building Student-Instructor Relationship, Usability and Risk, Cost and Time Reduction. The diagram shown in Fig. 9 illustrates the generated codes and sub codes using MAX Maps of MXQDA20.

Figure 10

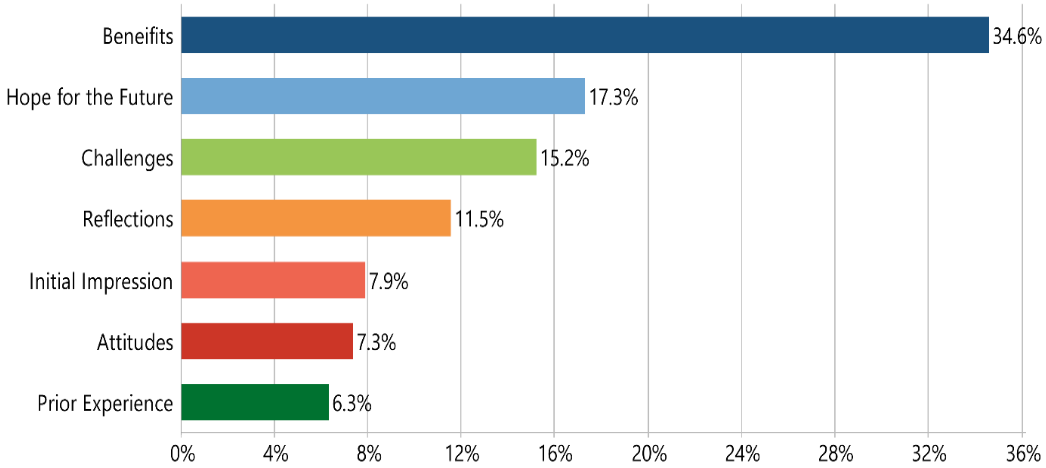
Code-sub code-segments model in MAXMaps.



According to the thematic coding and the qualitative data analysis, the researcher classified them into seven codes; three of them have their own sub codes. Figure 10illustrates the code segments' frequency distribution. The MXQDA program calculates the frequency of each theme by counting the number of instances or segments of data that are assigned to each theme. This provides an indication of how frequently certain themes appear in the data. The highest frequency was for benefits with 34.6% and the lowest frequency was for prior experience with 6.3%.

Figure 11

Frequency distribution of the code segments.



The main question to be answered in this section i.e., the qualitative research states:

What are the learners' viewpoints towards integrating AR technology in the learning environment?

In order to answer the question above, which is the last research question, the following sections discuss the extracted themes and subthemes of the qualitative analysis based on semi structured interviews with the sample.

3.2.2Prior Experience

Prior experience refers to students' previous knowledge about some topic or skills related to some technology (Rakap, 2010), or what the learner already knows about a topic or other related topics (Svinicki, 2004). Teaching and learning in a new learning environment are influenced by Previous Knowledge, which could be a set of misconceptions significantly interfering with the new concepts (Naah & Osei-Himah, 2021). Results show that all students had not any background or prior experience related to AR or VR in education. Moreover, their experience in other fields is divided between either no prior experience in their life, or some experience in 3D virtual games, cinema, and in watching 3D film using TV classes, scientific experiments using VR, or VR books using mobile applications.

For instance, AA said, *"I have some knowledge related to VR-based games not in education or learning. For example, I used to play VR-based games such as zombie and racing. It was a good experience, and since that day I have a passion for virtual games".*

Moreover, AS added, *"My previous knowledge of VR was related to games in which I was not interested. I used to watch movies explaining the concept of VR, wondering how oculus operates. I also read some articles related to AR technology and admired it. I did not expect that I will use this technology and practice it in my classes."*

3.2.2 Initial Impression

Initial impression can be defined as an initial opinion and perception formed regarding people, phenomena, technologies, events or concepts facing a human being or he is experienced with for the first time(Haselton&Funder, 2006). Results show that the students were divided into two groups, the first struggled with using AR to study at the beginning and was afraid from dealing with this new technology. Also, some female students had techno stress when they wore the oculus and immersed within the virtual world.

For instance, SN said, "*It was hard to learn based on AR technology right now, since I am overloaded in the last year of my study. Even though it was enthusiastic experience".*

On the other hand, the second group felt exited to use AR technology to understand the difficult concepts, since engineering topics are described as imaginative topics. They were satisfied with doing their assignments and homework and achievement using AR/VR.

AGh said, *"I am satisfied with my achievement while working on this course using AR technology. It was wonderful and perfect course, and I am proud of my instructor who gave me this opportunity"*.

Moreover, MGh described AR as relevant with the course material. He said, *"I learned to identify the main components of the generator and how it operates, in addition to generator maintenance without the need to be present in an electrical station. AR technology made a big change in my life".*

3.2.3 Benefits

This section summarizes the students' perceptions of the main benefits gained during their experiment in the AR-based courses. Some sub codes are similar to those introduced in the previous studies. For instance, advantages of AR in learning physics by Fidan & Tuncel (2019) introduced codes such as better understanding and analyzing the problem scenarios; retention of concepts; facilitation and concretization in learning; autonomous learning; interesting, realistic, enjoyful, interactive as a learning environment.

Delello (2014) described the strengths of using AR for student learning in three themes: Motivation and engagement, Teacher acceptance, and Community of practice, whereas Chang et al. (2014) provided six advantages: high autonomy, frequent human-computer collaborative interaction, good visual effects, detailed observations toward specific parts of a picture, convenient content management, and long-term benefits. Furthermore, Safar et al. (2017) coded effectiveness in communication and use of senses, whereas Ziden et al. (2022) proposed three themes: interactive, motivating, and enjoyable learning. In this research, the AR benefits were classified into five subthemes as discussed below.

3.2.3.1Building Student-Instructor Relationship

Student-instructor relationships affects learning outcomes, where students with strong connection with teachers reported better learning outcomes and academic achievement. Further, they were more confident and self-directed (Creasey et al., 2009).

In this research, the students expressed that their relationship with the instructor was changed. As a result, they became cooperative team members. Moreover, the students expressed their satisfaction in dealing with the instructor as a result of continuous communication inside and outside the classroom.

ES said, "*I have certainly strengthened my relationship with the instructor. I used to see him during the lecture only. I began to see him and communicate more often in the center to help us understand things*".

SH added, "*The instructor started to communicate with us more often during the lecture while following up with us, as he is working hard for this experiment to succeed*".

In short, the relationship between the students and their instructor has turned into a friendship.

MGh said, *"I was happy with my instructor and our relationship has changed. We became friends, not just a student-instructor relationship*".

This strong relationship led to more student commitment to the lectures, as the instructor allocated time, space, equipment and learning resources.

AA said, *"For the instructor, we were very comfortable with him. He provided us with an equipped laboratory, AR/VR headsets and learning resources."*

3.2.3.2Usability (Ease of Use)

The students described the AR-EON platform as an easy one. It supports Arabic language as well. Any student with basic IT skills can use it without the need for advanced skills.

TS said, *"It was not difficult and didn't need high experience. Nowadays, it's all on mobiles, and everyone knows how to use Google and YouTube*."

Even though, students might require some initial training to get acquainted with the platform and use the available ready-made AR/VR models. Moreover, it is suitable for all ages and disciplines.

Where RQ added, "*Anyone can use the platform because it is easy. With some short training, students will be able to use it without the need for a specialized course*".

AA added, "*The platform is suitable for all disciplines and all ages".*

3.2.3.3Deep Understanding

The students described Telecom engineering and its courses such as microwave engineering and digital communication as applied courses and require some imagination skills. They include concepts that can be forgotten quickly, but after using AR in practice, such concepts became easy to memorize and understand.

AGh said, *"We started to understand the concepts more because our major is all about imagination. Even the term 'imagine' has been mentioned in almost every single lecture"*

AA added, "W*e became more familiar with the new concepts and understand them in physical sense based on AR and 3D visualization."*

Moreover, ES added, "*I used to enroll such university courses and understand them, but after a while, I forget most of the concepts, especially in complicated topics. With the new approach, such concepts started to grave into our memories and catch our attention."*

She said, *"When the instructor explained the concept of towers, we did not deal with them in practice. When we developed a 3D model for towers using an oculus, we navigated into the tower and its components and how it operates. This was immersed in my mind and it would be impossible to forget this concept".*

The interviewees mentioned that the new concepts became easier to understand when they design the lessons themselves in a practical way and their responsibility and challenge to accomplish their assignments.

TS confirmed, "*It will be better consolidated in mind when I design a system and develop it with its components. In the traditional approach, after we finish a course, we might miss what we learned, but with AR and deep understanding, we never forget it. The instructor assigned us tasks, and we accepted the challenge"*.

This experience has affected students' understanding of the different system components, including installation and uninstallation, especially that digital communication courses cover a wide range of concepts and systems containing a lot of components.

ZH said, "*We benefited a lot, when we become able to look inside the components, identify, separate, and insert them into a system, and adding audio/video to explain and learn it easily. It became easy for the teacher to communicate the idea to us. Instead of an image, we deal with a 3D model, move, rotate and identify its operation principle".*

ASadded,*"for instance, I've never seen the inertia model described by the instructor as a black box that I was not able to imagine it. After dealing with this model, I became familiar with this box as described by my instructor that I'll never forget".*

In addition, with AR, the students can deal with a device and its components without any harm or damage, and help them to deal with them in the future in the real world.

ZH said, *"Instead of climbing a tower, we can deal with it virtually to keep safe from risks and harmful effects on our health or life".*

MA added, *"Instead of being shocked when we deal with objects in the real world at the workplace, we deal with them virtually to be more familiar. For example, transformers are very large electrical devices, and their cooling depends on the oil that needs to be changes periodically. So, we can do that virtually for self-training before we go to the field".*

3.2.3.4Interest and Enjoyment

The students expressed their interest in using AR in teaching and learning as a unique and new experience, where the students enjoyed while doing their assignments, as EON provides different models that could be used as the most appropriate ones in a motivating way. Moreover, students disseminated their experience to their families and colleagues and expressed their interest and passion. Some of them suggested to design models and present their graduation projects using AR/VR technologies.

RQ said, *"Frankly, I enjoyed AR technology and liked it, since it nicely motivated me to learn more and show my creativity and talent".*

SN added, "*I told my family a lot about AR and showed them pictures while using the oculus to navigate the different models, touristic and religious places. They would like to attend the lectures and try AR themselves".*

3.2.3.5 Risk, Cost and Time Reduction

One of the most important benefits of AR in education is related to time and cost reduction while practicing the practical part of a course.

SH *reported "AR based learning saves our time and money when we design a virtual model instead of using the real hardware".*

AR technology can also reduce the risk throughout their practice at workshops and other training places, such as antenna towers and electrical stations.

MH said, *"During the practice in the field such as climbing the antenna towers, it might be an unsafe environment. In our practice with AR, I was able investigate a tower closely. I grabbed the tower, gazed inside it and looked at all its components."*

In addition, TS confirmed, *"For example, when I want to change a wire on an antenna tower, I might make a mistake and get harmed. Instead, VR/AR can help repeating the operation till success before doing it actually".*

A.A added, *"The instructor taught us how to change the transformer's oil using AR, which helped us to avoid danger and risk".*

Finally, AR-based learning offers more benefits such as enhancing students' self-confidence and research skills. It positively changed their personalities and the way of dealing with their colleagues through the team work and the desire to learn emerging technologies.

ES said, *"I felt my personality changed positively, and I felt that I was doing something new".*

TS added*: "We started working in a team and my personality became stronger than before. Although I am in my fourth year, I used to attend lectures and leave".*

While looking for different models, videos, tutorials and solutions for technical problems, the students improved their research skills.

AGh said, *"I used to search for certain 3D objects and models, which enhanced my research abilities. I was trying to design a model and upload it to the portal, but the upload process failed. I contacted the company to solve this technical error, and I'm still waiting for their respond".*

3.2.4Challenges

As any other emerging technology, AR has several advantages and provides users with a lot of benefits. At the same time, it has some disadvantages and users might face some challenges. Fidan & Tuncel (2019) referred to the limitation of using AR, which includes effects on physical health and technical difficulties in the learning activities. Moreover, Delello (2014) mentioned three challenges of using VR in education: Teacher rejection, teacher time, and technology limitations. It is obvious that both studies share the sub codes generated in this research. This research generated five sub codes as will be discussed in the following subsections.

3.2.4.1 AR Technology Resistance

The main challenge that faced the students in this experiment was AR technology resistance, which is related to rejection or no acceptance of the emerging technologies.

TS said, *"Some team members did not prefer to work with AR technology. I think they will feel sorry, since we are approaching a lifetime that is full of AR and other emerging technologies".*

3.2.4.2 Lack of Relevant Models

The students need AR models that are relevant to their specialization, and it was difficult to find appropriate models.

AA said, "*Many models are not designed for our specialization or, sometimes, do not exist".*

For the above reason, students had to pay for the required models or to design them using appropriate applications.

ES said, *"It was so difficult to find suitable 3D models. Therefore, we would have to design them on Solid Works or AutoCAD. Unfortunately, we do not have any experience with neither software, and would have to get some training on them".*

3.2.4.3 Technical Issues

The students encountered some technical obstacles in file patching or in the design process itself, such as identifying the model's parts. This prompted them to contact technical support, which needs three working days to respond.

RQ said, *"For example, in the digital communication project, we could not disassemble the 3D model into its components and could not label them. We also struggled during the microwave engineering project in the 3D model recording and saving".*

AGh added*, "At first, we faced some problems in downloading files that took two days to be solved. Some technical issues required me to contact the institution, which responded after three working days".*

3.2.4.4 Time Issues

Another challenge was the short time allocated for students to perform their assignments, as they need a lot of time to search for appropriate models and prepare the necessary educational resources.

AA said, *"The problem was the short time required to conduct activities".* MH disagreed by saying, *"The time for each project was convenient, but I was overload with other courses. In general, I was able to submit all projects on time".*

TS added, *"The tasks require time to look for a free model, because we still do not have the skills to design new models".*

3.2.4.5 Negative Health Effects

Some of the other obstacles were related to negative health effects, which included stress and bad effects on the eyes, vision fatigues and body imbalance when wearing the oculus and immersed within the AR/VR environment.

SH said, *"I should be able to balance, because I was dizzy and felt body imbalance when I immersed within the VR environment".*

TS agreed with her saying, *"Wearing oculus headset for a while will eventually affect my vision. I was dizzy wearing it for 6-7minutes".*

3.2.5 Hope for the Future

This theme is related to students' future expectations and desires after the new experience using AR/VR in education. Hope for the future can play a major role in improving resilience and social wellbeing. Hope is described as a cornerstone in coping, overcoming distress, and living under unusual and painful life experiences (Mahamid, 2020). The thematic coding yielded four subthemes, developing ideas, identifying career path, spotting opportunities, and tracking learning.

3.2.5.1 Developing Ideas

VR/AR technologies can be employed in marketing and developing business ideas or project proposals.

AA said, *"AR can be used to present ideas effectively, I can develop a 3D model for an idea that illustrates the main concept. This helps to market your ideas and yourself in the field of work".*

AR-based learning experience can be transferred to schools as a new idea. In the future, it would be possible to provide students and teachers with suitable training to apply it at schools.

AGh said, *"We present the idea and provide the school teachers with training of trainers (ToT) program who transfer the training to the students. We can help teachers to develop lessons with AR-3D models to be delivered to their students".*

More ideas were generated to present the university's programs and activities using AR technology.

TS added, *"The Public Relations departments can use this application to design announcements and introductory models about the universities and their academic programs for new students".*

3.2.5.2 Identifying Career Path

AR technology opened new career paths and job opportunities, and students can add this experience to their CVs. It will be the future profession, and the students should be encouraged with some kind of incentives for training of others.

AA said, *"AR technology and Metaverse experience can enrich students' CVs"*.

In addition, it opens new job opportunities for 3D model designers to design more models for selling via the Internet".

MH said, *"You can design specific 3D models and publish them on the Internet to be sold"*.

MH supported him by saying, *"For example, the EON-XR sometimes lack to 3D models in the application library. This case, one should design them from scratch, using Sketch Up or Solid Works, as an additional source of income"*.

3.2.5.3 Spotting Opportunities

It can be described as using imagination and abilities to identify opportunities for creating a value (Bacigalupo et al., 2016). In the nearest future, modern technologies, such as XR, will spot new business or investment opportunities.

TS said, *"It is possible to become a full-fledged virtual company that operates online without having any headquarters, with employees who also work online"*.

On the other hand, University administration supports and motivates their students.

TS said, "*The University encourages the students to enroll in a training course, and rewards them by granting a portion of their installment. This is a student's right as long as he provides a lot of useful resources"*.

Moreover, TS suggested, *"We should benefit from the students' output by organizing exhibitions to present their projects and disseminate ideas that open new job opportunities in the future"*.

TS spotted another opportunity when she said, *"This new technology can be used in marketing for the university and its various academic programs"*.

3.2.5.4 Tracking Students' Learning

The use of AR/VR in education can positively affect the students' learning methods, as it transforms learning into a vibrant, motivating and enjoyable process, especially for school students to understand difficult topics.

RKh said, *"Some lectures are usually boring, but with EON you can zoom in and zoom out 3D models and explain complicated topics in a couple of words in nice and understandable way".*

MGh added, "*Younger students at schools will enjoy AR-based learning with excitement and enthusiasm. This enables them to use AR effectively to learn more complex topics later when they enroll universities".*

3.2.6 Reflections

Reflection can be defined as giving the students an opportunity to do self-evaluation and debriefing at the end of a lesson or evaluation of a technology (Zimlich, 2015). At this point, students should set some of their own goals, monitor their progress, show evidences of what they have learned and share it with others (Cavilla, 2017). This code focuses on the students' reflections regarding the use of AR in learning during the courses.

The students were asked the following questions to reflect on their experience after completion of the AR-based classes:

1. After completing the assignments of this course, what did you learn in terms of concepts and skills?
2. How do you think VR/AR may help you understand the concepts of this course?
3. What is the difference between the design of this course and those of previous courses?
4. What are the similarities and differences between this course and other courses?
5. What are the obstacles that you encountered while performing the course activities?
6. What can be added to improve the course using augmented reality?

Results show that the students' experience in AR-based learning was reflected positively on their learning progress. Their imagination skills were improved when they manipulated the 3D models for new concepts. This enabled them to employ visualization, drawing and design of new models to view them clearly in details, which led to effective acquisition of new concepts and improved their knowledge.

AA said, "*Engineering requires some imagination skills. The instructor used to show us some systems in the surrounding environment such as the communication towers on the* *mountains that we could not see very well. With AR, we can see these towers closely in details and the instructor can explain better, so we generated some new ideas that have been in our minds before."*

Moreover, compared with individual work, which is described as boring, team work encouraged the students to exchange knowledge and engage into new experiences that enhanced social networking.

AGh said, *"Individual work was boring, while team work encouraged us to try other models that are not assigned to our lesson. For example, we tried a plane model and enjoyed it. The spirit of a team is very important, since team members can warn you when you get out or mess up an object".*

The instructor used to present an idea at the beginning to choose between the AR or the traditional method, and he had a great role in increasing the students' desire to learn, being cooperative and providing them with their requirements including learning resources and a training lab. Moreover, the students enjoyed the new method being different and comforting.

MGh said, *"The instructor offered two options, the new method with VR, or the traditional method. Frankly speaking, according to what I saw, those who chose VR were more relaxed and comfortable than those who used the traditional method".*

However, the students faced some obstacles due to lack of previous experiences and time limitations, which reflected negatively in terms of increasing pressure, and positively in terms of achievement. At first, they thought that the AR-based method is boring, but after getting acquainted with the program, they realized its importance in both the course and the daily life.

AA said, *"The main obstacle we faced was that we never dealt with VR/AR before and required to do many activities within a short time. Although I was in stress during the course, the positive point was the new achievement".*

Furthermore, students should have some necessary skills, such as design, presentation, research, persuasion, and imagination skills. This facilitates how the students present their ideas, and can be easily acquired easily throughout the training sessions.

AGh said, *"Of course, imagination, recitation and idea delivery are the most important skills, i.e., how the student arranges his speech and presentation, since not all of us have the same design skills. I took on the role of a teacher who wants to present a lesson efficiently".*

MGh added, "*The design skills are easy to learn and be acquired, especially that YouTube or any other platform offer several tutorials".*

Training at an earlier age at schools is more interesting and useful, since they have a plenty of time to understand the basics, which reflects positively at a university stage in more complex topics.

MGh said, *"Younger students at schools will enjoy it and will be more excited with VR/AR when they have a plenty of time for training".*

Also, students depend on the internet to prepare their research projects and unnecessarily understand them in a boring manner. On the contrast, when they XR-EON, the process will be more enjoyable, since the student controls the presentation and explains his idea shortly.

ES said, *"All our projects are based on research and presentation. For example, in a physiology project, I used to copy and paste to prepare the article, and summarize it in simple words during the presentation in a boring manner. It will be better to use XR-EON to present my idea nicely with a couple of words".*

The students indicated the importance of VR/AR technology in the future's job opportunities and career path development. MGh said, *"I think, within the next 20 years, the whole world will switch into VR with more job opportunities".*

A.A added, *"The EON-XR library provides a limited number of 3D models, but more don't exist. You may have to design your own models from the scratch using SketchUp or Solid Works to be sold as a new career path and a new source of income".*

3.2.7 Attitudes

Attitudes towards a behavior refer to the individual's positive or negative evaluation of a behavior (Patricia Aguilera-Hermida, 2020). It can be seen as environmental education, cultural awareness, curiosity, seeking learning opportunities, work with technology experts and trying new technologies (Sahin & Yilmaz, 2020; Zimlich, 2015).

The AR intervention was attractive that made it easier to learn and memorize, as the instructor used to show students a set of videos and simulations, making it easier for him to explain the lesson and easier for the students to understand. It also led to increasing students' desire to design 3D models that are not available on the Internet free of charge.

AGh said: *"When we develop a lesson in details and answer its questions, the instructor will not pay big efforts to explain it and we will understand it easily".*

ES added, *"It was very nice, and I really like to design my models, since they are not available on the Internet, or need to pay for them".*

Unlike the traditional methods, students feel that they were actually living the experience, and the training increased their challenge and willingness to study.

MGh said, *"Unlike other courses, I started to learn more and to gain more knowledge".*

Moreover, the common interest among the students increased, which helped to strengthen their interrelationship. In addition, the relationship with the instructor transformed into a friendship as he cooperated with the students.

MGh said, *"When I learned how to use the EON platform with the oculus, my colleagues asked me for help. Therefore, I got to know students with common interests, which strengthened our relationship".*

He added, *"At first, our instructor seemed like any other instructor. But when we worked closely on AR/VR, I got to know him more and built a better relationship. Now, I can see him as a friend".*

This experiment helped some students to devote the new concepts in a way they will never forget, because they designed their models in details. At the beginning, some students doubt they will benefit from the training, but they realized its importance and advantages, which enhanced their positive attitudes towards learning.

MGh said, *"Frankly speaking, I benefited from this experiment within this course. When I performed the course work with AR/VR and the hand-on training, I will never forget what I have learned. I encourage other instructors and students to use AR/VR in their courses"*.

A.A added, "*We learned many things and we are more excited to get a training course on using Metaverse in teaching and learning"*.

Chapter Four

Discussion and Conclusion

In this research, the researcher used a mixed-method research design, which aims at revealing the efficacy of using AR technology in learners' motivation and reflective thinking. The researcher used quantitative method based on ARCS-V motivation scale and reflective thinking scale among university students. The reliability for the scales, the values of Cronbach's alpha are .901 for ARCS-V scale and .749 for reflective thinking scale, which are suitable for the research purposes. Moreover, she used qualitative method based on semi-structured interviews that were conducted with students from the experimental group. In the previous chapter, the researcher presented the results of both quantitative and qualitative methods. In order to answer the research questions, the researcher benefited from both quantitative and qualitative analysis of the sample's responses who enrolled two AR-based courses in telecom engineering at An-Najah National University; Microwave Engineering and Digital Communication. In Microwave Engineering, all students have been selected as experiment group, while students of Digital Communication were divided into experiment and control groups. This chapter goes through discussion of the obtained results in section 4.1 and conclusion and future work in section 4.2.

4.1 Discussion

This discussion starts with a summary of the research findings. Referring to the efficacy of AR-based teaching on motivation of the experimental group, results show statically significant differences in Attention, Relevance, Confidence, Satisfaction, and Volition dimensions for the Microwave Engineering course. On contrast, there were no significant differences in motivation pre-test and post-test mean ranks due to gender. In addition, results show statically significant differences in all dimensions of reflective thinking that include Habitual Action, Understanding, and Critical Reflection except Reflection. As for the differences in gender, the matter is similar to the motivation, where there were no significant differences in the reflective thinking pre-test and post-test mean ranks due gender.

As for Digital Communication course, results show significant differences between experimental and control groups on the motivation dimensions in favor of the experimental group except for the Confidence dimension. In contrast, results show no significant differences due to gender, pre-test and interaction between group and gender on the motivation dimensions except for Volition. As for the reflective thinking scale there were significant differences between experimental and control groups on all dimensions in favor of the experimental group except for Reflection. In contrast, results show no significant differences due to gender, pre-test and interaction between group and gender on Reflective thinking dimensions. In addition, the researcher found a significant positive correlation between motivation and reflective thinking and significant differences on the students' achievement scores between experimental and control groups.

In summary, the findings revealed a contribution of AR-based learning to improve all dimensions of student motivation (Attention, Relevance, Confidence, Satisfaction, and Volition) for microwave engineering course, which matches the findings of some previous studies (Bacca, Baldiris, Fabregat, & Graf, 2014; Badilla-Quintana et al., 2020; Cabero-Almenara & Roig-Vila, 2019; Clarke, 2008; Di Serio et al., 2013; Ibáñez et al., 2020; Khan et al., 2019). The researcher justifies the contribution of instructional design using AR in developing learners' motivation that the learner's motivation develops when his curiosity is aroused, when the learning is meaningful to him and related to his goals, when he has confidence in his ability to succeed in learning tasks, and when he obtains results that bring him satisfaction with what he has learned. This means taking action to achieve his learning goals, endeavoring to achieve his plans. So, the learners raise their motivation towards the learning material, the various learning activities, the use of animation and videos, recording their voice to explain a lesson, searching for suitable model or design of a model from scratch, illustrations and examples linking the content to the learner's field of work and study, simplifying concepts, providing practical exercises and final projects to prepare his future career. AR-based learning assists learners in communication with other learners through team work, and provides appropriate feedback to the learners' need and achievement. Moreover, sharing the AR projects via EON-XR platform, exchange of experience and discussion among students and instructor, and time/place flexibility, all have a potential impact on the development of learners' motivation.

Similarly, in digital communication course the experiments results showed that AR-based learning activities affect motivation dimensions except confidence, such as attention, relevance, satisfaction, and volition. This is because learners should build confidence by feeling control and expectancy for success. For instance, unconfident people fear of anything new, and they are worried about failure. In this case, it will be the teacher's responsibility to support students' self-confidence, show them different examples, and re-design the course or tasks if they are not comfortable for them (Keller, 1987). Results suggest that AR technology does not foster better levels of confidence than control group. Therefore, further research is necessary to identify the students' feel in control while using AR in learning and to measure their perceptions toward success in performing AR-based learning activities. This helps to overcome this obstacle and achieve better level of confidence. Our results match Khan's regarding motivation in both attention and satisfaction dimensions, but contravene with relevance and confidence dimensions (Khan et al., 2019).

In addition, results indicate no significant differences due to gender on the motivation for both courses using AR technology. This result is considered logical, since the students are among the digital generation who live in the similar circumstances, and they are supposed to be digitally literate with similar ICT skills, indicating a narrowing of the gender digital gap as some studies suggest (Korlat et al., 2021). Other studies indicated enhanced learning motivation in digital contexts, which made the content meaningful and relevant for both genders.

In general, our results agree with Moreno-Guerrero et al. (2020) results which indicated that all of the motivation dimensions had a very high significant relationship. They concluded that AR was effective in teaching high school students in physical education, especially for the acquisition of spatial-oriented content.

In addition, AR-based educational methods take into account the individual differences among the students, and thus increases the students' self-confidence as each student proceeds in the educational process according to his ability, desire and speed. Therefore, students could learn without fear, which positively affects the development of motivation among them.

Furthermore, results show that AR methods simplifies the complicated and abstract concepts, which has an impact on motivation. This can be attributed to the diversity of activities and teaching methods, since the difficulty of the topics assigned to the students reduces his motivation, as stated by Alhanai & Almanthari (2019). This result can also be justified by the fact that AR-based methods improve the student's engagement into the lessons and increase their educational interaction that allow better understanding. This agrees with Ivanova & Ivanov (2011) who reported a positive impact of AR technology on the development of students' motivation.

As for the result showing significant differences in achievement between the experimental and the control groups, it is consistent with other relevant research such as Badilla-Quintana et al. (2020), Ibáñez et al. (2020), Sahin & Yilmaz (2020) and Ziden et al. (2022). This includes different aspects, such as the increased student engagement and enjoyment (Cen et al., 2017; Ozdamli & Hursen, 2017), the increased student interaction (Safar et al., 2017a), interest (Medina Herrera et al., 2019) and fun learning (Chang & Hwang, 2018), which all improve students motivation.

According to the research findings, AR applications and activities developed for the digital communication course were extremely enjoyable, motivating, and intriguing to affect student success. In addition, a positive correlation of 0.619 was found between motivation and reflective thinking, which agrees with previous studies like (Cavilla, 2017; Nur'Azizah et al., 2021) quantitative research with a correlation coefficient of 0.931. This result indicates evidence of a strong relationship between the research variables of our research. It supports the researcher's suggestion that reflective thinking assists students to reflect on their practices, activities and lessons that improves students' self-efficacy and motivation. This result matches (Phan, 2009), which can be attributed to the fact that the learning outcomes are reflections of students' abilities, such as cognitive abilities which cover six domains: knowledge; understanding; application; analysis; synthesis; and evaluation. Moreover, reflection helps the alumni to focus being motivated to continue innovation while identifying their career path. Clarke (2008) reported that reflective thinking model represents an excellent reflection tool to detect improvement opportunities and an effective method to learn from others' experience.

Our findings show that the experimental groups' reflective thinking supplemented with AR applications are significantly higher in dimensions such as Habitual Action, Understanding and Critical Reflection in the digital communication course. The researcher explained this result that a student begins to design an AR model many times and to solve the related activity without difficulty (i.e., a habitual action activity). This lets him understand the concept in a better way (i.e., understanding activity), think about his work (i.e., a reflection activity) and then try to make work better in a different way in the second time (i.e., critical thinking activity). Our results in this regard conform with (Chang, 2019; Ozdamli & Hursen, 2017), which point to positive views toward AR applications in education, where the AR group achieved higher scores.

Our findings show that the reflection dimension was not significant, since reflection appears on exploring an action reasons or assumptions that usually occur but rarely are observed (Kember et al., 2000). In addition, reflection may affect students' affective levels rather than cognitive levels. In order to improve the students' reflection, the researchers suggest that students should be provided with training on writing reflections. Moreover, reflection should be implemented in a structured and intentional manner throughout the students' academic career to improve their academic performance (Cavilla, 2017). In this research, the experimental groups' reflective thinking supplemented with AR was significantly higher than the control one's. Even though, both groups' skills increased since both implemented reflective learning activities, but still AR-based learning have more significant impact on reflective thinking. (Tok, 2008)supports our findings that reflective thinking has a positive impact on the students' performance.

Reflective thinking can contribute to motivation by helping individuals better understand their own thoughts, feelings, and behaviors. When we reflect on our experiences, we are able to identify patterns and insights that can inform our future actions and decision-making. This increased self-awareness can also help individuals set more meaningful goals, as they are better able to align their aspirations with their values and interests.

Furthermore, reflective thinking can help individuals build resilience and perseverance in the face of challenges. By examining setbacks and failures in a constructive manner, individuals can identify the underlying causes and develop strategies to address them.

This can lead to a greater sense of control and agency over one's life, which in turn can foster a stronger sense of motivation and commitment to achieving one's goals. Overall, reflective thinking can serve as a powerful tool for self-improvement and personal growth, and can help individuals cultivate a more positive and motivated outlook on life.

The discussion above relates to the quantitative approach. This point forward provides discussion of the qualitative approach, mainly the interviews. Our findings revealed seven themes in the codebook: Prior Experience, Initial Impression, Benefits, Challenges, Attitudes, Hope for the Future, and Reflection. Some codes have two or more subthemes. Benefits yielded Deep Understanding, Interest and Enjoyment, Building Student-Instructor Relationship, Usability and Risk, Cost and Time Reduction. Challenges yielded AR Technology Resistance, Lack of Relevant Models, Technical Issues, Time Issues, and Negative Health Effects. Hope for the Future yielded Developing Ideas, Identifying Career Path, Spotting Opportunities, and Tracking Learning.

The above themes agree with either themes or subthemes of the previous studies. For instance, Ozdamli & Hursen (2017) reveled advantages theme that includes subthemes like Enhanced enjoyment, Increased interest, and Help to understand. Moreover, Karagozlu (2021) proposed codes such as easing understanding, getting excited, being happy, making the lesson fun, and permanence of what is learnt. More similar themes include feeling interested and motivated, wasting time (Medina Herrera et al., 2019), ease learning process, increase interest, interactive, assist visualization task, increase concept (Omar et al., 2019). In addition, Motivation and engagement and Teacher acceptance themes were suggested (Delello, 2014), as well as opportunity for collaborative communication and problem-solving among students (Kamarainen et al., 2013). These themes and/or subthemes match with themes/subthemes of our codebook such as benefits, hope for the future and challenge.

Our codes and evidence segments quoted from the sample students in both Microwave Engineering and Digital communication courses revealed that the AR videos through EON-XR platform assisted to explain the complex concepts being taught. The AR features increased students' motivation to memorize these concepts as well. Furthermore, design of AR models enabled students to align the lessons learnt with their life skills, and the related activities were useful in engaging students and asking more questions. These activities were more student-driven and less teacher-directed, which enhanced their learning, and therefore, performed better on their assignments and exams.

4.2 Limitations

This research has some limitations that should be addressed later in the future research. The sample size is relatively small. In addition, the experiment focused on one course in telecommunication engineering and needs to be implemented on other subject areas. In addition, practicing the AR-based learning was based on one 16-weeks semester, which is too short to get results that could be generalized. Moreover, AR applications and models require considerable resources and special training for students that is insufficient within one semester. As for the research instruments based on (ARCS-V) motivation and reflective thinking scales, they need to be tested more frequently in the Palestinian education context on AR-based courses. Furthermore, the novelty of the Augmented and Virtual Reality Center at An-Najah National University, where AR is employed in teaching and learning for the first time in the semester of our experiment. Accordingly, the participants expressed that the implementation of AR needs experience, training and evaluation for the next experiments.

4.3Conclusion

This research adds a new contribution to the field of teaching and learning. It investigates two important factors that affect students’ learning and instructors’ teaching methods, motivation and reflective thinking, while implementing a new experience in education with an emerging technology for both students and instructors. This technology shapes the future of several aspects of the met averse, namely in education, which is Augmented Reality (AR). It is a comprehensive study that uses the ARCS-V model, which added volition variable to the ARCS model. This section provides a summary of our main conclusions after an intensive work with students and instructors practicing AR via EON-XR platform in learning and teaching two telecommunication engineering courses at An-Najah National University.

This research approved that AR-based learning contributes to improve students’ motivation, since it assists learners to communicate with each other effectively. It enables learners to develop their motivation via appropriate feedback, sharing AR projects, exchange of experience, time/place flexibility, and discussion among students and their instructor. The AR-based methods improve engagement into the lessons and increase their educational interaction for better understanding. Furthermore, AR applications and activities make learning extremely enjoyable, motivating, and interest to affect student success. In addition, AR-based educational methods consider the individual differences among the students, where each student learns without fear according to his ability, desire and speed. Moreover, AR lessons assist instructors to explain the complex concepts being taught and enable students to memorize them. Design of AR models and related student-driven activities enhance students' learning and engagement and therefore, perform better on their assignments and exams. They acquire more skills that enable them to align what they have learnt with life skills.

4.4 Recommendations

Since AR is an emerging technology, the Palestinian education system could benefit from its advantages by integrating AR into the learning process in the Palestinian schools and universities. Accordingly, the researcher suggests that the curricula in the Palestinian HEIs should be supported with AR in science, technology and engineering courses in the first phase, as these courses are plentiful with complex concepts that require imagination skills. In the next phases, this experience can be transferred gradually to other courses in different disciplines.

In order to succeed in this initiative, essential training programs should be developed and delivered for teachers and supervisors to design their courses and lessons based on both AR and VR applications. Also, it is suggested that teachers optimize the existing features according to the available ICT infrastructure to better facilitate students learning. Moreover, networking with peer institutions in other countries is necessary to work on joint projects that provide the necessary equipment and requirements to implement this technology, like applications, technical equipment, tutorials and training and exchange of experience and best practices. This initiative should be lead with developing educational policies and strategies towards integrating AR into education. This will raise the opportunities for students to be highly motivated and weaponed with reflective thinking skills in their learning and lifelong practices.

As the results show, AR technology does not foster better levels of confidence. Therefore, further research will be conducted to identify the students' feel in control while using AR in learning and to measure their perceptions toward success in performing AR-based learning activities. This helps to achieve better level of confidence. Moreover, some previous studies show that enhancing motivation in the digital context makes the content meaningful and relevant. So, further research will be done to investigate the importance of interaction with AR in learning different disciplines.

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Appendices

Appendix A: ARCS-V Scale (Original Version in English)

1. When I first looked at this lesson, I had the impression that it would beeasy for me.
2. There was something interesting at the beginning of this lesson that got my attention.
3. This material was more difficult to understand than I would like for it to be.
4. After reading the introductory information, I felt confident that I knew what I was supposed to learn from this lesson.
5. Completing the exercises in this lesson gave me a satisfying feeling of accomplishment.
6. It is clear to me how the content of this material is related to things I already know.
7. Many of the pages had so much information that it was hard to pick out and remember the important points.
8. These materials are eye-catching.
9. There were stories, pictures, or examples that showed me how this material could be important to some people.
10. Completing this lesson successfully was important to me.
11. The quality of the writing helped to hold my attention.
12. This lesson is so abstract that it was hard to keep my attention on it.
13. As I worked on this lesson, I was confident that I could learn the content.
14. I enjoyed this lesson so much that I would like to know more about this topic.
15. The pages of this lesson look dry and unappealing.
16. The content of this material is relevant to my interests.
17. The way the information is arranged on the pages helped keep my attention.
18. There are explanations or examples of how people use the knowledge in this lesson.
19. The exercises in this lesson were too difficult.
20. This lesson has things that stimulated my curiosity.
21. I really enjoyed studying this lesson.
22. The amount of repetition in this lesson caused me to get bored sometimes.
23. The content and style of writing in this lesson convey the impression that its content is worth knowing.
24. I learned some things that were surprising or unexpected.
25. After working on this lesson for awhile, I was confident that I would beable to pass a test on it.
26. This lesson was not relevant to my needs because I already knew most of it.
27. The wording of feedback after the exercises, or of other comments in this lesson, helped me feel rewarded for my effort.

28. The variety of reading passages, exercises, illustrations, etc., helped keep my attention on the lesson.
29. The style of writing is boring.
30. I could relate the content of this lesson to things I have seen, done, or thought about in my own life.
31. There are so many words on each page that it is irritating.
32. It felt good to successfully complete this lesson.
33. The content of this lesson will be useful to me.
34. I could not really understand quite a bit of the material in this lesson.
35. The good organization of the content helped me be confident that I would learn this material.
36. It was a pleasure to work on such a well-designed lesson.
37. My commitment to achieve the goals in this class was strong relative to the goals in my other classes.
38. I set up goals for my learning.
39. I was confident that I could avoid obstacles while doing my work.
40. I was prepared to work hard to achieve my goals no matter what my other classes required.
41. I was able to prepare a study plan that listed concrete tasks.
42. I kept my feelings under control while working to complete this class.
43. I added more effort to stay on task if my focus on my goal in this class began to decline.
44. I was able to avoid being distracted by competing goals.
45. I was able to create a setting free of uncontrollable distractions.
46. I was able to know when to stop looking for more information to prepare for an exam.
47. I didn’t let social pressure affect my performance.
48. I anticipated personal or social events that might cause me to get behind.
49. When my motivation decreased, I was able to think of things to do to build it back up again.

Appendix B: Reflective Thinking Scale (Original Version in English)

Habitual Action

1. When I am working on some activities, I can do them without thinking about what I am doing.
2. In this course we do things so many times that I started doing them without thinking about it
3. As long as I can remember handout material for examinations, I do not have to think too much.
4. If I follow what the lecturer says, I do not have to think too much on this course.

Understanding

1. This course requires us to understand concepts taught by the lecturer.
2. To pass this course you need to understand the content.
3. I need to understand the material taught by the teacher in order to perform practical tasks.
4. In this course you have to continually think about the material you are being taught.

Reflection

1. I sometimes question the way others do something and try to think of a better way.
2. I like to think over what I have been doing and consider alternative ways of doing it.
3. I often reflect on my actions to see whether I could have improved on what I did.
4. I often re-appraise e my experience e so I can learn from it and improve for my next performance

Critical Reflection

1. As a result of this course, I have changed the way I look at myself.
2. This course has challenged some of my firmly held ideas.
3. As a result of this course, I have changed my normal way of doing things.
4. During this course, I discovered faults in what I had previously believed to be right.

Appendix C: Motivation Scale (Initial Version in Arabic)

النسخة الأولية لمقياس الدافعية

عزيزي/تي المشارك/ة:

تحية طيبة وبعد،

تقوم الباحثة ببحث بعنوان: "فاعلية دمج الواقع المعزز في التعليم في الدافعية والتفكير التأملي للتعلم لدى الطلبة الجامعيين"،الرجاء قراءة فقرات الاستبانة بشكل جيد، ثم الإجابة عن الفقرات بشكل موضوعي وبشفافية عالية، علما بأن بيانات هذه الاستبانة مخصصة للبحث العلمي، وسيتم التعامل مع البيانات لأغراض البحث العلمي فقط، لن يستغرق منكم تعبئة الاستبانة أكثر من عشر دقائق.

وتقبلوا فائق الاحترام والتقدير،

الباحثة

أولاً: البيانات الديمغرافية

يرجى وضع دائرة حول الخيار المناسب في الفقرات الآتية:

1. **الجنس:**

أ. ذكر ب. أنثى

2. **الكلية:**

أ. كلية إنسانية ب. كلية علمية

3. **السنة الجامعية:**

أ. أولى ب. ثانية ج. ثالثة د. رابعة هـ. أكثر من 4 سنوات

ثانياً: المجالات

يرجى اختيار الاستجابة المناسبة على الفقرات الآتية التي تتعلق بتصرفاتك وفهمك وتأملاتك في المساق[1].

الرقم	البنود	بدرجة كبيرة جدا	بدرجة كبيرة	بدرجة متوسطة	بدرجة قليلة	بدرجة قليلة جدا
.1	تكون لدي انطباع أولي بأن المساق سيكون سهلاً.					
.2	هناك شيء أثار اهتمامي في بداية المساق.					
.3	هذه المادة أصعب في الفهم مما كنت أعتقد.					

[1] أي مساق التحقت في هذا الفصل.

.4	بعد قراءة مقدمة المساق، شعرت بثقة بأنني أعرف ما المفترض أن أتعلمه في هذا المساق.					
.5	يمنحني حل تمارين المساق شعورًا مرضيًا بالإنجاز.					
.6	يرتبط محتوى المساق بمعارفي الحالية.					
.7	تحتوي صفحات المساق على معلومات كثيرة يصعب تذكر النقاط المهمة من بينها.					
.8	تثير المادة التعليمية للمساق انتباهي.					
.9	تظهر امثلة المساق بأنه قد تكون مهمة.					
.10	يهمني إكمال المساق بنجاح.					
.11	تساعد جودة كتابة المحتوى في جذب انتباهي.					
.12	يصعب التركيز بشكل متواصل في المساق كونه نظريا.					
.13	أثق بقدرتي على تعلم محتوى المساق إذا قمت بتنفيذ مهماتي.					
.14	أستمتع بالمساق لدرجة زيادة رغبتي بمعرفة المزيد حول المواضيع المطروحة.					
.15	تبدو لي صفحات المساق غير جذابة.					
.16	يرتبط محتوى المساق بمجال اهتمامي.					
.17	تساعدني طريقة عرض المعلومات على صفحات الكتاب على البقاء منتبها.					
.18	يتضمن المساق توضيحات لكيفية توظيف المعلومات.					
.19	يصعب عليّ حل التمارين التي يتضمنها هذا المساق.					
.20	تثير مواضيع المساق فضولي.					
.21	أستمتع بدراسة المساق.					
.22	يصيبني الملل من تكرار موضوعات المساق.					
.23	يزيد أسلوب كتابة محتوى المساق من قناعتي بأنه يستحق الدراسة.					
.24	أتعلم في المساق موضوعات مدهشة غير متوقعة.					
.25	أثق بقدرتي على اجتياز اختبارات هذا المساق بعد دراسته.					
.26	لم يكن المساق وثيق الصلة باحتياجاتي لأنني أعرف معظمه مسبقاً.					
.27	تساعدني التغذية الراجعةبعد حل التمارين على تعزيز الشعور بتقدير الجهود التي أبذلها.					
.28	يساعدني تنوع موضوعات المساق على البقاء منتبها.					
.29	أسلوب كتابة المساق ملل بالنسبة لي.					
.30	يمكنني ربط محتوى هذا المساق بمواقف حياتية مررت بها.					
.31	يصيبني اكتظاظ صفحات الكتاب بالانزعاج.					
.32	أشعر بالارتياح تجاه إتمام هذا المساق بنجاح.					
.33	محتوى المساق مفيد بالنسبة لي.					

					لم أتمكن من فهم معظم مادة المساق.	.34
					يساعدني التنظيم الجيد للمحتوى بالثقة بأنني سأتمكن من تعلم معظم اجزاءه.	.35
					يجبرني العمل على تنفيذ محتوى المساق كونه مصمم جيداً.	.36
					التزم بتحقيق أهداف المساق بشكل أكبر مقارنة بالمساقات الأخرى.	.37
					أضع أهدافا لتعلمي مسبقا.	.38
					أثق بقدرتي على تجاوز المعقبات أثناء القيام بعملي.	.39
					استعد للعمل بجد لتحقيق أهدافي بغض النظر عن متطلبات المساقات الأخرى.	.40
					أعد خطة دراسية تتضمن مهامًا محددة.	.41
					أسيطر على انفعالاتي اثناء إتمام متطلبات هذا المساق.	.42
					أبذل جهداً إضافياً لاستئناف مهمتي كلما قل تركيزي على هدفي في هذا المساق.	.43
					أتجنب المشتتات من خلال وضع أهداف تنافسية.	.44
					أتمكن من ضبط المشتتات غير المتوقعة.	.45
					أعرف متى اتوقف عن البحث لمزيد من المعلومات اثناء التحضير للامتحان.	.46
					لا أسمح للضغوط الاجتماعية أن تؤثر على أدائي.	.47
					أتوقع أحداثًا شخصية أو اجتماعية قد تسبب تراجعي في المساق.	.48
					أفكر بالقيام بأنشطة ترفع دافعيتي عند انخفاضها.	.49

Appendix D: Reflective Thinking Scale (Initial Version in Arabic)

النسخة الأولية لمقياس التفكير التأملي

عزيزي/تي المشارك/ة:

تحية طيبة وبعد،

تقوم الباحثة ببحث بعنوان: "فاعلية دمج الواقع المعزز في التعليم في الدافعية والتفكير التأملي للتعلم لدى الطلبة الجامعيين"،الرجاء منكم قراءة فقرات الاستبانة بشكل جيد، ثم الإجابة عن الفقرات بشكل موضوعي وبشفافية عالية، علما بأن بيانات هذا الاستبانة مخصصة للبحث العلمي، وسيتم التعامل مع البيانات لأغراض البحث العلمي فقط، لن يستغرق منكم تعبئة الاستبانة أكثر من عشر دقائق.

تقبلوا فائق الاحترام والتقدير.

الباحثة

أولاً: البيانات الديمغرافية

يرجى وضع دائرة حول الخيار المناسب في الفقرات الآتية:

1. **الجنس:** أ. ذكر ب. أنثى

2. **المجموعة:** أ. ضابطة ب. تجريبية

3. **المساق:**

أ.الاتصالات الرقمية (Digital Communication).

ب. الأمواج الدقيقة (Microwave Engineering).

4.السنة الجامعية:

أ. أولى ب. ثانية ج. ثالثة د. رابعة فأكثر

ثانياً: المجالات

يرجى اختيار الاستجابة المناسبة على الفقرات الآتية، التي تتعلق بتصرفاتك وفهمك وتأملاتك في المساق[2].

الرقم	**البنود**	**بدرجة كبيرة جدا**	**بدرجة كبيرة**	**بدرجة متوسطة**	**بدرجة قليلة**	**بدرجة قليلة جدا**
.1	أنفذ بعض الانشطة دون الحاجة الى التفكير بها.					
.2	يتطلب هذا المساق استيعاب المفاهيم التي يشرحها المحاضر.					
.3	أتساءل عن الطريقة التي ينفذ بها الآخرون أعمالهم، وأفكر بطريقة أفضل لتنفيذها.					
.4	تغيرت نظرتي إلى نفسي بعد هذا المساق.					
.5	أنفذ المهمات مرات عدة في هذه المساق، لدرجة أنني أصبحت أنفذها دون الحاجة إلى تفكير.					
.6	أحتاج إلى فهم المحتوى لاجتياز هذا المساق.					
.7	أفكر مليا بما اقوم به وبالبدائل اخرى ممكنة للقيام بها.					
.8	شكل هذا المساق تحدياً لتعديل بعض افكاري الراسخة.					
.9	طالما أنني أتذكر ملخصات مادة الامتحانات، فلا حاجة لأن أفكر بها كثيراً.					
.10	أحتاج إلى فهم المادة التي يشرحها المحاضر لتنفيذ المهمات العملية.					
.11	أتامل فيما افعل وفي امكانية تحسينه باستمرار.					
.12	كنتيجة لهذا المساق غيرت طريقة ادائي المعتادة للعديد من الاشياء.					
.13	عندما اتبع تعليمات المحاضر لا داعي للتفكير مليا بهذا المساق.					
.14	في هذا المساق، عليك أن تفكر وتتأمل المادة التي تدرسها باستمرار.					
.15	أعيد تقييم تجربتي باستمرار لأتمكن من تحسين ادائي مستقبلا.					
.16	كشفت دراستي للمساق عن اخطاء اعتقدت انها صواب.					

[2]أي مساق التحقت به في هذا الفصل.

Appendix E: Motivation Scale (Final Version in Arabic)

النسخة النهائية لمقياس الدافعية

مقياس الدافعية

عزيزي/تي المشارك/ة:

تحية طيبة وبعد،

تقوم الباحثة ببحث بعنوان: "فاعلية دمج الواقع المعزز في التعليم في الدافعية والتفكير التأملي للتعلم لدى الطلبة الجامعيين"،الرجاء قراءة فقرات الاستبانة بشكل جيد، ثم الإجابة عن الفقرات بشكل موضوعي وبشفافية عالية، علما بأن بيانات هذه الاستبانة مخصصة للبحث العلمي، وسيتم التعامل مع البيانات لأغراض البحث العلمي فقط، لن يستغرق منكم تعبئة الاستبانة أكثر من عشر دقائق.

وتقبلوا فائق الاحترام والتقدير،

الباحثة

أولاً: البيانات الديمغرافية

يرجى وضع دائرة حول الخيار المناسب في الفقرات الآتية:

1. الجنس: أ. ذكر ب. أنثى

2. المجموعة: أ. ضابطة ب. تجريبية

3. المساق:

أ.الاتصالات الرقمية (Digital Communication).

ب. الأمواج الدقيقة (Microwave Engineering).

4. السنة الجامعية:

أ.أولى ب. ثانية ج. ثالثة د. رابعة فأكثر

ثانياً: المجالات

يرجى اختيار الاستجابة المناسبة على الفقرات الآتية التي تتعلق بتصرفاتك وفهمك وتأملاتك في المساق.

الرقم	البنود	بدرجة كبيرة جدا	بدرجة كبيرة	بدرجة متوسطة	بدرجة قليلة	بدرجة قليلة جدا
.1	هناك شيء أثار اهتمامي في بداية المساق.					
.2	تثير المادة التعليمية للمساق انتباهي.					
.3	تساعد جودة كتابة المحتوى في جذب انتباهي.					

.4	يسهل التركيز بشكل متواصل في المساق كونه غير نظري.					
.5	تبدو لي صفحات المساق جذابة.					
.6	تساعدني طريقة عرض المعلومات على صفحات الكتاب على البقاء منتبها.					
.7	تثير مواضيع المساق فضولي.					
.8	لا يصيبني الملل من تكرار موضوعات المساق.					
.9	أتعلم في المساق موضوعات مدهشة غير متوقعة.					
.10	يساعدني تنوع موضوعات المساق على البقاء منتبها.					
.11	أسلوب كتابة المساق ممتع بالنسبة لي.					
.12	أشعر بالارتياح لتوزيع المحتوى على صفحات الكتاب.					
.13	يرتبط محتوى المساق بمعارفي الحالية.					
.14	تظهر امثلة المساق بأنه قد تكون مهمة.					
.15	يهمني إكمال المساق بنجاح.					
.16	يرتبط محتوى المساق بمجال اهتمامي.					
.17	يتضمن المساق شروحات توضيحية لتوظيف المعلومات.					
.18	يزيد أسلوب كتابة محتوى المساق من قناعتي بأنه يستحق الدراسة.					
.19	المساق وثيق الصلة باحتياجاتي لأنني لم أدرس معظم مواضيعه مسبقاً.					
.20	يمكنني ربط محتوى هذا المساق بمواقف حياتية مررت بها.					
.21	محتوى المساق مفيد بالنسبة لي.					
.22	تكون لدي انطباع أولي بأن المساق سيكون سهلاً.					
.23	هذه المادة أسهل في الفهم مما توقعت.					
.24	بعد قراءة مقدمة المساق، شعرت بثقة بأنني أعرف ما المفترض أن أتعلمه في هذا المساق.					
.25	تحتوي صفحات المساق على معلومات قليلة تساعد على تذكر النقاط المهمة.					
.26	أثق بقدرتي على تعلم محتوى المساق إذا قمت بتنفيذ مهماتي.					
.27	يسهل عليّ حل التمارين التي يتضمنها هذا المساق.					
.28	أثق بقدرتي على اجتياز اختبارات هذا المساق بعد دراسته.					
.29	تمكنت من فهم معظم مادة المساق.					
.30	يساعدني التنظيم الجيد للمحتوى بالثقة بأنني سأتمكن من تعلم معظم اجزاءه.					
.31	يمنحني حل تمارين المساق شعورًا مرضيًا بالإنجاز.					

.32	أستمتع بالمساق لدرجة زيادة رغبتي بمعرفة المزيد حول المواضيع المطروحة.					
.33	أستمتع بدراسة المساق.					
.34	تساعدني التغذية الراجعة بعد حل التمارين على تعزيز الشعور بتقدير الجهود التي أبذلها.					
.35	أشعر بالارتياح تجاه إتمام هذا المساق بنجاح.					
.36	يسرني العمل على تنفيذ محتوى المساق كونه مصمم جيداً.					
.37	التزم بتحقيق أهداف المساق بشكل أكبر مقارنة بالمساقات الأخرى.					
.38	أضع أهدافا لتعلمي مسبقا.					
.39	أثق بقدرتي على تجاوز المعقبات أثناء القيام بعملي.					
.40	استعد للعمل بجد لتحقيق أهدافي بغض النظر عن متطلبات المساقات الأخرى.					
.41	أعد خطة دراسية تتضمن مهامًا محددة.					
.42	أسيطر على انفعالاتي اثناء إتمام متطلبات هذا المساق.					
.43	أبذل جهداً إضافياً لاستئناف مهمتي كلما قل تركيزي على هدفي في هذا المساق.					
.44	أتجنب المشتتات من خلال وضع أهداف تنافسية.					
.45	أتمكن من ضبط المشتتات غير المتوقعة.					
.46	أعرف متى أتوقف عن البحث عن مزيد من المعلومات أثناء التحضير للامتحان.					
.47	لا أسمح للضغوط الاجتماعية أن تؤثر على أدائي.					
.48	أفكر بالقيام بأنشطة ترفع دافعيتي عند انخفاضها.					

Appendix F: Reflective Thinking Scale (Final Version in Arabic)

النسخة النهائية لمقياس التفكير التأملي

عزيزي/تي المشارك/ة:

تحية طيبة وبعد،

تقوم الباحثة ببحث حول دمج الواقع المعزز في الممارسات التعليمية كاستراتيجية تعلم في التعليم العالي، الرجاء منكم قراءة فقرات الاستبيان بشكل جيد، ثم الإجابة عن الفقرات بشكل موضوعي وبشفافية عالية، علما بأن بيانات هذا الاستبيان مخصصة للبحث العلمي فقط، وسيتم التعامل مع البيانات لأغراض البحث العلمي فقط، لن يستغرق منكم تعبئة الاستبيان غير 10 دقائق.

تقبلوا فائق الاحترام والتقدير.

أولاً: البيانات الديمغرافية

يرجى وضع دائرة حول الخيار المناسب في الفقرات الآتية:

1. الجنس: أ. ذكر ب. أنثى

2. المجموعة: أ. ضابطة ب. تجريبية

3. المساق:

أ.الاتصالات الرقمية (Digital Communication).

ب. الأمواج الدقيقة (Microwave Engineering).

4.السنة الجامعية: أ.أولى ب. ثانية ج. ثالثة د. رابعة فأكثر

ثانياً: المجالات

يرجى اختيار الاستجابة المناسبة على الفقرات الآتية، التي تتعلق بتصرفاتك وفهمك وتأملاتك في هذا المساق.

الرقم	**البنود**	**موافق بشدة**	**موافق**	**محايد**	**معارض**	**معارض بشدة**
.1	أنفذ بعض الأنشطة دون الحاجة إلى التفكير بها.					
.2	أنفذ المهمات مرات عدة في هذا المساق، لدرجة أنني أصبحت أنفذها دون الحاجة إلى التفكير.					
.3	لا أحتاج للتفكير بالامتحان طالما أتذكر ملخص المادة المطلوبة.					

4.	عندما أتبع تعليمات المحاضر لا داعي للتفكير ملياً بهذا المساق.					
5.	يتطلب هذا المساق استيعاب المفاهيم التي يشرحها المحاضر.					
6.	أحتاج إلى فهم المحتوى لاجتياز هذا المساق.					
7.	أحتاج إلى فهم المادة التي يشرحها المحاضر لتنفيذ المهمات العملية.					
8.	في هذا المساق، عليك أن تفكر وتتأمل المادة التي تدرسها باستمرار.					
9.	أتساءل عن الطريقة التي ينفذ بها الآخرون أعمالهم، وأفكر بطريقة أفضل لتنفيذها.					
10	أفكر ملياً بما أقوم به وببدائل أخرى ممكنة للقيام بها.					
11	أتأمل فيما أفعل، وفي إمكانية تحسينه باستمرار.					
12	أعيد تقييم تجربتي باستمرار لأتمكن من تحسين أدائي مستقبلاً					
13	تغيرت نظرتي إلى نفسي في هذا المساق.					
14	شكل هذا المساق تحدياً لتعديل بعض أفكاري الراسخة.					
15	كنتيجة لهذا المساق تغيرت طريقة أدائي المعتادة للعديد من الأشياء					
16	كشفت دراستي للمساق عن أخطاء اعتقدت أنها صواب					

Appendix G: Interview Questions (Final Version in Arabic)

أسئلة المقابلة

1. اشرح لي خبراتك السابقة عن موضوع استخدام الواقع المعزز والافتراضي في التعليم؟
2. ما هو انطباعك الأولي عند استخدامك تطبيق XR؟
3. ما التغير الذي شعرت به بعد استخدامك تطبيق XR في التعلم؟
4. من وجهة نظرك، ما هي أهم إيجابيات استخدام تطبيق XR في عملية التعلم؟
5. برأيك، ما العقبات التي واجهتك أثناء استخدام تطبيق XRفي التعليم؟
6. باعتقادك، كيف يسهم استخدام تطبيق XRفي تحسين مستقبلك التعليمي والمهني؟
7. من خلال تجربتك الشخصية، هل تنصح زملائك من الطلبة باستخدام التطبيق في التعلّم؟ ولماذا؟
8. ما أهم المهارات المسبقة التي يجب أن تتوفر لدى الطالب قبل استخدام تطبيقXR في التعليم والتعلم؟

Appendix H: Interview Transcripts

On the following link or QR code:

https://docs.google.com/document/d/1qCpXJSKTE2Bww382iRltmG6nWrdQAFMQ/edit?usp=sharing&ouid=105701049519119246792&rtpof=true&sd=true

Appendix I: Published Papers

Paper1 title: Augmented Reality Based Learning: The Efficacy on Learner’s Motivation and Reflective Thinking.

Journal Title: International Journal of Information and Education Technology (IJIET)

http://www.ijiet.org/

Paper2 title: Role of Augmented Reality Learning in Enhancing Palestinian University Students' Motivation and Reflective Thinking.

Journal Title: Journal of Social Studies Education Research

https://www.jsser.org/index.php

paper3 tile: Augmented Reality in Higher Education: Perspectives of telecommunication Engineering Students

Conference title: First International Conference and Expo on "Innovation and Sustainability in Engineering & Technology" ICEISET-2023, An-Najah National University, Nablus, Palestine, June 14-15, 2023.

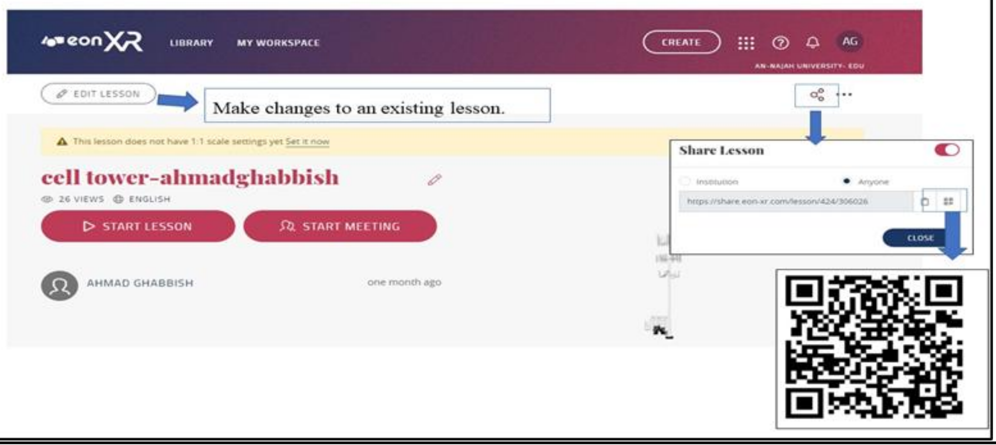
https://easychair.org/my/conference?conf=iceiset2023

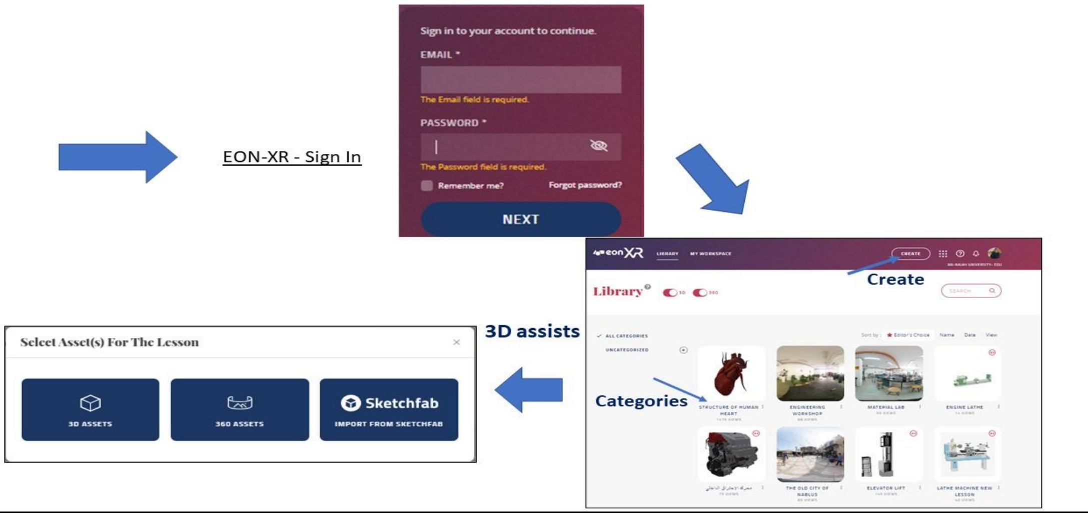
Appendix K: Training Material for Developing Lessons using EON-XR Platform

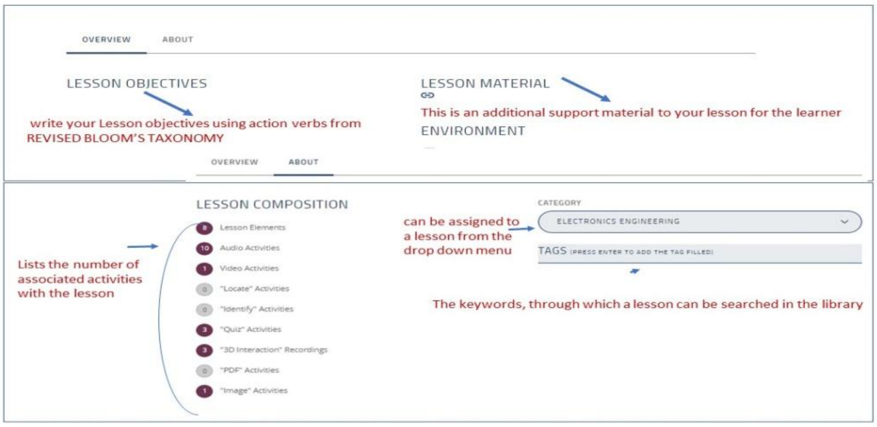
On the following link or QR code:

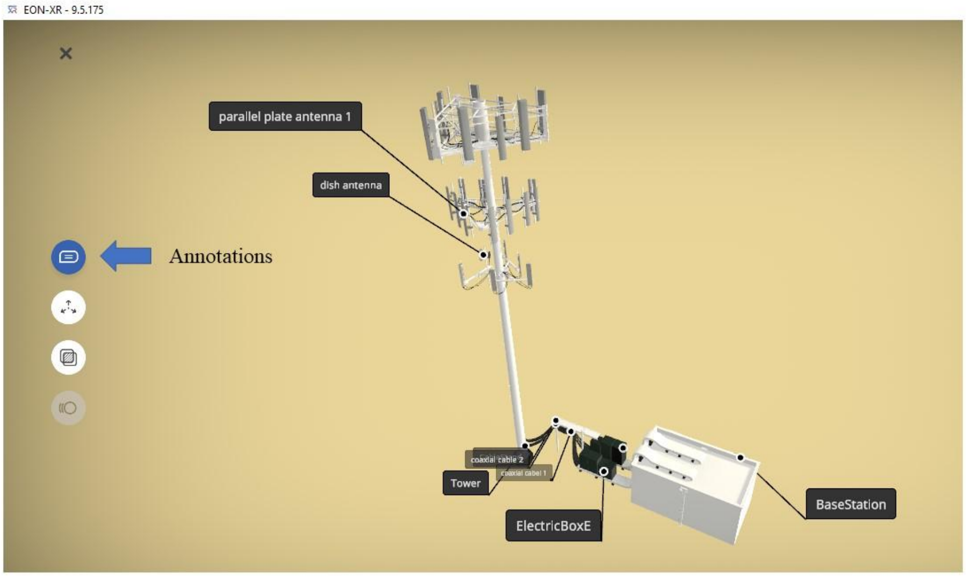
https://docs.google.com/presentation/d/1A_r0274q90HZDjqR0waO5iOEKs4jqcSr/edit?usp=sharing&ouid=105701049519119246792&rtpof=true&sd=true

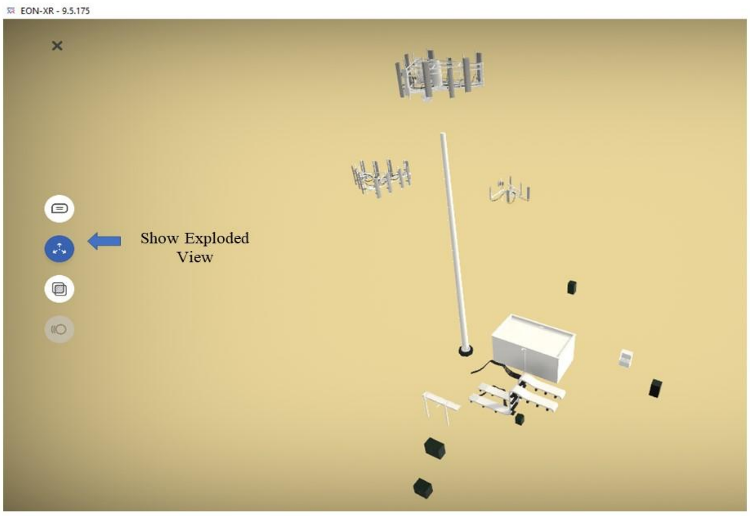
Developing sample lesson steps using EON

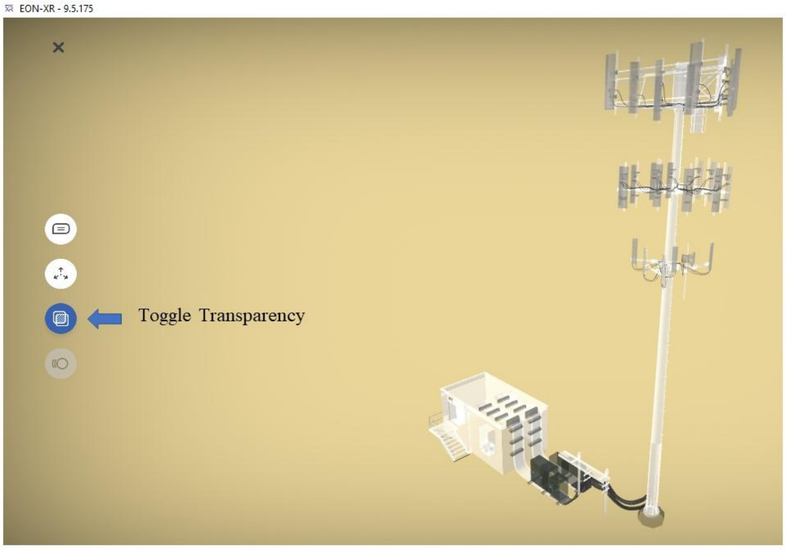


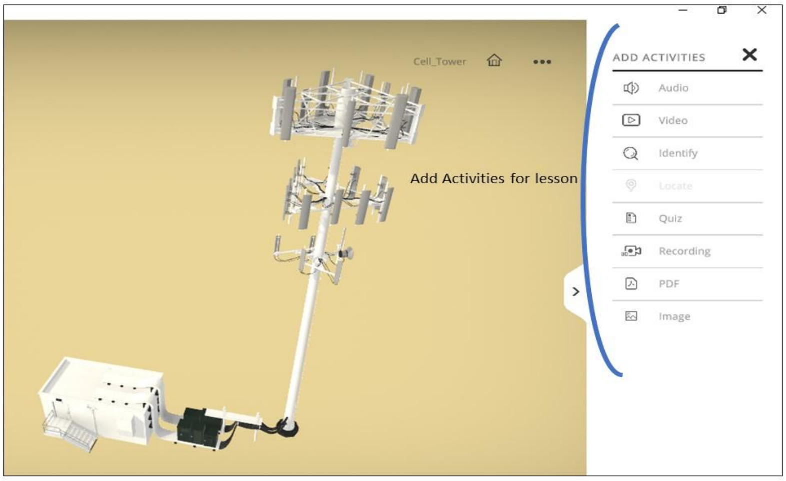


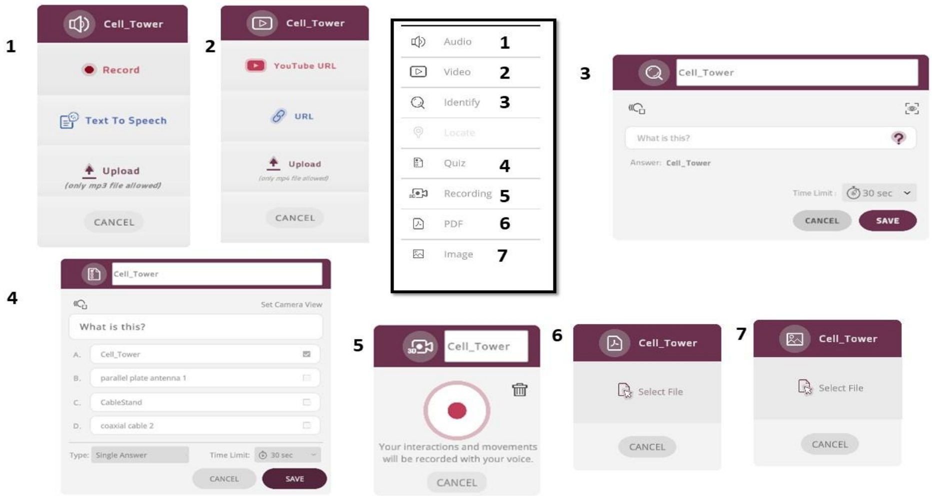

OVERVIEW
ABOUT
LESSON OBJECTIVES
write your Lesson objectives using action verbs from REVISED BLOOM'S TAXONOMY
LESSON MATERIAL
This is an additional support material to your lesson for the learner
ENVIRONMENT
OVERVIEW
ABOUT
LESSON COMPOSITION
Lists the number of associated activities with the lesson
Lesson Elements
Audio Activities
Video Activities
"Locate" Activities
"Identify" Activities
"Quiz" Activities
"3D Interaction" Recordings
"PDF" Activities
"Image" Activities
can be assigned to a lesson from the drop down menu
CATEGORY
ELECTRONICS ENGINEERING
TAGS
The keywords, through which a lesson can be searched in the library


EON-XR - 9.5.175
parallel plate antenna 1
dish antenna
Annotations
Tower
ElectricBoxE
BaseStation


EON-XR - 9.5.175
Show Exploded View


EON-XR - 9.5.175
Toggle Transparency


Cell_Tower
ADD ACTIVITIES
Audio
Video
Identify
Locate
Quiz
Recording
PDF
Image
Add Activities for lesson


1
Cell_Tower
Record
Text To Speech
Upload
(only mp3 file allowed)
CANCEL
2
Cell_Tower
YouTube URL
URL
Upload
CANCEL
Audio 1
Video 2
Identify 3
Locate
Quiz 4
Recording 5
PDF 6
Image 7
3
Cell_Tower
What is this?
Answer: Cell_Tower
Time Limit: 30 sec
CANCEL
SAVE
4
Cell_Tower
Set Camera View
What is this?
A. Cell_Tower
B. parallel plate antenna 1
C. CableStand
D. coaxial cable 2
Type: Single Answer
Time Limit: 30 sec
CANCEL
SAVE
5
Cell_Tower
Your interactions and movements will be recorded with your voice.
CANCEL
6
Cell_Tower
Select File
CANCEL
7
Cell_Tower
Select File
CANCEL

EON Lesson functions

- Annotations: add labels to represent the name of each part of the 3D model.
- AR Mode: A 3D model can be viewed / manipulated against a real background.
- Build Puzzle: solving activity for evaluating learner’s understanding.
- Create: Create a new lesson by using a 3D asset / 360 image.
- Edit: Make changes to an existing 3D / 360 lesson.
- Identify: activity for evaluating learner’s understanding.
- Intro: first screen in a 3D/360 lesson. Shows the whole model with audio and video.
- Locate: Allows the user to spot an evaluation activity for model part in a 3D lesson.

  - Memo: Smaller parts of a 3D model/ image (360). Can include audio and video content.
  - Model Parts: The hierarchy and parts of a 3D model.
  - 3D Recording: The whole interaction of screen manipulation of 3D model parts and simultaneous voice-over gets recorded. This can be played later as an AV animation.
  - Quiz: An activity for evaluating learner’s understanding. Multiple and single choice.
  - Touch Mode: Use finger to touch and manipulate the objects.
  - TTS (Text to speech): Converts the typed text to a computerized voice.
  - VR Mode: User can experience the 3D model in a real time environment.

Appendix L: Tables

Table 11

Pearson Correlation Coefficients of Volition items with Volition dimension and total score (n = 77)

Items	Volition	Total
My commitment to achieve the goals in this class was strong relative to the goals in my other classes.	.594**	.646**
I set up goals for my learning.	.650**	.591**
I was confident that I could avoid obstacles while doing my work.	.692**	.616**
I was prepared to work hard to achieve my goals no matter what my other classes required.	.644**	.649**
I was able to prepare a study plan that listed concrete tasks.	.698**	.598**
I kept my feelings under control while working to complete this class.	.661**	.465**
I added more effort to stay on task if my focus on my goal in this class began to decline.	.632**	.480**
I was able to avoid being distracted by competing goals.	.706**	.543**
I was able to create a setting free of uncontrollable distractions.	.652**	.425**
I was able to know when to stop looking for more information to prepare for an exam.	.779**	.695**
I didn’t let social pressure affect my performance.	.659**	.490**
When my motivation decreased, I was able to think of things to do to build it back up again.	.583**	.649**

*p < 0.05. **p < 0.01

Table 12

Pearson Correlation Coefficients of Habitual Action items with their dimension and the total score (n = 77)

Items	Habitual Action	Total
When I am working on some activities, I can do them without thinking about what I am doing.	655**	.296**
In this course we do things so many times that I started doing them without thinking about it	.627**	.306**
As long as I can remember handout material for examinations, I do not have to think too much.	.544**	.243**
If I follow what the lecturer says, I do not have to think too much on this course.	.628**	.388**

*p < 0.05. **p < 0.01

Table 13

Pearson Correlation Coefficients of Understanding items with their dimension and the total score (n = 77)

Items	Understanding	Total
This course requires us to understand concepts taught by the lecturer.	.697**	.279**
To pass this course you need to understand the content.	.692**	.408**
I need to understand the material taught by the teacher in order to perform practical tasks.	.756**	.529**
In this course you have to continually think about the material you are being taught.	.660**	.412**

*p < 0.05. **p < 0.01

Table 14

Pearson Correlation Coefficients of Reflection items with dimension and total score (n = 77)

Items	Reflection	Total
I sometimes question the way others do something and try to think of a better way.	.550**	.368**
I like to think over what I have been doing and consider alternative ways of doing it.	.761**	.533**
I often reflect on my actions to see whether I could have improved on what I did.	.759**	.656**
I often re-appraise e my experience e so I can learn from it and improve for my next performance	.735**	.540**

*p < 0.05. **p < 0.01

Table 15

Pearson Correlation Coefficients of Critical Reflection items with dimension and total score (n = 77)

Items	Critical Reflection	Total
As a result of this course, I have changed the way I look at myself.	.787**	.625**
This course has challenged some of my firmly held ideas.	.791**	.593**
As a result of this course, I have changed my normal way of doing things.	.740**	.558**
During this course, I discovered faults in what I had previously believed to be right.	.718**	.506**

*p < 0.05. **p < 0.01

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Table 16

Results of confirmatory factor analysis.

Item	Habitual Action	Understanding	Reflection	Critical thinking
HA1	.787			
HA2	.765			
HA3	.410			
HA4	.409			
U1		.826		
U2		.75		
U3		.337		
U4		.317		
R1			.759	
R2			.662	
R3			.651	
R4			.382	
CR1				.77
CR2				.717
CR3				.7
CR4				.589
Variance %	23.361	8.787	9.189	13.886

Table 17

Cronbach's Alpha coefficients of ARCS-V dimensions and total score of all dimensions.

Measure	Cronbach's Alpha	Guttmann Split- Half
Attention	.702	
Relevance	.772	
Confidence	.824	
Satisfaction	.717	
Volition	.883	
Total	.901	.864

Table 18

Cronbach's Alpha coefficients of Reflective Thinking dimensions and total score of all dimensions.

Measure	Cronbach's Alpha	Guttmann Split- Half
Habitual Action	.621	
Understanding	.652	
Reflection	.651	
Critical Reflection	.739	
Total	.749	.657

Table 19

A sample lesson for microwave engineering course based on ADDIE model.

LESSON TITLE

Power Divider.

LESSON INTRODUCTION

Power dividers and directional couplers are passive devices used mostly in the field of radio technology. They couple a defined amount of the electromagnetic power in a transmission line to a port enabling the signal to be used in another circuit.

INTENDED LESSON LEARNING OUTCOMES/OBJECTIVES

(*What do you expect users to know and be able to do by the end of the lesson?)*

The aims of this project are:

1. Describe the shape of the main components of the power divider.
2. List the types of power dividers.

DESCRIPTION	USER ACTIONS
*(What will users see, what happens in this lesson?) Digital Asset/Model Name:*The model added from the grabcad site, which have tone input port and three output ports.	*(e.g. explore model, Xray, exploded view)* Xray

SCRIPT INFORMATION:

Text to Speech: Yes

Audio uploaded file: Yes

SUPPLEMENTARY MATERIALS	VIDEO DESCRIPTION
Video Used: Yes Copyrights: Yes	The video talk about the describe model.

LESSON OPTIONS	AR APPROACH
The lesson can be presented using VRwith oculus and using ARwithsmartphone. Both require an EON-XRaccount and the App.	*(How will learners use AR?)* Download EON-XR mobileApp, then open the App and start the lesson, and click the option that operates AR.

SCREEN RECORDING

1. Components of power divider
2. Type of power divider
3. Applications of power divider
4. Uses of power divider
5. How the power divider works.
6. The other names of power divider.

IDENTIFY

The main aim of this project is showing the power divider using virtual reality, and the basic concept of strip line in practical example, not in theoretical equation.

QUIZZES: (*How many quizzes are there, and where will they be located?)*

Four questions are designed:

Q1. This model is called:

a) Power splitter
b) Power compiler
c) Power divider
d) All

Q2. What is the type of power divider?

a) reactive
b) resistive
c) A&B
d) No type

Q3: What are the uses of power divider:

a) To divide a power source equally between the output signals
b) A&D
c) Not mention
d) Test system to measure two different characteristic signals.

Q4: The model is:

a) 2 ports
b) 4 ports
c) 5 ports
d) 8 ports

THE LESSON’S LINK

https://share.eon-xr.com/lesson/424/312534

LESSON TITLE

Power Divider.

LESSON INTRODUCTION

https://share.eon-xr.com/lesson/424/312534

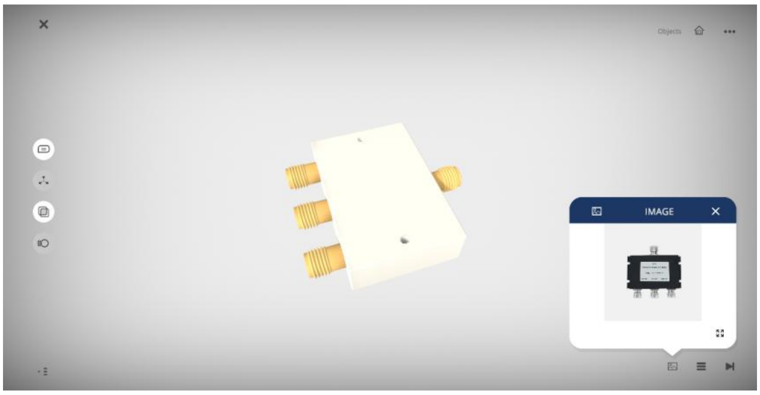

Table 20

A sample lesson for digital communication course based on ADDIE model.

LESSON TITLE	
Matched filter	
LESSON INTRODUCTION	
The matched filter is the optimal linear filter for maximizing the signal-to-noise ratio (SNR) in the presence of additive stochastic noise. Matched filters are commonly used in radars.	
INTENDED LESSON LEARNING OUTCOMES/OBJECTIVES:	
(What do you expect users to know and be able to do by the end of the lesson?) 1. Describe the matched filter. 2. Understand how a matched filter operates. 3. Identify the parts of the filter.	
DESCRIPTION	USER ACTIONS
(What will users see, what happens in this lesson?)	*(e.g. explore model, Xray, exploded view)*
The user will see the parts of matched filter andunderstand this concept and its operation.	X-ray Exploded view
SCRIPT INFORMATION	
Text to Speech: Yes Audio uploaded file: No	
SUPPLEMENTARY MATERIALS:	VIDEO DESCRIPTION:
Video Used: Yes Copyrights: Yes	The video talks about the filter and how to improve its (SNR). Other videos explain the parts of the matched filter.
LESSON OPTIONS	AR APPROACH
We can display the lesson with both AR&VR	*(How will learners use AR – in groups?)* By using AR smart glasses, VR glasses and controllers.

IDENTIFY

PCB CCT, Delay IC, Integrator IC, Differential IC, Capacitor

QUIZZES *(How many quizzes are there, and where will they be located?)*

Three questions have been developed:

1. Where can we use the matched filter?
2. Why is the matched filter important?
3. What are the objectives of a matched filter?

THE LESSON'S LINK

https://core.eon-xr.com/Lesson/Lesson3DDetail?id=309859

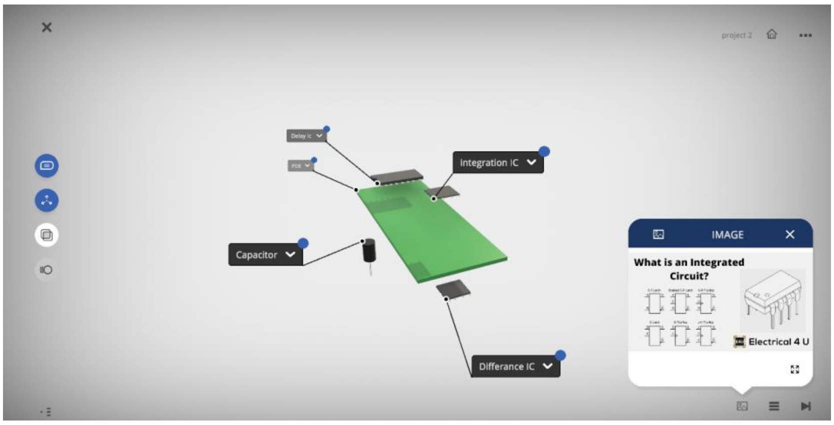

Table 21

Means, standard deviations and Median for the experimental groups on pre and post tests for motivation scale.

	Pre test			Post test		
Dimensions	M	S. D	Median	M	S. D	Median
Attention	3.2564	.70091	3.3333	3.8718	.68179	3.5000
Relevance	3.6752	.65336	3.5556	4.0513	.56586	4.0000
Confidence	3.3504	.65396	3.2222	3.9316	.60780	3.8889
Satisfaction	3.6410	.55213	3.6667	4.0897	.57581	3.8333
Volition	3.3205	.55886	3.2500	3.8590	.53401	3.6667
Total	3.4167	.57181	3.3333	3.9407	.56249	3.6458

Table 22

Mann-Whitney U test on pre- motivation and post- motivation due to gender.

Test	Variable		N	Mean Rank	Sum of Ranks	Mann-Whitney U	Wilcoxon W	Z	Sig
Pre-Motivation	Gender	Female	11	6.45	71.00	5.000	71.000	-1.188	.235
		Male	2	10.00	20.00				
Post-Motivation	Gender	Female	11	6.91	76.00	10.000	76.000	-.198	.843
		Male	2	7.5	15.00				

Table 23

Wilcoxon's signed ranks test for the pre-test and post-test for the motivation scale.

Test	Ranks	N	Mean Rank	Sum of Ranks	Z	Sig
Post-Pre-Total	Negative Ranks	3	4.00	12.00	-2.343	.019
	Positive Ranks	10	7.90	79.00		
	Ties	0				
Post-Pre-Attention	Negative Ranks	3	3.17	9.50	-2.090	.037
	Positive Ranks	8	7.06	56.50		
	Ties	2				
Post-Pre-Relevance	Negative Ranks	2	2.50	5.00	-2.077	.038
	Positive Ranks	7	5.71	40.00		
	Ties	4				
Post-Pre-Confidence	Negative Ranks	3	4.50	13.50	-2.238	.025
	Positive Ranks	10	7.75	77.50		
		0				
Post-Pre-Satisfaction	Negative Ranks	4	3.00	12.00	-2.357	.018
	Positive Ranks	9	8.78	79.00		
	Ties	0				
Post-Pre-Volition	Negative Ranks	4	4.38	17.50	-1.959	.050
	Positive Ranks	9	8.17	73.50		
	Ties	0				

Table 24

Means, standard deviations and medians for the experimental group on pre-test and post-test for the reflective thinking scale.

	Pre-test			Post-test		
Dimension	M	S. D	Median	M	S. D	Median
Habitual Action	3.0962	.69626	3.0000	3.6346	.67404	3.7500
Understanding	4.0769	.44936	4.0000	4.6731	.37339	4.7500
Reflection	4.0192	.60778	4.0000	4.3077	.46942	4.2500
Critical Reflection	3.3462	1.14354	3.7500	4.2115	.88886	4.5000
Total	3.6346	.55718	3.5000	4.2067	.45742	4.1875

Table 25

Mann-Whitney U test on pre-reflective thinking and post-reflective thinking due to gender.

Test	Variable		N	Mean Rank	Sum of Ranks	Mann-Whitney U	Wilcoxon W	Z	Sig
Pre-Reflective thinking	Gender	Female	11	7.36	81.00	7.000	10.000	-.790	.430
		Male	2	5.00	10.00				
Post-Reflective Thinking	Gender	Female	11	7.41	81.5	6.5	9.5	-.891	.373
		Male	2	4.75	9.5				

Table 26

Wilcoxon's signed ranks test for pre and posttests of reflective thinking scale for the Microwave Engineering course.

Test	Ranks	N	Mean Rank	Sum of Ranks	Z	Sig
Post-Pre-Habitual Action	Negative Ranks	2	6.75	13.50	-2.254	.024
	Positive Ranks	11	7.05	77.50		
	Ties	0				
Post-Pre-Understanding	Negative Ranks	2	2.00	4.00	-2.590	.010
	Positive Ranks	9	6.89	62.00		
	Ties	2				
Post-Pre-Reflection	Negative Ranks	5	4.40	22.00	-.985	.324
	Positive Ranks	6	7.33	44.00		
	Ties	2				
Post-Pre-Critical Reflection	Negative Ranks	1	7.00	7.00	-2.520	.012
	Positive Ranks	11	6.45	71.00		
	Ties	1				
Post-Pre-Total	Negative Ranks	1	8.00	8.00	-2.623	.009
	Positive Ranks	12	6.92	83.00		
	Ties	0				

Table 27

Independent t-test on pre-motivation due to group and gender.

Test	Variables		N	M	S. D	t-value	p-value
Pre- motivation	Group	Control	12	3.0104	.47991	-2.280	.334
		Experiment	12	3.4080	.36697		
	Gender	Female	12	3.3333	.52419	1.331	.442
		Male	12	3.0851	.37788		

Table 28

Means, standard deviations and Median for the experimental and control group on pre-test and post-test for the motivation scale.

Dimension	Group	N	Pre-test		Post-test	
			M	S. D	M	S. D
Attention	Control	12	2.9722	.37493	3.0556	.45273
	Experiment	12	3.3264	.26699	3.7083	.44735
	Female	12	3.2083	.35266	3.4375	.61456
	Male	12	3.0903	.38511	3.3264	.50309
	Total	24	3.1493	.36612	3.3819	.55218
Relevance	Control	12	3.2315	.31590	3.4444	.37605
	Experiment	12	3.3796	.47011	4.0093	.33986
	Female	12	3.4167	.42409	3.9537	.38038
	Male	12	3.1944	.35494	3.5000	.41709
	Total	24	3.3056	.39894	3.7269	.45398
Confidence	Control	12	2.9630	.38587	3.1759	.51783
	Experiment	12	3.2870	.43022	3.7593	.48277
	Female	12	3.2407	.51864	3.6574	.58882
	Male	12	3.0093	.30506	3.2778	.51137
	Total	24	3.1250	.43259	3.4676	.57313
Satisfaction	Control	12	3.3194	.65697	3.3611	.50669
	Experiment	12	3.1806	.63746	3.9861	.49979
	Female	12	3.3889	.60442	3.8472	.62546
	Male	12	3.1111	.66414	3.5000	.51247
	Total	24	3.2500	.63702	3.6736	.58665
Volition	Control	12	3.1458	.30177	3.0486	.72948
	Experiment	12	3.2222	.38817	3.7639	.44215
	Female	12	3.2639	.39542	3.6389	.67076
	Male	12	3.1042	.27323	3.1736	.66235
	Total	24	3.1840	.34225	3.4063	.69388
Total	Control	12	3.1059	.29973	3.1753	.38409
	Experiment	12	3.2847	.33231	3.8229	.35417
	Female	12	3.2899	.36900	3.6667	.49357
	Male	12	3.1007	.24902	3.3316	.44368
	Total	24	3.1953	.32268	3.4991	.48984

Table 29

Analysis of covariance (ANCOVA) for total score of the motivation scale due to group and gender

Dependent Variable	Source	Sum Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Motivation	Total Pre-test	.547	1	.547	4.589	.045	0.195
	Group	1.468	1	1.468	12.322	.002	0.393
	Gender	.018	1	.018	.149	.704	0.008
	Group * Gender	.139	1	.139	1.169	.293	
	Error	2.264	19	.119			
	Total	299.373	24				

Table 30.

Multiple analysis of covariance (MANCOVA) for the motivation dimensions due to groups and gender.

Dependent Variable	Source	Sum Squares	df	Mean Square	F	Sig.	Partial Eta Square
Attention(post)	Group	.728	1	.728	4.573	.046	0.243
Relevance(post)		1.125	1	1.125	9.240	.007	0.332
Confidence(post)		.776	1	.776	3.246	.087	0.255
Satisfaction(post)		2.242	1	2.242	9.732	.006	0.498
Volition(post)		1.977	1	1.977	7.286	.014	0.466
Attention(post)	Gender	.077	1	.077	.480	.497	0.033
Relevance(post)		.425	1	.425	3.490	.077	0.158
Confidence(post)		.122	1	.122	.509	.484	0.051
Satisfaction(post)		.005	1	.005	.021	.886	0.002
Volition(post)		.091	1	.091	.337	.568	0.039
Attention(post)	Group * Gender	.189	1	.189	1.186	.290	0.077
Relevance(post)		.032	1	.032	.266	.612	0.014
Confidence(post)		.347	1	.347	1.452	.243	0.133
Satisfaction(post)		.114	1	.114	.495	.490	0.048
Volition(post)		1.497	1	1.497	5.515	.030	0.398
Attention(post)	Attention(pre)	1.311	1	1.311	8.231	.010	0.367
Relevance(post)	Relevance(pre)	.005	1	.005	.045	.835	0.002
Confidence(post)	Confidence(pre)	.539	1	.539	2.254	.150	0.192
Satisfaction(post)	Satisfaction(pre)	.993	1	.993	4.311	.052	0.305
Volition(post)	Volition(pre)	1.551	1	1.551	5.716	.027	0.407

Table 31

Independent t-test on pre-reflective thinking due to group and gender.

Test	Variable		N	M	S. D	t-value	p-value
Pre-Reflective Thinking	Group	Control	12	3.1458	.23436	-.195	.587
		Experiment	12	3.1667	.28620		
	Gender	Female	12	3.2240	.24923	1.316	.940
		Male	12	3.0885	.25487		

Table 32

Means, standard deviations and medians for the experimental and control groups on pre-test and post-test for reflective thinking scale and its dimensions.

Dimensions	Variable		N	Pre-test		Post-test	
				M	S. D	M	S. D
Habitual Action	Group	Control	12	2.7292	.48216	3.5833	.35887
		Experiment	12	2.9167	.40358	3.9792	.37626
	Gender	Female	12	2.9375	.41458	3.7500	.52223
		Male	12	2.7083	.46262	3.8125	.28455
		Total	24	2.8229	.44526	3.7812	.41252
Understanding	Group	Control	12	3.4167	.35887	3.7917	.49810
		Experiment	12	3.3958	.24905	4.4167	.24618
	Gender	Female	12	3.5000	.28204	4.0625	.55519
		Male	12	3.3125	.30386	4.1458	.45799
		Total	24	3.4063	.30228	4.1042	.49955
Reflection	Group	Control	12	3.5417	.39648	3.7292	.43247
		Experiment	12	3.3125	.47822	4.0833	.62462
	Gender	Female	12	3.3958	.45799	3.7917	.64696
		Male	12	3.4583	.45017	4.0208	.44541
		Total	24	3.4271	.44526	3.9063	.55566
Critical Reflection	Group	Control	12	2.8958	.34474	3.7500	.42640
		Experiment	12	3.0417	.39648	4.2500	.36927
	Gender	Female	12	3.0625	.41458	3.9792	.51631
		Male	12	2.8750	.31079	4.0208	.43247
		Total	24	2.9688	.37090	4.0000	.46625
Total	Group	Control	12	3.1458	.23436	3.7135	.29850
		Experiment	12	3.1667	.28620	4.1823	.27754
	Gender	Female	12	3.2240	.24923	3.8958	.45096
		Male	12	3.0885	.25487	4.0000	.27696
		Total	24	3.1563	.25604	3.9479	.36983

Table 33

Analysis of covariance (ACNOVA) for total score of Reflective Thinking scale due to group and gender.

Dependent Variable	Source	Sum Squares	df	Mean Square	F	Sig.	Partial Eta Square
Reflective Thinking	Total _Pretest	.001	1	.001	.008	.931	0.001
	Group	1.459	1	1.459	19.958	.000	0.512
	Gender	.195	1	.195	2.674	.118	0.123
	Group * Gender	.217	1	.217	2.973	.101	
	Error	1.389	19	.073			
	Total	377.211	24				

Table 34

Multiple analysis of covariance (MANCOVA) for reflective thinking dimensions due to group and gender.

Dependent Variable	Source	Sum Squares	df	Mean Square	F	Sig.	Partial Eta Square
Habitual Action(post)	Group	1.459	1	1.459	19.958	.000	0.512
Understanding(post)		2.474	1	2.474	16.270	.001	0.640
Reflection(post)		.694	1	.694	2.352	.142	0.333
Critical Reflection(post)		1.336	1	1.336	8.235	.010	0.490
Habitual Action(post)	Gender	.195	1	.195	2.674	.118	0.123
Understanding(post)		.172	1	.172	1.134	.300	0.110
Reflection(post)		.530	1	.530	1.797	.196	0.276
Critical Reflection(post)		.175	1	.175	1.079	.312	0.112
Habitual Action(post)	Group * Gender	.217	1	.217	2.973	.101	0.135
Understanding(post)		.228	1	.228	1.496	.236	0.141
Reflection(post)		.087	1	.087	.296	.593	0.059
Critical Reflection(post)		.015	1	.015	.095	.762	0.011
Habitual Action(post)	Habitual Action(pre)	.001	1	.001	.008	.931	0.001
Understanding(post)	Understanding(pre)	.004	1	.004	.025	.876	0.003
Reflection(post)	Reflection(pre)	.177	1	.177	.602	.447	0.113
Critical Reflection (post)	Critical Reflection (pre)	.226	1	.226	1.391	.253	0.140

Table 35

Means, standard deviations and paired samples T-Test for Motivation scale and its dimension.

Dimension	Test	Mean	S. D	T-value	Df	Sig
Attention	Post-Test	3.7083	.44735	-3.142	11	.009
	Pre-Test	3.3264	.26699			
Relevance	Post-Test	4.0093	.33986	-3.928	11	.002
	Pre-Test	3.3796	.47011			
Confidence	Post-Test	3.7593	.48277	-2.517	11	.029
	Pre-Test	3.2870	.43022			
Satisfaction	Post-Test	3.9861	.49979	-4.120	11	.002
	Pre-Test	3.1806	.63746			
Volition	Post-Test	3.7639	.44215	-3.540	11	.005
	Pre-Test	3.2222	.38817			
Total	Post-Test	3.8229	.35417	-4.346	11	.001
	Pre-Test	3.2847	.33231			

Table 36

Means, standard deviations and paired samples T-Test for Reflective Thinking scale and its dimension.

Dimension	Test	Mean	S. D	T-value	Df	Sig
Habitual Action	Post-Test	3.9792	.37626	-8.110	11	.000
	Pre-Test	2.9167	.40358			
Understanding	Post-Test	4.4167	.24618	-9.043	11	.000
	Pre-Test	3.3958	.24905			
Reflection	Post-Test	4.0833	.62462	-3.458	11	.005
	Pre-Test	3.3125	.47822			
Critical Reflection	Post-Test	4.2500	.36927	-9.570	11	.000
	Pre-Test	3.0417	.39648			
Total	Post-Test	4.1823	.27754	-10.921	11	.000
	Pre-Test	3.1667	.28620			

Table 37

Pearson Product Moment Correlation Coefficient to investigate the relationship between motivation and reflective thinking.

Reflective Thinking		Motivation		r	Sig
Mean	S. D	Mean	S. D		
4.1823	.27754	3.8229	.35417	.619*	0.032

Table 38

Linear regression to predict motivation.

Predictor	B	S. E	β	T	P
Reflective Thinking	.500	.201	.619	2.492	.032*

Table 39

Independent t-test on students' achievement scores due to group.

Test	Variables		N	M	S. D	t-value	p-value
Achievement Score	Group	Control	12	68.9596	26.89358	-1.368	.017

Appendix M: Certificate of acceptance of the research extracted from the dissertation

Research title: **Augmented Reality-Based Learning: The Efficacy on Learner's Motivation and Reflective Thinking**

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Dear *Kifaya Sabbah, Fayez Mahamid, and Allam Mousa*,

We are pleased to inform you that the following paper has been accepted for publication in "**International Journal of Information and Education Technology**".

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كلية الدراسات العليا

فعالية دمج الواقع المعزز في التعليم على دافعية المتعلم والتفكير التأملي لطلبة الجامعات

إعداد

كفاية أحمد فيصل "علي حسن"

إشراف

د. فايز محاميد

أ.د. علام موسى

قدمت هذه الرسالة استكمالاً لمتطلبات الحصول على درجه الدكتوراه في التعلم والتعليم، من كلية الدراسات العليا، في جامعة النجاح الوطنية، نابلس– فلسطين.

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الملخص

تقدم هذه الرسالة تجربة جديدة في سياق التعليم العالي الفلسطيني تستند إلى تقنية الواقع المعزز. و تهدف إلى دراسة فعالية التعلم القائم على الواقع المعزز في دافعية الطلبة والتفكير التأملي كمقاييس مهمة لتعلم هم وتحصيلهم العلمي. تعتمد الدراسة على دمج المنهجين الكمي والنوعي باستخدام مقاييس الدافعية والتفكير التأملي للمنهجية الكمية، والمقابلات شبه المنظمة للمنهجية النوعية. طبقت التجربة على عينة قصدية تتكون من 24 طالباً وطالبة ملتحقين بمساق الاتصالات الرقمية و13 طالباً وطالبة ملتحقين بمساق الأمواج الدقيقة في برنامج هندسة الاتصالات في جامعة النجاح الوطنية.

تشير النتائج إلى وجود تأثير إيجابي لاستخدام تقنية الواقع المعزز في الت عليم والتعلم على جميع أبعاد الدافعية باستثناء مجال الثقة، وتتضمن الانتباه والملاءمة والرضا وإرادة التعلم. وبالمثل، فإن الواقع المعزز يؤثر إيجابياً على جميع أبعاد التفكير التأملي باستثناء مجال التأملات ، وتتضمن العمل الروتيني المعتاد، والفهم، والتأمل الناقد. من جانب آخر، تم استخلاص سبعة مواضيع رئيسة من خلال التحليل النوعي والترميز الموضوعي، هي الإيجابيات، والمستقبل المأمول، والتحديات، والتأملات، والانطباع الأولي، والاتجاهات، والخبرات السابقة.

رغم النتائج المهمة، فقد ظهرت في الدراسة بعض المحددات،شملت حجم العينة، وفترة التجربة التي استمرت فصلاً دراسيًا واحداً، وحداثة تقنية الواقع المعزز ، إذ تتطلب تدريب المدرسين والطلبة وتعريفهم بهذه التقنية الناشئة واستخدامها في التعليم، الأمر الذي قد يتطلب أيضاً توفير نماذج أو لبنات التعلم المستندة إلى الواقع المعزز.

أوصت الباحثة بالاستفادة من دمج الواقع المعزز بالمناهج في نظام التعليم الفلسطيني وتقديم برامج تدريبية للطلبة وأعضاء الهيئة التدريسية، كما أوصت بالتشبيك مع المؤسسات النظيرة، وتطوير السياسات والاستراتيجيات التعليمية لدمج الواقع المعزز في التعليم. أخيرًا، أوصت الباحثة بمزيد من البحث لتحديد مستويات ثقة الطلبة عند استخدام الواقع المعزز.

الكلمات المفتاحية:التفكير التأملي، الدافعية، الواقع المعزز.