UTILIZATION OF MOBILE AUGMENTED REALITY IN A COURSE CONTENT: AN IMPACT STUDY

Saud AL-Amri[1], Suraya Hamid[2], Nurul Fazmidar Mohd Noor[3*], Abdullah Gani[4]

[1,2,3,4]Faculty of Computer Science and Information Technology, University of Malaya, Kuala Lumpur 50603, Malaysia

[4]Faculty of Computing and Informatics, University Malaysia Sabah, International Campus Labuan, WP Labuan, Malaysia

Email: saud-alamri@hotmail.com[1], suraya_hamid@um.edu.my[2], fazmidar@um.edu.my[3*](corresponding author), abdullahgani@ums.edu.my[4]

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ABSTRACT

With the rapid evolution of interactive technology, the popularity of mobile augmented reality (MAR) as a learning aid has continued to grow. However, several studies have revealed that research on the impact of AR in the educational domain is both insufficient and in an early phase. More studies are required to evaluate the effectiveness of utilizing MAR in this domain. The purpose of this study was to measure the effect of a mobile training course designed using MAR on trainees' motivation. We reviewed the associated concepts, highlighted the importance and effectiveness of MAR and explained the benefits and challenges of employing MAR in the educational domain. This study drew on John Keller's motivational model components and emphasized the significance of intrinsic motivation. We used a quantitative approach and designed a mobile training course that uses MAR to train government employees in Oman. A total of 32 employees were randomly divided into an experimental group and a control group. The experimental group used the designed application, and the control group took a training course online via computers. A motivational survey was conducted, and SPSS statistical software was used for data analysis. The results revealed that there was a significant difference in the mean motivation value for the experimental group: the trainees from the experimental group were more motivated than those from the control group. This study confirms that learners are motivated to participate in mobile training courses designed using MAR, which can contribute to the development of human resources in various domains.

Keywords: Mobile Augmented Reality, Mobile Training Course Content, ARCS, Motivation in Learning

1.0 INTRODUCTION

Given the ongoing development of technology and the extensive use of emerging interactive technologies, such as augmented reality (AR), in various fields, interest in learning via AR has increased. However, several studies have shown that there is a lack of research on the impact of AR in the field of education, and research on AR applications in this domain is still in its initial stages [1–4]. One of the most important requirements when AR is utilized in education is to select and design appropriate content that is compatible with AR technology.

Recent studies have emerged concerning updated topics in this fast-changing and mobile environment due to mobile technology innovations, including GPS, mobile augmented reality (MAR), cameras, multimedia options, sensors, new applications and communication tools. Currently, there are many features available on mobile devices, and many new technologies have been developed to enhance the learning and training process. One of these features is AR, a technology that integrates the interactive real world with the interactive virtual world using computers to enhance a user's perception of reality [5]. According to Carmigniani et al. [6], the aim of AR is to make a user's life easier by presenting virtual details that are not present in the user's actual environment but do represent a realistic environment and augment the user's comprehension of and interaction with the real world, such as through the direct broadcast of a video. AR can be applied in the educational field to offer more interactive content and help more participants to engage in the learning process [7]. AR has excellent educational potential, which has been recognized by researchers. The effectiveness of AR increases when it is integrated with different types of technologies, such as mobile devices [7]. This combination is called mobile augmented reality. Learning-based MAR focuses on games and simulations. Mobile devices, which have portability, connectivity, social interactivity, individuality and context sensitivity features, offer a learning experience that is more meaningful, interactive

and exciting [8]. Using MAR in mobile training (m-training) is effective because it offers an immersive experience via AR simulations and provides the realistic gamification of content related to the proposed m-training topics, with visible reactions in activities and assessments. These factors help trainees gain knowledge and develop skills.

Motivation can be defined as a human aspect that is related to why individuals attempt to achieve a goal and why they actively endeavor to achieve that goal [9]. Motivation for learning is a learner's willingness to engage in the learning process [2]. Utilizing effective interactive learning theories in this context, such as those discussed by Chiang et al. [10], is considered an important way to increase learners' motivation, and this increases the amount of interaction among learners [11]. Some studies pertaining to utilizing AR in the educational field have revealed that the main advantages of applying AR in learning are improving learners' achievements and increasing their motivation [10], [12], [13], [14]. Thus, when course materials are designed using MAR, effective course content that stimulates and sustains trainees' motivation should be designed.

This study aims to measure the impact of designing interactive mobile training course content using AR on trainees' motivation. To accomplish this objective, it is necessary to answer the following research question:

What is the impact of designing interactive mobile training course content using MAR on trainees' motivation?

We conducted a quantitative study to achieve the research objective. Initially, we implemented a mobile training program designed using MAR on essential communication skills in the workplace for government employees in Oman based on their actual needs. At the end of the course, we applied the Instructional Material Motivational Survey (IMMS) to measure the impact of the course designed using MAR on trainees' motivation. Following a discussion of the results, the study is concluded with some recommendations for future research.

2.0 BACKGROUND

This section presents the theoretical background of the research topic, including relevant concepts and definitions.

2.1 Mobile Training (m-training)

Mobile training (m-training) refers to a training application designed and developed on a mobile device to train individuals via their mobile devices within a short period of time to achieve predefined goals according to the analysis of their actual training needs. This is associated with self-learning and problem-solving, which are carried out by trainees depending on their needs via mobile devices with the support and aid of trainers [15], [16].

The primary goal of this kind of training is to transfer knowledge, enhance skills and change attitudes, convictions or behaviors depending on the actual training needs of mobile employees (trainees) who are not bound to a particular location when performing their tasks or jobs [16].

This training depends on mobile learning technology, which is utilized to develop mobile learning courses and has advanced significantly in recent years. M-training is a novel training approach derived from electronic training (e-training). It is regarded as an evolution of the traditional training paradigm, combining the primary features of traditional training with mobile device technology [15].

2.2 Mobile Training Course Content (MTCC)

MTCC is associated with the information that is developed and presented on mobile devices to allow participants in m-training programs to acquire new knowledge or improve their skills. This content comprises materials, exercises, activities, tests, quizzes, etc., which are presented in assorted forms; they may be presented using images, text, graphics, video, GPS, QR codes, games, simulations or other interactive tools to simplify the training topic [17], [18]. Course content can be classified based on the training topic requirements into two types of content: quick and simple content and professional learning content. Quick and simple content does not require high technical authoring skills, such as the skills required to use authoring tools and create training videos, podcasts and e-books, whereas professional learning content does require high technical authoring skills and the utilization of advanced technology, which may require more time, professional teams and a higher budget. The creation of professional learning content may involve developing serious games for training purposes, developing training content using professional software that uses virtual and augmented reality and creating interactive videos [19]. The most important consideration when this content is created is that it should be developed based on the participants'

actual training needs. A proper content design framework that utilizes suitable learning and design strategies and identifies the information and type of content best suited to participants' needs should be followed.

2.3 Using AR in Education

In recent years, AR has become widely employed in the educational field. It has been found that some applications can effectively simplify the learning process by providing interactive content using three-dimensional (3D) shapes to simplify complicated topics [3].

Tan and Lee [20] concluded that employing AR in education has a positive effect and that it offers an effective, interesting and exciting technique for motivating learners and assisting them in learning. Yuen et al. [21] showed that augmented reality technology provides learners with continuous feedback through instant interaction with the content, allowing them to control and direct their learning processes.

With the continual advancement of this technology, discovery-based learning has emerged as a prominent area in which augmented reality technology is employed [21]. The critical issue to address is the question of how AR technologies promote and enable effective learning [3]. Considering AR as an approach rather than as a specific type of technology may be advantageous to educators [3]. The involvement of instructors is crucial to the development of useful AR applications for learning, and it increases the chance of AR being employed in education [22].

Although AR has many capabilities and features that provide content in an interactive and interesting manner to simplify educational content and make it more understandable, using AR in education is not without its challenges. For example, there are technical challenges related to the lack of some of the hardware and software required to design appropriate educational content [23]. Other challenges are related to the efficiency and availability of communication networks [3]. There are also challenges related to the tracking and sensing system, which can cause virtual objects or images to appear slowly, be delayed or not appear accurately in the real environment, which might lead to inaccuracies in the information given to the learner [5]. This is in addition to other challenges, such as errors in the interface.

Some AR challenges are associated with usability issues, as some learners lack the knowledge needed to use AR and regard it as a complicated technology [1]. Hence, they become confused and sometimes face difficulties as they navigate between virtual and real environments [3]. Other challenges are related to learners' negative attitudes about the technology's effectiveness in facilitating and simplifying learning and, therefore, they refuse to use it [1]. Some educators also face challenges due to a lack of experience in designing content, such as 3D objects [23].

Some of these challenges can be handled by increasing awareness of the importance of AR technology in the educational domain. It is recommended that short courses on the usage, capabilities and features of AR that add value to the educational field should be delivered. Policies and strategies for deploying AR in education should be applied; this should include providing the technological requirements that will allow the educational institution to keep up with emerging technologies. Moreover, training sessions could be offered to educators to teach them to use user-friendly authoring tools and platforms to design and develop interactive AR content by following an effective framework for designing course content using AR. Hence, this would enable them to create customised AR applications based on their own requirements [3]. Despite all these challenges, AR technology is developing quickly, and most of these issues will be managed and addressed in the near future.

2.4 Enhancing the Design of Interactive m-training Course Content by using MAR

Several studies have demonstrated that the quality of learning and training can be enhanced by using MAR, which merges the artificial world with the real world in a virtual setting on a mobile device and enhances engagement in learning [24].

When developing content, there are different types of AR interactive techniques that can be utilized. These techniques include marker-based, marker-less, outlining, projection and superimposition AR [25]. Oufqir et al. [26] classified AR techniques into two types: marker-based and marker-less techniques. The marker-based method depends on a camera and visual indicators or markers to produce an image that is easy to recognize and track. This approach uses a mobile camera to read content, such as QR codes, and superimposes virtual images over real-world objects. The marker-less method relies on the natural characteristics of an environment; for example, in location-based AR, a GPS, an accelerometer, a digital compass or

a velocity meter can be used to obtain location data in addition to providing AR visualisations. Projection AR, outlining AR and superimposition AR are categorized as marker-less methods.

AR emerged in the 1960s and has been applied in many different fields. However, the implementation of AR in mobile learning started in approximately 2000, when the University of Australia developed AR Quake, which allowed users to engage with the application internally and externally [7]. The first application developed using MAR technology was Wikitude Drive. It was launched in 2008 and utilizes a mobile device to guide drivers to a specific location [7].

When mobile device developers started to introduce MAR environment authoring tools and MAR applications, such as BlippAR, LayAR and Wikitude, the capabilities of the AR browser were limited. For example, the ability to overlay objects was limited [27]. However, as mobile technology has evolved, these capabilities have improved [27], and various educational applications have been developed. For instance, Google Sky Map was developed to teach astronomy, and FETCH! and Lunch Rush were designed to teach math skills [28]. Most of these applications allow users to utilise mobile device tools such as cameras, GPS, compasses, gyroscopes and touch screens. As a result, new applications have extended AR capabilities to offer information via auditory, visual and tactile interactions.

According to Statista, which specializes in online statistics, market research and business intelligence portals, the global market for MAR revenue increased from $12.45 billion in 2021 to about $17 billion in 2022. A massive increase in this revenue is expected to occur in subsequent years; it is projected to reach over $36 billion by 2026 [29]. As technology has become more cost-effective and publicly available, the application of technology has also become a trend in learning and development, creating more opportunities for more interactive and dynamic education.

As a result, AR is considered one of the best approaches to improving the learning and development process. Therefore, applying AR on mobile devices will facilitate the achievement of this objective due to the interactive features of MAR, which are available on most new mobile devices. Thus, MAR technology was used to design mobile training course content for several reasons [30]:

1. AR increases motivation and engagement in the learning process. According to several studies, AR increases the motivation to learn [10]. MAR technology improves students' motivation and engagement in learning [13].

2. MAR simplifies the presentation of data and facilitates the understanding of information. MAR can be used to simplify the presentation of statistics or numbers in different ways. For instance, it can engage users by asking them to use their mobile phones to scan a QR code, and information will then be presented through an image, sound or video. Thus, data visualization facilitates knowledge acquisition and provides new experiences.

3. AR provides an opportunity for an educational experience through social learning. Technology has made AR one of the best options for social learning. Through this methodology, people can learn from each other through observation, imitation or modelling. The features that are available on new mobile devices, including MAR applications, make this technology easy to access and easy to use to communicate and share a social learning experience [30].

4. MAR encourages the implementation of a practical approach to meet the needs of learners. The use of MAR encourages users to learn by implementing a practical approach to enable learners to achieve their goals. For example, mobile devices can be used in factories to train workers to assemble or install parts and to repair components using MAR applications when users hold their mobile device over a selected machine part. This approach leads users through practical sessions and steps that encourage them to continue toward the final goal of gaining knowledge and skills in this field. Thus, their work will become more efficient and contribute to increased production [30]. Additionally, MAR can be applied as a learning approach. For instance, databases of books in a library can be linked with applications on mobile devices using QR codes. This could help users to easily find the information they need, such as the locations of books on shelves, show a summary of content or even explain how to use the search method, making it easier to access knowledge [31].

AR offers an enhanced delivery of mobile learning content by attracting learners' attention and motivating learners to be involved in the learning and training process. Some studies have shown positive effects and outcomes of AR. However, it is important to innovate and concentrate on appropriate learning theories that are consistent with MAR when developing AR

applications or designing training content to be used for m-training since the educational value of AR is not solely based on the AR features that are available on mobile devices [24], [32]. Therefore, future studies should concentrate more on using MAR technology for educational purposes due to its vast potential implications and benefits for learning, especially in a training environment.

2.5 Motivation in Learning (Intrinsic Motivation and ARCS Model)

Keller [9] described motivational design as a systemic approach to increase individuals' motivation using procedures and resources. Keller's [9] theory of motivational design uses existing studies on human motivation and is influenced by various elements, including the learning environment and instruction. Motivational design endeavors to make learning more intrinsically attractive; there should be a link between the motivational characteristics of learning and the learning objectives to encourage learning [9].

2.5.1 Intrinsic Motivation

Motivation toward learning represents the energy that activates a learner's desire to participate in the learning experience [2]. Applying effective learning strategies in the context of learning is considered an important way to increase learners' motivation [10], and the usage of interactive learning theories in a learning environment increases the interaction among learners [11].

The intrinsic motivation to learn is associated with the internal willpower of learners to learn by themselves without external rewards or pressure [33], [34]. There are four main factors that stimulate intrinsic motivation: curiosity, being challenged, control and fantasy [35]. The most important requirements for sustaining motivation in learning are a positive attitude and willpower, and intrinsic motivation stimulates the learner to engage in academic activities without pressure or the expectation of external rewards [35]. Thus, intrinsic motivation can disseminate positivity and allow learned information to be retained for an extended period of time.

The motivation of learners can be affected by attractive content or interactive learning materials that are created based on motivational design to enhance learners' motivation to learn [9]. Learners are more stimulated and more positive about learning when an intrinsic motivation strategy is used during the learning process [33]. Implementing intrinsic motivation in mobile applications using AR and multimedia technology has positive impacts on learners' motivation, as shown by several studies [2], [10], [35], [36], [37]. Hence, learners are influenced by using interactive and attractive content that captures their attention [35]. Therefore, it is crucial to design interactive content that motivates learners who are using mobile devices to learn.

2.5.2 ARCS Model of Motivational Design

John Keller's ARCS model is a motivational design approach that suggests strategies that can be used to motivate learners [9]. The ARCS model consists of four major elements: attention, relevance, confidence and satisfaction. All four elements increase and sustain motivation throughout the learning process. The aim of the ARCS model is to make learning experiences enjoyable and engaging, which in turn improves the learning process [9]. The Instructional Materials Motivation Survey (IMMS) is related to the ARCS model, and it was designed by Keller to measure learners' motivation levels in terms of the ARCS model [9]. The IMMS has 36 items. The attention element contains 12 items, the relevance and confidence elements contain 9 items each and the satisfaction element contains 6 items. Table 1 presents the definitions of these elements based on Keller's ARCS model of motivation [9].

Table 1: Definitions of elements based on Keller's ARCS model of motivation [9]

Categories	Definitions
Attention (A)	Attracting learners' attention and motivating learning
Relevance (R)	Fulfilling the learner's individual needs/goals to create a positive viewpoint
Confidence (C)	Helping learners believe in their ability to succeed
Satisfaction (S)	Enhancing achievement with rewards (internally and externally)

The attention factor is the most crucial since it begins to motivate learners by attracting learners' attention, and learners are typically eager to invest their time and pay attention when they are interested [38]. Active participation, the usage of humor, conflict, diversity in the types of media used and real-world examples are all effective ways of capturing learners' attention [39].

According to Keller [9], achieving relevance requires three strategies: goal orientation, motive matching and familiarity. Goal orientation can be attained by explaining to the learners how the knowledge will benefit them today and in the future; motive matching is achieved by evaluating the learners' needs and learning purpose to offer options that are in line with their motives; and familiarity is established by offering examples that pertain to the subject matter and are relevant to the learners' experience [38].

Confidence is associated with learners' beliefs and feelings and can be established by providing timely and meaningful feedback that positively reinforces personal accomplishments [38].

The satisfaction factor is related to the sensation of reinforcing success and a sense of satisfaction with the results acquired from the learning process, where learners can use the knowledge that they have gained in meaningful ways [9].

3.0 RESEARCH METHOD

To measure the impact of the designed course on trainees' motivation, a quantitative study was applied. The study targeted government employees: they were taught essential communication skills in the workplace based on an analysis of their actual training needs. The mobile training course was designed and developed in an MAR environment. The Metaverse Studio platform was utilized to develop the course content on essential communication skills in the workplace. Metaverse Studio is an augmented reality platform and authoring tool that enables the creation of MAR content online; this content can be exported to and viewed on mobile devices. It is compatible with the iOS and Android mobile operating systems, and the Metaverse Studio app makes it possible to create and import content for the scenes that are chosen and merged, with various triggers and overlay selections. The output is a mobile training application that contains interactive content and has an interactive interface and activities that use mobile augmented reality technology and multimedia tools. Additionally, the training application includes tools for assessment and evaluation.

This study utilized the ARCS model of motivational design to measure trainees' motivation by applying the IMMS. It was designed to run on mobile devices and on computers via web browsers. The IMMS form was linked to Google Forms, which were completed by the trainees after the end of the course.

Participants were selected from different government institutions based on their training needs and then divided randomly into two different groups. Thirty-two government employees were selected and divided randomly into the following two groups: the experimental group (16 employees) and the control group (16 employees). This sample size was determined according to the training needs of the participants and is close to the average sample sizes of other relevant studies [2], [7], [40], [41], [42].

The same training topic was assigned to both groups. The experimental group utilized the developed m-training application via mobile devices, and the control group joined an electronic course on the Google platform via computers. Participants'

consent was obtained before conducting the training program. They had not attended similar courses before and had a gap in their training. This was shown by the analysis of their training needs. Ethical and professional issues such as language translation were also considered. The training began in February 2021, and participants were given the flexibility to decide when to complete the training depending on their work circumstances. However, the training had to be completed within one month for both groups. Fig 1 summarizes the experimental setup.

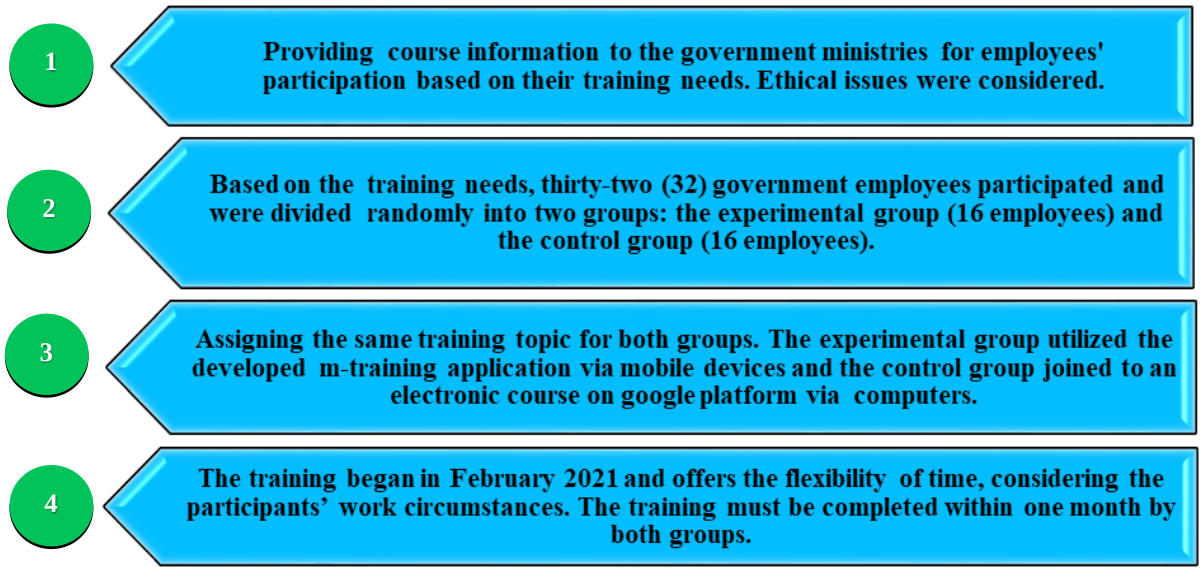

Fig. 1: Experimental setup

Fig. 2 shows scenes from preparing to conduct the training and from checking the m-training application before starting the training program.

(a) Application icon on mobile device.

(b) Course interface showing the trainer introducing the course.

(c) Sample of an activity that uses QR codes.

(d) An activity that uses image recognition.

Fig. 2: Preparing and checking course content before starting the training program

Fig 3 displays some photos taken during the implementation of the training program. There were several activities involved. Trainees were engaged in activities that use marker-based MAR methods, such as image recognition and QR codes. Some

activities developed by using the marker-less MAR method, which is based on locations determined by using GPS, allow trainees to interact with the course content from specific locations. Multimedia tools were used in designing the content of activities by integrating various items such as text, graphics, audio, video, and animation to attract trainees.

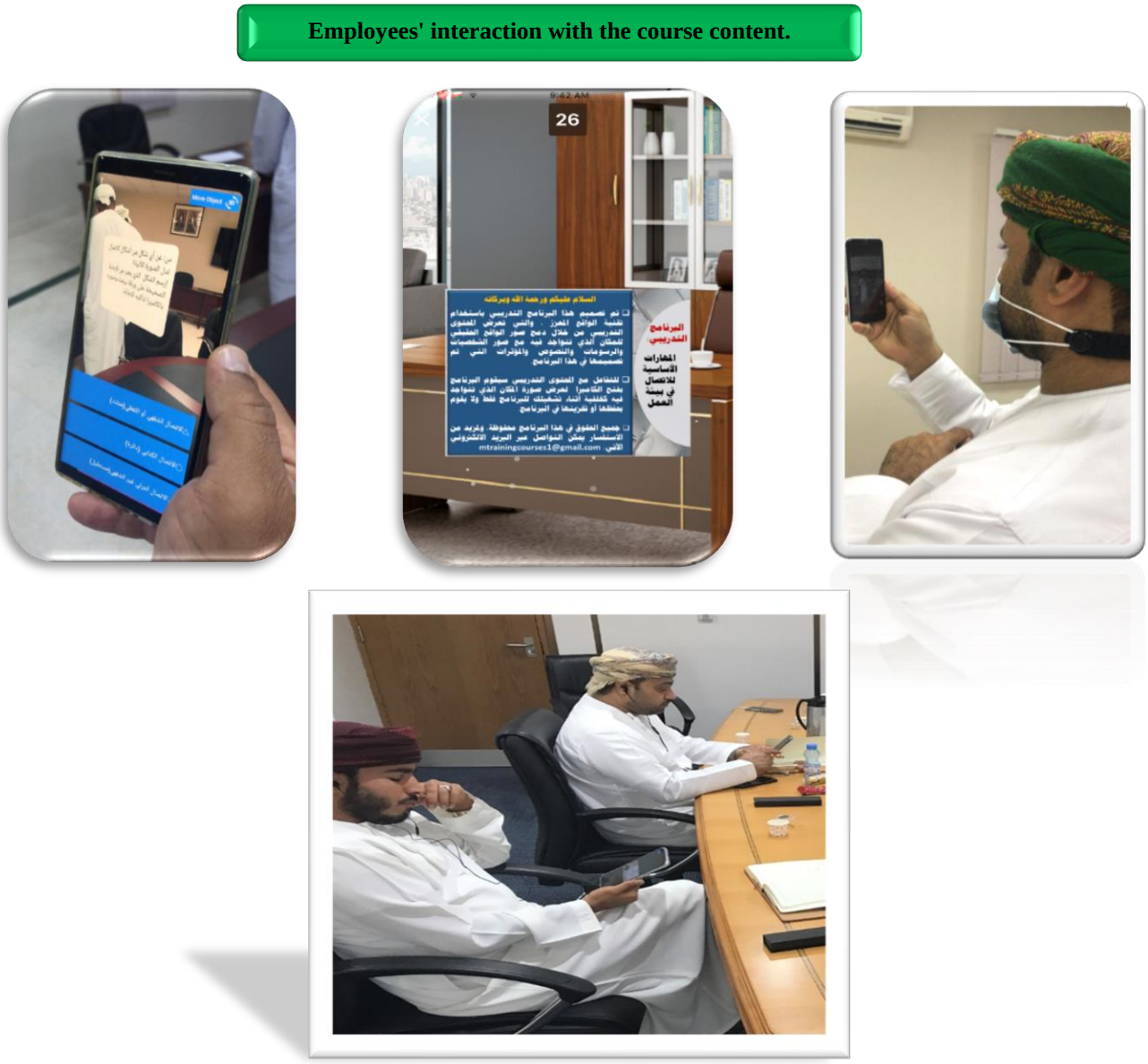

Fig. 3: Photos taken during the implementation of the training program

The next section explains the procedures that were utilised after the end of the training to analyse the responses of the trainees to the IMMS.

4.0 DATA ANALYSIS

The Statistical Package for the Social Sciences (SPSS) and Microsoft Excel software were used for the analysis of the Instructional Materials Motivation Survey (IMMS). The central limit theorem (CLT) indicates that if the sample size is greater than or equal to 30, it is safe to assume that the data follow a normal distribution [43], [44], [45]. Therefore, the CLT suggests that the assumption of normality (normal distribution) is valid for these data. The professional language translation of the

motivational survey content took into account that it needed to be easily understood by the trainees. There are 36 items in the IMMS. These items are grouped into four aspects: attention, relevance, confidence and satisfaction. The attention element has 12 items, the relevance and confidence elements have 9 items each and the satisfaction element has 6 items [9].

Table 2 explains these aspects and items.

The trainees use the following values to indicate their response to each item (i.e. a 5-point Likert-type scale): (1) = not true, (2) = slightly true, (3) = moderately true, (4) = mostly true and (5) = very true.

Table 2: Instructional Materials Motivation Survey (IMMS) ([9], [46])

Subscale	Items
Attention	Q1.There was something interesting at the beginning of this course that got my attention. Q2.These materials are eye-catching. Q3.The quality of the writing helped to hold my attention. Q4.This course is so abstract that it was hard to keep my attention. (reverse item) Q5.The pages of this course look dry and unappealing. (reverse item) Q6.The way the information is arranged on the pages helped keep my attention. Q7.This course has things that stimulated my curiosity. Q8.The amount of repetition in this course caused me to get bored sometimes. (reverse item) Q9.I learned some things that were surprising or unexpected. Q10.The variety of reading passages, exercises, illustrations, etc., helped keep my attention on the course. Q11.The style of writing is boring. (reverse item) Q12.There are so many words on each page that it is irritating. (reverse item)
Relevance	Q1.It is clear to me how the content of this material is related to things I already know. Q2.There were stories, pictures or examples that showed me how this material could be important to some people. Q3.Completing this course successfully was important to me. Q4.The content of this material is relevant to my interests. Q5.There are explanations or examples of how people use the knowledge in this course. Q6.The content and style of writing in this course convey the impression that its content is worth knowing. Q7.This course was not relevant to my needs because I already knew most of it. (reverse item) Q8.I could relate the content of this course to things I have seen, done or thought about in my own life. Q9.The content of this course will be useful to me.
Confidence	Q1.When I first looked at this course, I had the impression that it would be easy for me. Q2.This material was more difficult to understand than I would like for it to be. (reverse item) Q3.After reading the introductory information, I felt confident that I knew what I was supposed to learn from this course. Q4.Many of the pages had so much information that it was hard to pick out and remember the important points. (reverse item) Q5.As I worked on this course, I was confident that I could learn the content. Q6.The exercises in this course were too difficult. (reverse item) Q7.After working on this course for a while, I was confident that I would be able to pass a test on it. Q8.I could not truly understand some of the material in this course. (reverse item) Q9.The good organization of the content helped me be confident that I would learn this material.
Satisfaction	Q1.Completing the exercises in this course gave me a satisfying feeling of accomplishment. Q2.I enjoyed this course so much that I would like to know more about this topic. Q3.I truly enjoyed studying this course. Q4.The wording of feedback after the exercises or of other comments in this course helped me feel rewarded for my effort. Q5.It felt good to successfully complete this course. Q6.It was a pleasure to work on such a well-designed course.

There are 10 reverse items in the IMMS instrument (5 items from the 'attention' aspect, one item from the 'relevance' aspect and 4 items from the 'confidence' aspect). The scores of the reverse items were manually calculated. The lower a trainee's score on the reverse item, the higher the trainee's motivational score. According to Keller [9], if the first three subscales are observed, ultimately the learners' satisfaction will increase.

Reliability is the capacity to generate stable and consistent outcomes. Testing the reliability of a questionnaire is an important part of determining how well the questions for each element fit into the questionnaire. The Cronbach's alpha coefficient is the most widely used internal consistency metric [47]. According to Namdeo and Rout [48], an alpha score of 0.7 or higher is regarded as acceptable, whereas an alpha score of 0.8 or higher is regarded as good and an alpha score of 0.9 or higher is regarded as excellent. A Cronbach's alpha scale was used in this research to measure the reliability of the outcome from both groups by utilising SPSS software for data analysis.

The overall mean values were used to compare the trainees' learning motivation between the two groups (experimental and control) and to determine if there was a statistically significant difference in the motivation. The null hypothesis was that the experimental group's mean value was equal to the control group's mean value. The alternative hypothesis was that the experimental group's mean value differed from the control group's mean value. A benchmark level of 0.05 was set: if p-values were less than 0.05, they were considered significant, whereas if p-values were greater than 0.05, they were not considered significant. An independent t-test was conducted to compare the mean motivation values of the experimental group and the control group. This data analysis helped to measure the trainees' motivation and is explained in the next section.

Researchers utilise the eta-squared statistic to measure the effect size to compare the effects of groups of independent and dependent variables [49]. Eta-squared was used to measure the effect size of the significant difference between the two groups (experimental and control) in terms of the motivation. The basic rules of the eta-squared effect size are the following: if η^2 is greater than or equal to 0.01 and less than 0.06, this indicates a small effect; if η^2 is greater than or equal to 0.06 and less than 0.14, this indicates a medium effect; and if η^2 is greater than or equal to 0.14, this indicates a large effect [50], [51]. Analysing these data made it possible to measure the effect size for trainees' motivation.

5.0 RESULTS AND DISCUSSION

5.1 Results

This section discusses the results of analyzing the IMMS data to measure the motivation of trainees in the experimental and control groups to participate in the training conducted for each group.

5.1.1 Reliability Scale

The overall reliability of the questionnaire shows how well the questions for each ARCS construct fit into the questionnaire. A Cronbach's alpha scale was used to measure the reliability of the results. It was utilized to evaluate the questionnaire responses from both groups to determine the reliability of the questionnaire. Table 3 shows the Cronbach's alpha scale for each ARCS factor (reliability scale). Scores above 0.90 were achieved for each factor, and the overall reliability score was 0.985.

Table 3: Cronbach's alpha values for each ARCS factor

ARCS Factors	Reliability Scale (Cronbach's Alpha)	No. of Items
Attention	0.960	12
Relevance	0.907	9
Confidence	0 .952	9
Satisfaction	0 .974	6
Overall reliability	**0.985**	**36**

5.1.2 Comparison of Trainee Groups' Responses to the IMMS Items

This section displays the results obtained from the responses of the trainees to the motivational items for the four ARCS factors: attention, relevance, confidence and satisfaction. Additionally, it presents a comparison of the average scores given to each IMMS item by the experimental group and the control group. Table 4 shows a comparison of the scores given to the IMMS items for each ARCS factor by each group.

Table 4: Comparison of the scores given to the IMMS items for each ARCS factor by each group

ARCS Factors	Items	Experimental Group Mean	Control Group Mean
Attention	Q1.There was something interesting at the beginning of this course that got my attention.	**4.56**	**3.50**
	Q2.These materials are eye-catching.	**4.19**	**3.63**
	Q3.The quality of the writing helped to hold my attention.	**4.63**	**3.75**
	Q4.This course is so abstract that it was hard to keep my attention. (reverse item)	**4.81**	**3.00**
	Q5.The pages of this course look dry and unappealing. (reverse item)	**4.88**	**3.81**
	Q6.The way the information is arranged on the pages helped keep my attention.	**4.81**	**3.50**
	Q7.This course has things that stimulated my curiosity.	**4.88**	**3.94**
	Q8.The amount of repetition in this course caused me to get bored sometimes. (reverse item)	**4.75**	**4.06**
	Q9.I learned some things that were surprising or unexpected.	**3.88**	**3.38**
	Q10.The variety of reading passages, exercises, illustrations, etc., helped keep my attention on the course.	**4.56**	**2.88**
	Q11.The style of writing is boring. (reverse item)	**4.50**	**3.88**
	Q12.There are so many words on each page that it is irritating. (reverse item)	**4.38**	**4.00**
Relevance	Q1.It is clear to me how the content of this material is related to things I already know.	**3.06**	**3.75**
	Q2.There were stories, pictures or examples that showed me how this material could be important to some people.	**4.25**	**3.44**
	Q3.Completing this course successfully was important to me.	**4.56**	**4.38**
	Q4.The content of this material is relevant to my interests.	**4.38**	**3.94**
	Q5.There are explanations or examples of how people use the knowledge in this course.	**4.50**	**3.31**
	Q6.The content and style of writing in this course convey the impression that its content is worth knowing.	**4.44**	**4.06**
	Q7.This course was not relevant to my needs because I already knew most of it. (reverse item)	**4.38**	**4.13**
	Q8.I could relate the content of this course to things I have seen, done or thought about in my own life.	**4.25**	**4.19**
	Q9.The content of this course will be useful to me.	**4.63**	**3.94**
Confidence	Q1.When I first looked at this course, I had the impression that it would be easy for me.	**3.88**	**3.50**
	Q2.This material was more difficult to understand than I would like for it to be. (reverse item)	**4.94**	**4.00**

ARCS Factors	Items	Experimental Group Mean	Control Group Mean
	Q3.After reading the introductory information, I felt confident that I knew what I was supposed to learn from this course.	**4.31**	**3.50**
	Q4.Many of the pages had so much information that it was hard to pick out and remember the important points. (reverse item)	**4.88**	**3.31**
	Q5.As I worked on this course, I was confident that I could learn the content.	**4.19**	**3.56**
	Q6.The exercises in this course were too difficult. (reverse item)	**4.81**	**4.00**
	Q7.After working on this course for a while, I was confident that I would be able to pass a test on it.	**4.56**	**3.69**
	Q8.I could not truly understand some of the material in this course. (reverse item)	**4.81**	**4.00**
	Q9.The good organization of the content helped me be confident that I would learn this material.	**4.69**	**3.56**
Satisfaction	Q1.Completing the exercises in this course gave me a satisfying feeling of accomplishment.	**4.44**	**3.75**
	Q2.I enjoyed this course so much that I would like to know more about this topic.	**4.75**	**3.69**
	Q3.I truly enjoyed studying this course.	**4.75**	**3.88**
	Q4.The wording of feedback after the exercises or of other comments in this course helped me feel rewarded for my effort.	**4.38**	**3.63**
	Q5.It felt good to successfully complete this course.	**4.56**	**4.13**
	Q6.It was a pleasure to work on such a well-designed course.	**4.75**	**3.75**

There were reasonable differences in the motivation levels of trainees in both groups according to their responses to the attention factor items. The highest average motivation level for the attention factor items was 4.88, which was the average score for the experimental group for Q5 and Q7. Q5 (a reverse question) was related to the displayed content in this course, and Q7 pertained to stimulating the curiosity of trainees. This result emphasized that the displayed content was attractive and that the course content design stimulated participants' curiosity. In contrast, the lowest average motivation level was 2.88, which was the average score for the control group for Q10. Q10 asked if the variety of reading passages, exercises, illustrations, etc., helped the trainees to focus on the training course. Trainees in the control group had a lower motivation level for this item than the experimental group participants who participated in the m-training course that used mobile augmented reality; the percentage difference was about 58.3%.

The highest average motivation level for the relevance factor items was 4.63, which was the average score for the experimental group for Q9. Q9 asks to what extent the course content will be useful for the participants. The lowest average motivation level was 3.31, which was the average score for the control group for Q5. Q5 was related to offering examples of how people use the knowledge provided in the course. The relevance factor showed the lowest difference in motivation between the experimental group and control group, which was 1.4%, for Q8. Q8 asked if trainees could relate the content of this course to things they had seen, done or thought about in their own lives. This indicates that there was no large difference in the course content, because both groups were assigned the same topic, but there was a difference in how the content was designed.

The confidence factor had the highest average motivation level of 4.94, which was the average score for the experimental group for Q2 (a reverse question). Q2 asked whether the material was more difficult to understand than trainees would like for it to be. The responses to this question indicated that 98.8% of the trainees who used the designed m-training application felt that the material was not difficult to understand; this indicates that utilising MAR facilitates the learning process, as found in previous studies. On the contrary, the lowest average motivation level was 3.31, which was the average score for the control group for Q4 (a reverse question). Q4 was related to the information in the displayed scenes. This question revealed that about

66.2% of the trainees who did not utilise the MAR training application found it challenging to pick out and remember the important points in the displayed scenes.

There were three items (Q2, Q3 and Q6) in the satisfaction construct for the experimental group that had the same average score (4.75), which represents the highest average motivation level for this factor. The responses to these questions indicated that 95% of the trainees in the experimental group truly enjoyed this course, would like to know more about this topic and also found it a pleasure to work on such a well-designed course. In contrast, the lowest average motivation level was 3.63, which was the average score for the control group for Q4. Q4 asked if the feedback provided after the exercises or other comments in this course helped the trainees feel rewarded for their effort.
The following subsection displays the t-test results and compares the motivation levels of the trainees in the two groups using the overall mean values for each factor of the IMMS.

5.1.3 Comparison of Different Trainee Groups' Mean Motivation Values for Each ARCS Factor

The motivation levels of the trainees in the two groups are compared using the overall mean values. The findings of the independent t-test can be used to investigate whether the experimental group's mean value was equal to that of the control group. Additionally, it highlights whether there was a statistically significant difference in the motivation levels.
Fig 4 shows a comparison of the mean motivation values for the control group and the experimental group.

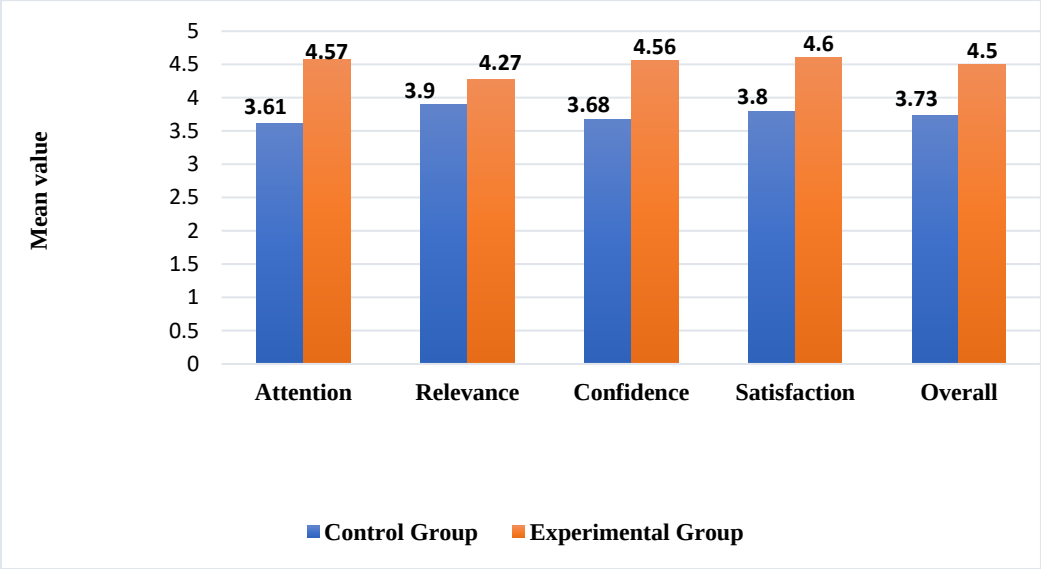

Fig. 4: A comparison of the mean motivation values for the control group and the experimental group

The results of the independent sample t-test and the percentage differences in the mean motivation values of the control group and the experimental group are displayed in Table 5.

Table 5: The t-test results and the differences in the mean values of both groups

ARCS Factors	Control Group	Experimental Group	Difference (E-C) / C*100
Attention	3.61	4.57	26.59%
Relevance	3.90	4.27	9.48%
Confidence	3.68	4.56	23.91%
Satisfaction	3.80	4.60	21.05%
Overall	**3.73**	**4.50**	**20.64%**
Std. deviation	**1.17**	**0.466**	
t		**2.429**	
P		**0.025**	

- The results revealed that there was a significant difference between the mean motivation values of the experimental group (M = 4.50, SD = 0.466) and those of the control group (M = 3.73, SD = 1.17) (t = 2.429, p = 0.025).
- The overall mean motivation value for the experimental group was higher than that for the control group by 0.77, which corresponds to a difference of 20.64%.
- The null hypothesis was rejected, and we accept the alternative hypothesis, which states that the experimental group's mean value was not equal to that of the control group.
- These results indicate that trainees from the experimental group were more motivated than those from the control group.

5.1.4 Measuring the Effect Size

Since the results indicated that there was a significant difference in the mean motivation values of the experimental and control groups, eta-squared was utilised to measure the effect size. Table 6 shows the effect size of using MAR in the designed course for trainees' motivation.

Table 6: The effect size of using MAR in the designed course for trainees' motivation

Measure of Association	Eta	Eta-squared
Effect size	0.405	0.164

The effect size was 0.16, which indicates that using MAR in the designed course had a large effect on motivation compared to the other training method, which does not use MAR.

5.2 Discussion

Keller's ARCS (attention, relevance, confidence and satisfaction) model and the IMMS were used to collect information about the motivation of the learners. In terms of measuring the reliability of the results for each ARCS factor and the overall reliability, a Cronbach's alpha scale was applied using SPSS statistical software. Table 3 shows scores above 0.90, which indicates excellent reliability, hence indicating that the results obtained are reliable [48].

An independent t-test was conducted to compare the mean motivation values of the experimental group and the control group. The results in Table 5 show an increase in the mean motivation values of the trainees who used the mobile training application with MAR (the experimental group) compared with the mean motivation values of the trainees who did not utilize this mobile training application (the control group).

The first criterion for motivating learners, according to the ARCS model, is attracting their attention, which should be achieved by excitement and diversity in the course content and directives. The results in Table 5 reveal that the highest difference in the mean motivation values of the experimental group (4.57) and the control group (3.61), which was approximately 26.59%, was related to the attention factor. This indicates that the m-training course had a positive impact in terms of attracting learners' attention and arousing their curiosity about the training process.

We applied different approaches to attract trainees. A simple and attractive interface was designed to attract trainees' attention. The introduction was designed with a motivating style, and we used various types of sound effects and simple graphics, pictures, videos, and drawings. Most of the trainees who utilized the m-training application group agreed that the designed course had attracted their attention and motivated them to learn; this was not the case for the trainees in the control group. This shows that the course content was delivered using an attractive and interactive style and that the training was conducted in a motivating training environment.

In contrast, the lowest difference between the experimental group and the control group in motivation was approximately 9.48%, and it was related to the relevance factor, which shows that there was no large difference in the course content created for the two groups. The designed course was relevant to the trainees' past experiences and fulfilled their needs and goals, creating a positive viewpoint.

The confidence factor in this study assesses the confidence level of trainees who were trained using the designed MAR mobile training application and the confidence level of other trainees who were not trained using the mobile training application. The results show a rise in the mean motivation values of the trainees from 3.68 for the control group to 4.56 for the experimental group. This indicates that the trainees in the experimental group felt more confident than those in the control group. The difference was about 24%, and this increase in confidence indicates that the designed mobile training application using MAR positively reinforces expectations for achieving success among trainees, as stated in previous studies such as the MALIK study [38].

The satisfaction factor measures trainees' sense of satisfaction with the outcomes of the training they attended. The results reveal an increase in the mean motivation value of 21.05% for trainees in the experimental group compared with trainees in the control group. This indicates that trainees who utilized the mobile training application (the experimental group) were more satisfied than those in the control group. This increase in the mean motivation value for the satisfaction factor for the experimental group indicates that the trainees had a sense of achievement, were entertained by the mobile training application and felt more satisfied with the outcomes they achieved. This encourages trainees to apply what they have learned in meaningful ways [9].

Based on the information provided in Table 5, there was a significant difference in the mean motivation values of the experimental group ($M = 4.50$, $SD = 0.466$) and the control group ($M = 3.73$, $SD = 1.17$) ($t = 2.429$, $p = 0.025$).
The motivation level of the trainees who used the AR mobile application increased by 20.64%. The attention, feeling of relevance, confidence and satisfaction of the trainees increased significantly by approximately 27%, 9.5%, 24% and 21%, respectively. This result was found to be consistent with previous studies, such as those performed by Di Serio et al. [2] and Chiang et al. [10], which emphasized a positive impact on trainees' motivation.

These findings made it possible to compare the motivation levels of trainees who used the designed AR mobile application (experimental group) and trainees who did not use this application (control group).

Therefore, the null hypothesis was rejected, and we accepted the alternative hypothesis, which states that the experimental group's mean motivation value was not equal to that of the control group. This proves that the trainees from the experimental group were more motivated than those from the control group.

The effect size was measured using eta-squared to compare the effects on the motivation levels of the two groups (experimental and control), and the results indicate that there was a large effect on the motivation of the experimental group. This outcome reveals that designing course content using MAR has a positive impact on trainees' motivation for m-training courses.

The validity of a study is related to its accuracy, and it clarifies the extent to which a study measures what it claims to measure. When a valid measurement is carried out, it provides a reliable result, and when the methodology utilised is unreliable, the results are most likely invalid [52][53]. Reliability involves issues related to the dependability, applicability, accuracy, rigor and consistency of the data, instruments, techniques and procedures used to produce the results; in other words, it measures whether or not another, the similar experiment would produce similar results [52][53].

To increase the trustworthiness of this study, several strategies were applied. For instance, to maintain the trustworthiness of the quantitative data collection and analysis, validity and reliability were considered in this study. Participants were informed about the study, and their consent was obtained prior to the implementation of the course. Moreover, professional language translation verification was utilized. The validity and reliability of quantitative data were measured and applied to the analysis of the data using SPSS statistical software. The Cronbach's alpha scale was used to ensure the reliability of the measurement tools utilized in this study. The results showed high-reliability values, which indicated that reliable instruments were being used. Furthermore, a t-test was performed to determine if the resulting difference between the values of the sample groups was too large to be a coincidental occurrence and to determine if any variation exists in the population being studied.
In summary, different strategies were applied in this study to enhance the findings' dependability and ensure reliability, validity and trustworthiness. Hence, the study can be regarded as trustworthy. The results of conducting an independent t-test to compare the mean motivation values of the experimental group and control group indicate that trainees from the experimental group were more motivated than trainees from the control group, and this outcome is consistent with previous studies. The findings indicate that learners' motivation can be increased by m-training courses using MAR. This in turn encourages more employees to participate in m-training courses and contributes to the development of human resources in various fields.

6.0 LIMITATIONS

The course content was developed in an MAR environment by using the Metaverse Studio as an AR platform; mobile applications with standard features that were suitable for the proposed course content design were developed. Nevertheless, many other MAR authoring tools and platforms could be used to design and develop course content with sophisticated functionalities and more possibilities for professional purposes. However, the tool that best corresponds to the proposed course content and the development needs must be selected.

The study was conducted during the COVID-19 pandemic, which necessitated many restrictions and lockdowns, resulting in limitations and delays in obtaining approval to conduct the training and during the execution of the training sessions. However, this issue was addressed by managing the study plan schedule and adjusting it according to pandemic restrictions.

This study adopted a quantitative method, which could have limitations in eliciting deeper insights to explore trainees' behavior, perceptions, and feelings and interpret the meanings of their actions with more details [54],[55]. However, we followed a systematic scientific method to enhance the dependability of the findings and provide reliable results to accomplish the study objective. We considered ethical, validity and reliability issues in this study, and we believe that this study offers a better understanding of how using MAR in an interactive m-training course impacts learners' motivation.

7.0 CONCLUSION

Certain studies have revealed a lack of research on the impact of AR applications in education [3], [4], [5], [10]. Thus, we explored the potential of AR in motivating learners to learn and participate in training courses via mobile devices, which might contribute to the development of their knowledge and skills.

The objective of this study was to evaluate an interactive m-training course with MAR that was designed to train government employees in Oman by measuring its impact on the trainees' motivation. Achieving this objective involved answering a research question concerning the impact of the designed m-training course on employees' motivation. A quantitative study was implemented to answer the research question, and the designed course on essential communication skills in the workplace was used to train government employees. The course was then evaluated by measuring its impact on trainees' motivation.

The introduction and background sections review several aspects related to the concepts relevant to this study. The importance and effectiveness of using AR to motivate learners and the benefits and challenges of employing AR in education were discussed.

We explained the importance of using intrinsic motivation to motivate learners, the ARCS motivational model and how to utilise IMMS to measure learners' motivational levels. Some suggestions were made concerning how to implement augmented reality and how to improve the design of educational content using augmented reality to motivate learners.

We conducted the training for 32 employees who were randomly divided into a control group and an experimental group. At the end of the training, we applied the IMMS as an evaluation instrument to measure participants' motivation. SPSS statistical software was used for data analysis. The results proved that the m-training course was motivational and had a positive impact on trainees' motivation to learn.

Future studies can be conducted to measure the impact of using mobile AR in an interactive m-training course on other variables, such as employees' achievements, behaviors or performance ergonomics. Furthermore, future research can focus on measuring the impact of training courses that use MAR on the return on training investment.

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