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A framework for designing interactive mobile training course content using augmented reality

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Abstract
Because mobile technology and the widespread usage of mobile devices have swiftly and radically evolved, several training centers have started to offer mobile training (m-training) via mobile devices. Thus, designing suitable m-training course content for training employees via mobile device applications has become an important professional development issue to allow employees to obtain knowledge and improve their skills in the rapidly changing mobile environment. Previous studies have identified challenges in this domain. One important challenge is that no solid theoretical framework serves as a foundation to provide instructional design guidelines for interactive m-training course content that motivates and attracts trainees to the training process via mobile devices. This study proposes a framework for designing interactive m-training course content using mobile augmented reality (MAR). A mixed-methods approach was adopted. Key elements were extracted from the literature to create an initial framework. Then, the framework was validated by interviewing experts, and it was tested by trainees. This integration led us to evaluate and prove the validity of the proposed framework. The framework follows a systematic approach guided by six key elements and offers a clear instructional design guideline checklist to ensure the design quality of interactive m-training course content. This study contributes to the knowledge by establishing a

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framework as a theoretical foundation for designing interactive m-training course content. Additionally, it supports the m-training domain by assisting trainers and designers in creating interactive m-training courses to train employees, thus increasing their engagement in m-training. Recommendations for future studies are proposed.

Keywords Designing mobile training course content · Mobile training · Mobile learning · Mobile augmented reality

1 Introduction

Given the ongoing development of mobile technology and the extensive use of mobile devices, interest has increased in enhancing learning through mobile technology. Globally, innovative initiatives have been developed related to m-learning applications for professional development. One such initiative is the mobile training (m-training) initiative, in which trainees perform self-learning and problem-solving tasks based on their training needs using mobile devices with trainer guidance [72]. M-training is considered a part of m-learning and is one of the categories classified by Traxler [70], who reviews previous studies published since the advent of mobile technologies. M-training involves activities that are designed for mobile devices in applications targeting trainees to attain specific goals based on their training needs. This form of training aims to transfer knowledge or improve skills according to remote participants' needs. The concept of m-training is based on technology that enables the creation of m-learning courses, a trend that has evolved swiftly in recent years. As a new learning model, it is a development of electronic training (e-training). Therefore, m-training is considered an extension of the traditional training model [72]. M-training and the traditional training model differ in several ways. Traditional training can be briefly described as training that is carried out when trainees go to a training location. Thus, it requires a training space with available training aides, and it includes direct interaction between the trainer and the trainees. Figure 1 shows how m-training is superior to traditional training [10, 21, 28].

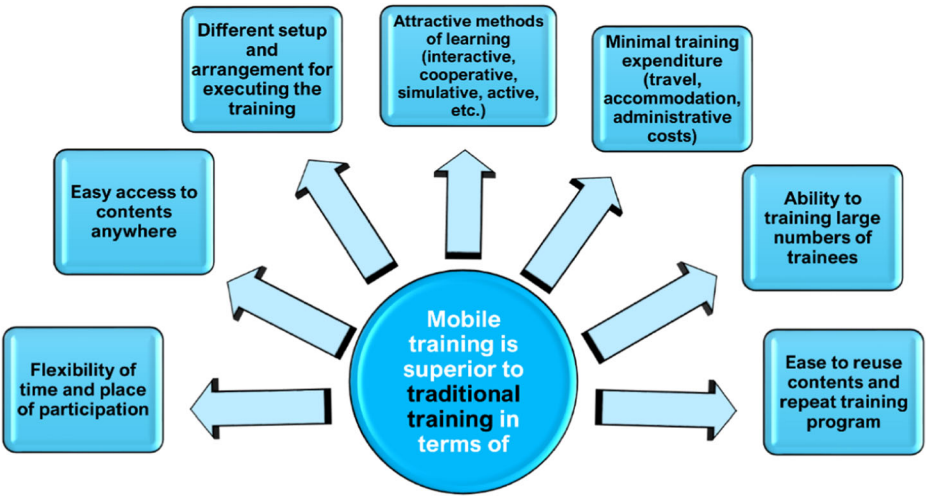

Fig. 1 Advantages and benefits of m-training over traditional training

Because mobile technologies have developed, institutions have started to offer training services via mobile devices. However, studies have indicated that this domain poses challenges. The main challenge is designing interactive m-training course content that can motivate and attract trainees to engage in the training process via mobile devices, while no stable framework serves as a theoretical foundation to provide instructional design guidelines.

To stay current with m-learning technology advancements, m-training courses should be designed and delivered for employees to acquire knowledge and develop their abilities in the quickly changing mobile environment. This study proposes a framework for designing interactive m-training course content using mobile augmented reality (MAR) technology. MAR was selected since many studies have noted the effectiveness of including augmented reality (AR) in learning materials. Interactive technology is available on most new mobile devices, and it helps motivate learners and enhance the quality of the learning process. Our framework assists trainers and designers in creating interactive m-training courses to train employees via mobile devices.

This study aims to fulfill the following objectives:

1. *Identify and propose the key elements to establish an initial framework for designing interactive m-training course content using MAR.*
2. *Validate the initial framework for designing interactive m-training course content using MAR.*
3. *Test the proposed framework with trainees (user evaluation).*

We propose the key elements, validate the initial framework's key elements and test the proposed framework for designing interactive m-training course content using MAR. The initial framework's key elements were identified based on the literature, and then, we validated the framework's key elements by interviewing experts. This validation process resulted in the establishment of a proposed framework. The proposed framework was tested by conducting an m-training course designed based on the proposed framework procedures and guidelines to train employees via mobile devices. Achieving this outcome ensures the usage of the proposed framework to design interactive m-training course content with the use of MAR technology. Finally, recommendations are presented for future studies.

2 Background and statement of the problem

This section presents the theoretical foundations of the research topic, such as basic concepts, definitions and relevant concepts. This section also states the research problem.

2.1 Definitions and relevant concepts

2.1.1 Mobile learning (m-learning)

The concept of m-learning has been identified in several studies. Previous studies have concentrated on understanding the features of mobile devices to improve learning considering the advantages and disadvantages of learning via mobile devices. Studies have shown that this type of learning complements and can be integrated with in-class learning or electronic learning [61]. Early definitions of m-learning have concentrated on the use of mobile technology and the ability

of learners to obtain knowledge from the learning process [65]. Following rapid advances in mobile technology, research has evolved in this field, and the definition of m-learning has developed. Some studies define m-learning from three perspectives: the mobility of the learner, the mobility of technology and learning mobility [47]. Several studies extend the m-learning definition to consider certain its characteristics, such as contextual m-learning and ubiquity [37, 45]. Ally & Samaka [5] define m-learning as delivering learning content via mobile devices and supporting learners by offering the flexibility to learn on the go.

Contemporary concepts of m-learning focus on social communication, interactivity, motivation and personality in the context of delivering interactive learning content that use the new features and capabilities of mobile devices, which include multimedia tools, global positioning systems (GPSs), MAR and social communication tools [13].

2.1.2 Mobile training course content (MTCC)

MTCC is related to information designed, developed and displayed on mobile devices for trainees in m-training courses who wish to gain knowledge or develop their skills. This content includes materials, activities, exercises, quizzes, tests, etc., presented in different forms such as text, images, video, graphics, QR codes, GPS, simulations, games or other interactive tools to facilitate an understanding of the training topic [9, 19]. Course content can be categorized based on the training topics into technical content, such as chemical components or manufacturing products, and nontechnical content focusing on managerial development, such communication skills or critical thinking and problem solving [19]. The most critical issue when designing this content is that content should be developed based on trainees' actual needs using a suitable framework following appropriate learning and design strategies and selecting content and information types best suited for their needs.

2.1.3 Mobile augmented reality (MAR)

Currently, mobile devices have many available features, and many new technologies have been developed to enhance the learning and training process. One of these technologies is AR, a technology that integrates the interactive real world with the interactive virtual world generated by computers in such a way that enhances users' perceptions of reality [11]. The aim of AR, as stated by Carmigniani et al. [16], is to make users' lives easier by presenting virtual details that are not present in their actual environment but that represent a realistic environment and augment users' comprehension of and interaction with the real world, such as the direct broadcast of video. AR can be applied in the educational field to offer more interactive content and attract more participants to engage in the learning process [15]. AR has excellent educational potential, which has been recognized and increased by researchers. The effectiveness of AR increases when it is integrated with different types of technologies, such as mobile devices [15]. This combination is called MAR. Researchers have pointed out that MAR based on learning is concentrated on games and simulations. Mobile devices, which have features of portability, connectivity, social interactivity, individuality and context sensitivity, offer a learning experience that is more meaningful, interactive and exciting [34]. Therefore, using MAR in m-training represents a strong solution since it offers immersive m-training via AR simulations and provides realistic gamification as content related to the proposed m-training topics with visible reactions in activities and assessments. All of these factors help trainees gain knowledge and develop their skills.

2.2 Statement of the problem

Due to the rapid development in mobile device technology, many training centers have started offering m-training services based on m-learning technology via mobile devices. Interactivity and attractive designs are crucial issues in designing m-training. However, m-training content currently suffers from low interactivity and low attractiveness because, as stated by several studies, no stable theoretical framework serves as a foundation for designing m-learning. For instance, Park [58] and Pedro et al. [60] mentioned the lack of a solid theoretical framework as a theoretical foundation for designing m-learning. Moreover, many studies in m-learning and development have focused on technologies more than the learning process [37, 63, 70].

In 2013, UNESCO conducted research in a series of working papers on m-learning, focusing on 2030 as a temporal horizon. One of the important recommendations provided by the study was to promote m-learning for all, to enhance and support the professional development of teachers through m-training and to train teachers in m-learning design [66].

Following a well-designed m-learning content methodology is important for stimulating learners' curiosities to engage in the learning process [30] and to facilitate increasing learners' learning achievement. Consequently, the issue arises of interactive content design for m-learning and m-training since no solid theoretical framework provides guidelines for designing mobile content that motivates and attracts trainees to be involved in the m-learning process [58]. This issue was emphasized by Pedro et al. [60], who mentioned that, in addition to the issue of executing m-learning practices for integration with the educational environment, a gap needs be filled regarding the shortage of the theoretical and pedagogical bases of m-learning. As a result, this issue represents the most significant pedagogical challenge in m-training content design, as stated in several studies [2].

Therefore, achieving the best learning enhancement requires considerable effort from more studies to establish stable frameworks for designing interactive m-training content.

3 Related work

3.1 Existing frameworks

To remain current with research studies, this study did not target older studies; it focused on studies conducted between 2015 and 2020. This study used two data-searching methods to discover the literature most relevant to the research topic. The first method was keyword searching from scientific databases. The search began with Web of Science (WoS) and proceeded with various other electronic databases: Scopus, Education Resources Information Center (ERIC), and the Institute of Electrical and Electronics Engineers (IEEE) Xplore Digital Library. The second method was the snowballing technique, which included searching references and bibliographies utilizing main articles or books linked to the study topic [74]. The objective of using more than one search method and different academic database search engines was to obtain a general review of the current research in the selected domain and to better understand the research problem. Therefore, the most reputable databases were selected that represented the largest available scientific online resources.

To search for existing frameworks for designing m-training course content, several keywords were used, such as mobile training course content design framework, mobile-based training course content design framework, mobile learning course content design framework,

Table 1 Inclusion and exclusion criteria

Inclusion Criteria		Exclusion Criteria	
In1	Title text and abstract are linked to the search keywords.	**Ex1**	Article is not relevant to the research topics.
In2	Published between 2015 and 2020.	**Ex2**	Title is not consistent with the purpose of the study.
In3	Relevant to the subject area (computer science, educational technology, educational research).	**Ex3**	Abstract does not address any aspect related to research topic.
In4	Full-text journal articles are available.	**Ex4**	Paper is a duplicate.
In5	Journal articles are filtered by keywords: ('design' AND 'mobile') in the title and the abstract.	**Ex5**	Articles are written in a language other than English.

mobile professional learning course content design framework, designing mobile learning course content, and mobile learning materials instructional design. The filtering process was identified for the search output and for the results of the snowballing technique to screen the relevant articles based on the inclusion/exclusion criteria shown in Table 1

In the filtering process, studies passed through the classification process described in the steps shown in Fig. 2 [2]:

1) The researcher read the abstracts searching for keywords and concepts linked to the research themes by utilizing synonyms.
2) If the abstract had insufficient data, the researcher read the introduction, conclusion and different sections as required.
3) When the keywords were found, a classification scheme was set up, and the articles were arranged into classes.

Following these steps allowed us to exclude unrelated studies and select pertinent ones by a selection process.

3.1.1 Search outcome

After synthesizing the outcomes and applying the filtering processes, the most relevant existing frameworks found from the search process for m-training course content design were selected. The results indicated that 11 previous frameworks and models were related to the research topic. These were classified based on the year of publication, key characteristics,

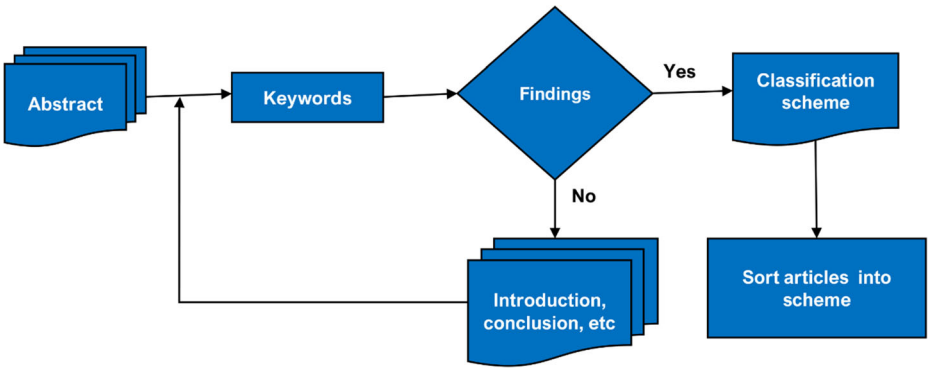

Fig. 2 Classification process

purpose of use, availability of design guidelines, theoretical backgrounds and outcomes. Table 2 summarizes these outcomes.

Based on the summary comparison of existing frameworks, the items in Table 3 provide a further explanation of the existing frameworks' analysis outcomes.

Overall, the outcome shows few shared key characteristics among frameworks such as pedagogy, learners and technology. However, the majority of the frameworks vary in their characteristics. Most of the frameworks use different theoretical backgrounds such as cognitive, collaborative, interactive, problem-based learning and experiential learning for various purposes of use, for instance, for evaluating language learning, assisting and encouraging educators, and proposing a thinking guide. These findings led to different framework outcomes. Moreover, few of the frameworks presented clear, standardized instructional design guidelines for designing m-training course content. Furthermore, the search results indicated that the majority of the frameworks did not focus on designing interactive m-training course content to train employees or defined for human resource development (Training). This outcome does not support the important recommendations and requirements indicated in several studies, such as the UNESCO study focusing on 2030 as a time horizon in addition to other studies [2, 6, 28, 66], to enhance and support professional development through m-training to train educators in m-learning design and to follow a well-designed mobile learning content methodology to expand the learning achievements of learners, which represents one of the important and essential requirements. This finding reveals the instability of m-learning design frameworks that can attract and motivate learners to participate effectively in the learning process via mobile devices and that emphasize the existence of the research problem.

All of these issues highlight the need to bridge the gap and build a stable theoretical basis for designing interactive m-training course content. Therefore, this study further explains the requirements of designing interactive training course content (learning materials) for mobile devices. In addition, it suggests a solution by establishing a framework for designing interactive m-training course content using MAR as interactive technology available in mobile devices.

3.2 Designing training course content for mobile devices

Because mobile devices are widely used and technological advancements must be kept up with, it is critical to think about how to create effective m-training content to boost learners' interest in m-learning courses [5]. Many studies have pointed out that designing attractive, interactive and user-friendly m-training course content to increase both learners' engagement and course accessibility via mobile devices differs from the design of electronic courses such as web-based courses accessible via an internet browser of a mobile device [1, 26]. M-learning content designers should consider mobile device limitations such as monitor size, input devices, bandwidth and navigation during browsing [5]. The majority of these technological features that must be considered when designing m-learning/training content have been indicated in several studies [5, 44, 60]. These issues are categorized based on the following factors [2]:

- **Physical conditions:** The use of mobile devices in outdoor environments, personal security issues, radio frequency radiation and excessive screen luminance.
- **Physical characteristics:** Small screen sizes, low memory, limited battery life and substantial weight.

Table 2 Comparison of existing frameworks

No.	Article Title, Year, Author	Key characteristics	Purpose of the use	Guidelines for interactive content design	Theoretical background	Outcomes
1	A model driven framework to address challenges in a m-learning environment, 2015 (Khaddage, Christensen, Lai, Knezek, Norris, & Soloway) [40]	Pedagogical, technological, policy and research challenges	Assisting and encouraging educators to integrate mobile devices into the educational process.	–	Collaborative methods	Guide or tool to support large-scale implementation of m-learning
2	Designing a M-learning Framework for a Formal Educational Context, 2015 (Rikala) [63] Framework for designing m-learning for a formal educational context	Pedagogy, context, learner aspect, device aspect, and social interactions	Designing m-learning for a formal educational context	Principles to imple-ment	m-learning in an edu-cational context	Teaching and learning methods that utilize mobile devices
3	Framework for Design of M-learning Strategies, 2015, (Figueredo O.R.B., Villamizar J.A.J.) [29]	Recognition, analysis, identification, bases, design, and implementation	Providing theoretical and practical tools for researchers and teachers for designing and implementing m-learning strategies that enhance teaching practice	–	M-learning theory based on learning analysis; motivational design using collaborative discussions and interactions	Framework for addressing the practical aspects of teachers' context and mobile technology integration
4	Framework for Designing M-learning Environments, 2016 (Churchill, Bob Fox and Mark King) [18]	Resources, activity, support and evaluation (RASE)	Apply to contemporary learning-centered pedago-gy	–	Contemporary learning-centered ped-agogy	Contemporary mobile technologies to present various tools for effective integration in teaching and learning
5						

Table 2 (continued)

No.	Article Title, Year, Author	Key characteristics	Purpose of the use	Guidelines for interactive content design	Theoretical background	Outcomes
	The Design and Development of MobiEKo: A Mobile Educational App For Microeconomics Module, 2017 (Muslimin, et al.) [55]	Analyze, design, develop, implement, and evaluate (ADDIE)	Learning a microeconomics module with the use of an m-learning application	General instructional design guidelines	Supply theory, instructional design theories, demand and elasticity theory	Framework for the design and development of a mobile educational application for learning a microeconomics module
6	A Smart M-learning Conceptual Framework for Professional Development of UAE In-Service Teachers, 2017 (Alawani & Singh, 2017) [3]	Instructional design, informed practices, and other sciences	Designing an m-learning course for teachers' professional development	Provide steps for content design	Learning design approach	A smart conceptual framework based on instructional design, personal and informed practices and other sciences
7	Framework for Designing Transformative M-learning, 2017 (Cochrane, et al.) [20]	Pedagogical integration of technology and assessment, lecturer modeling of the pedagogical use of the tools, creating a supportive learning community, appropriate choice of mobile devices and Web 2.0, technological and pedagogical support, and creating sustained interaction for the lecturers and the students	Shifting from teacher- to student-directed pedagogies and framing m-learning as a context to construct authentic learning communities	–	Sociocultural pedagogies, learner-centered collaboration and the support of authentic, community-based learning experiences	Evaluation of the extent to which the usage of mobile devices transforms the ecology of learning and assist in shifting the position of control toward student-generated contexts
8	State of the app: A taxonomy and framework for evaluating language	Technology, pedagogy, user experience and language learning	Evaluating language-learning mobile applications	–	Cognitive, collaborative, interactive, theories of mobile assisted language learning	Framework for evaluating language learning mobile apps

Table 2 (continued)

No.	Article Title, Year, Author	Key characteristics	Purpose of the use	Guidelines for interactive content design	Theoretical background	Outcomes
	learning mobile applications, 2017, (Rosell-Aguilar) [64]				(MALL) and second language acquisition (SLA)	
9	A framework for cooperative and interactive m-learning to improve online information evaluation skills, 2018 (Parsazadeh, et al.) [59]	Tasks, user, context and m-learning app usability attributes	Developing mobile apps that assist in improving the online information evaluation skills of students	–	Interactive learning theory and cooperative learning model	Set up an m- learning system that enables learners to be fully integrated with the learning environment
10	Designing a Theoretical Integration Framework for M-learning, 2019 (Zidoun, et al.) [76]	Pedagogy, content, mobile technology, learning environment and learner's profile	Proposing a thinking guide for integrating mobile devices into learning curricula	–	Collaborative learning, problem-based learning, and experiential learning	5-axis m-learning framework to assist educators with limited technological expertise in considering aspects of m-learning integration
11	Evolution of the iPAC Mobile Pedagogical Framework, 2020(Kearney M., Burden K., Schuck S.) [38]	Personalization: customization and agency, authenticity: task and context, collaboration: conversation and cocreation, and time–space	Foregrounding teachers' distinctively mobile pedagogies	–	Sociocultural pedagogical	Framework improving digital pedagogies that utilize new and developing mobile technologies

Table 3 Outcome of the existing frameworks analysis

No	Item	Clarification and Examples	
1	Key characteristics	Most of the frameworks have different key characteristics	• Pedagogical, technological, policy and research challenges • Pedagogy, context, learner aspect, device aspect, and social interaction • Recognition, analysis, identification, bases, design, and implementation • Resources, activity, support and evaluation (RASE) • Instructional design, informed practices, other sciences • Technology, pedagogy, user experience and language learning • Tasks, user, context and m-learning app usability attributes • Pedagogy, content, mobile technology, learning environment and learner's profile • Personalization, authenticity, collaboration
2	**Theoretical backgrounds**	**Using various theoretical backgrounds**	• Activity theory constructivism • Constructivism learning theory • Cognitive theory • Transactional distance theory • Sociocultural perspective • Demand and elasticity theory • Mobile assisted language learning (MALL) and second language acquisition (SLA) • Cooperative, collaborative learning, problem-based learning, experiential learning
3	**Outcomes**	**Different outcomes**	• Guide or tool supporting the large-scale implementation of m-learning • Framework for designing m-learning for a formal educational context • Framework for addressing practical aspects of teachers' context and mobile technology integration • Smart conceptual framework for professional development of teachers • Framework for evaluating language- learning mobile apps • Framework for assisting educators with limited technological expertise in considering aspects of m-learning integration • Framework for improving digital pedagogies that utilize new and developing mobile technologies
4	**Purpose of use**	**Variations in the purpose of use**	• Assist and encourage educators to integrate the use of mobile devices into the education process • Design m-learning for a formal educational context

Table 3 (continued)

No	Item	Clarification and Examples	
			• Provide theoretical and practical tools for researchers and teachers for designing and implementing m-learning strategies • Apply to contemporary learning-centered pedagogy • Design an m-learning course for teachers' professional development • Shift from teacher- to student-directed pedagogies and frame m-learning as a context to construct authentic learning communities • Evaluate language-learning mobile applications • Develop mobile apps that assist in improving online information evaluation skills of students • Propose a thinking guide for integrating mobile devices into learning curricula • Foreground teachers' distinctive mobile pedagogies
5	Lack of clear instructional design guidelines for designing interactive content	Most of the frameworks did not present clear instructional design guidelines for designing interactive content	• No standardized instructional design guidelines for designing interactive m-training course content.
6	Lack of design focus for interactive mobile training course content	Most of the frameworks did not concentrate on designing interactive m-training course content	• No focus on designing interactive m-training course content to train employees.

- **Software development for mobile applications:** Execution within mobile device environments, the development of an effective user interface, accessibility and conflicts between applications and conditions of use.
- **Mobile technology infrastructure:** Dependability and network capacity for data transmission.

Some studies, such as [4, 32, 70], have indicated that these concerns will be limited in the future. Most of these capabilities are improving, and devices have great potential for rich m-training experiences. Consequently, these technological limitations are considered temporary challenges.

Significant challenges are related to pedagogical methodologies. Proper learning methods and strategies must consider the technical aspects of mobile devices for designing motivating, attractive and interactive m-training content. Furthermore, instructional design guidelines are lacking for m-learning content design, which encumbers the establishment of an efficient approach to instructional design that could produce well-designed content following a solid theoretical framework. The majority of these issues have been pointed out in previous studies, such as Park [58], Haag & Berking [32], Ally & Samaka [5] and Pedro et al. [60].

Instructional design represents one of the main issues for the design of m-training content and is connected to learning theories, which play an important role in designing m-training course content on mobile devices as a foundation for enhancing the development of m-learning courses [3]. Figure 3 illustrates this relationship [27].

Learning theories that guide content design vary based on the content and instructional goals. For instance, behaviorism theory provides instruction for designing content that must be memorized and recited; cognitivism theory, for problem-solving and critical thinking; and constructivist theory, for community-based, learner-centered and open-ended learning [73]. Therefore, it is

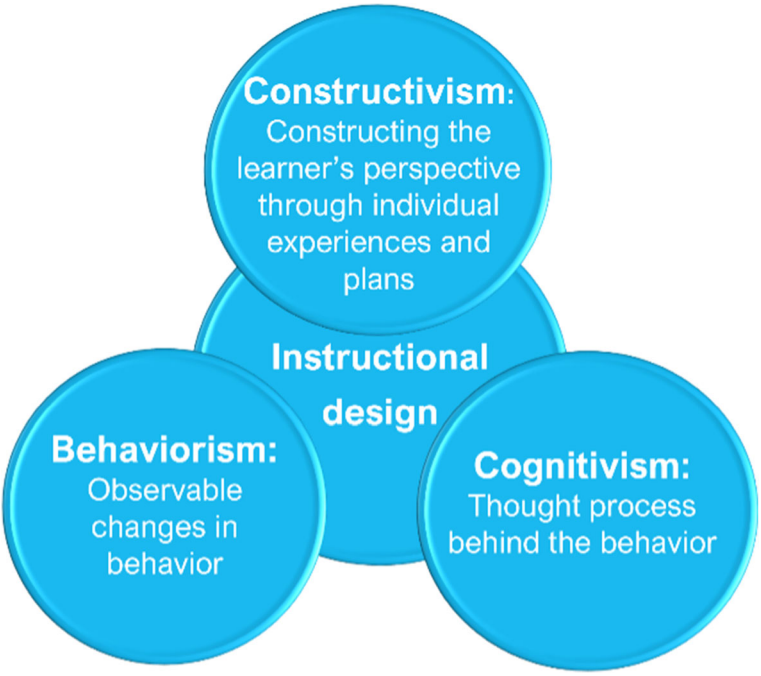

Fig. 3 Relationship between instructional design and learning theories

crucial to understand the relationship between instructional design and learning theories to select suitable theories for the design of appropriate learning content that achieves instructional goals.

The aim of utilizing mobile device technologies in designing and delivering m-learning course content is to facilitate the learning process via an interactive environment that offers suitable learning content and enhances the learning process [73]. However, this aim cannot be attained without considering the relationship between learning theories and instructional design, which can be established by integrating suitable learning theories into practical designs while designing learning content.

The systematic design and development of course content requires the application of a process or model that involves procedures and steps to be followed. Instructional design models offer guidelines to arrange course content design processes in a systematic manner to achieve objectives. There are various instructional design models, and some of them are generally acceptable, such as ADDIE, Assure, and Dick and Carey [48]. This study focused on the ADDIE model (analysis, design, development, implementation and evaluation) since it is a generic model that contains five systematic phases of work as guidelines for designing and developing course content and is most widely used in studies related to the training domain. The ADDIE model is an instructional systems design (ISD) model. It was first established by Florida State University for the U.S. Military during the 1970s [54]. Figure 4 illustrates the ADDIE model phases [54].

The five ADDIE phases are as follows [51]:

1. **(A) Analysis** of needs: Training needs are analyzed to determine and meet the needs of trainees, the content, the environment, instructional problems, instructional goals and overall training or learning objectives.
2. **(D) Design**: Design includes learning objectives, storyboards, course outlines, instructional strategy, content, media, delivery format, evaluation strategy and training budget.

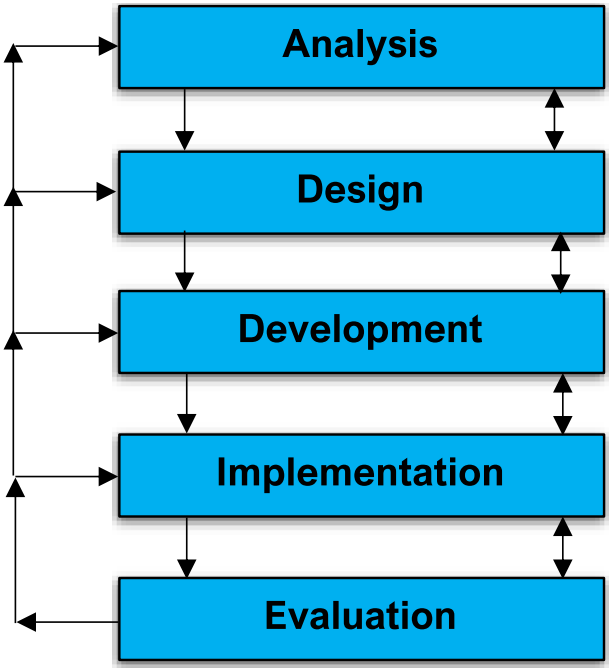

Fig. 4 ADDIE model [54]

3. **(D) Development** of course: Course materials, learning interactions, and prototypes are developed as outlined in the design phase (craft, produce and evaluate the course content), and pilot testing is conducted to review the development process.
4. **(I) Implementation** phase: Training, installation, managing trainees' activities and observation are executed.
5. **(E) Evaluation** phase: Pre- and post-assessments are conducted, as are formative and summative evaluations, feedback on results, final outcomes and the proposed plan to overcome challenges.

Appropriate theories and approaches should be considered that are consistent with targeted learners' characteristics. For instance, when designing training content for training adult learners such as employees, the adult learning approach (andragogy) must be considered. Malcolm Knowles developed an approach that includes principles emphasizing how to address adult learning needs. This approach can be summarized as follows [41]:

- Adults need to know why they are targeted in the training as well as how the training will be executed and the course objectives to be achieved to fulfil their training needs.
- Adults are self-directed, which means that they do not depend on others in their learning.
- Adults have prior knowledge and experience that must be built upon while designing training topics based on their actual training needs.
- Readiness to learn: Adults have varying degrees of the willingness to learn and different understandings of how learning will assist them in better gaining knowledge and developing skills to improve their performance for their social life or career.
- Orientation to learning: Adults learn better when learning helps them solve problems, gain knowledge and develop skills relevant to their work.
- Motivation to learn: Adults are more stimulated to learn when their motivation is intrinsic and when learning helps them solve problems in their lives.

Therefore, following such principles contributes to enhancing the design of effective m-learning for adult learners.

Motivation toward learning represents the energy that activates a learner's desire to participate in the learning experience [25]. Applying effective learning strategies in the context of learning is considered an important way of increasing learners' motivation [17], and the usage of interactive learning theories in a learning environment increases the interaction among learners [59]. Learners are more stimulated and positive when an intrinsic motivation strategy is used during the learning process [24]. Learner motivation can be affected by the usage of attractive content or interactive learning materials by applying a motivational design that enhances learners' motivation toward learning [39]. Therefore, interactive content must be designed that motivates learners while using mobile devices. John Keller's ARCS model suggests strategies to motivate learners [39].

The ARCS model consists of four major elements: attention, relevance, confidence and satisfaction. All four elements increase and sustain motivation throughout the learning process. Its aim is to make learning experiences enjoyable and engaging, which improves the learning process [39]. The Instructional Materials Motivation Survey (IMMS) is related to the ARCS model, and it was designed by Keller as an instrument to measure learners' motivation levels [39]. The IMMS has 36 items. The attention element contains 12 items, the relevance and confidence

Table 4 Element definitions based on Keller's ARCS model of motivation

Categories	Definitions based on Keller's ARCS model of motivation
Attention (A)	Attracting learners' concern, motivating curiosity for learning.
Relevance (R)	Fulfilling the learner's individual needs/goals in order to create a positive viewpoint.
Confidence (C)	Assisting learners in believing in their ability to succeed.
Satisfaction (S)	Enhancing achievement with rewards (internally and externally).

elements contain 9 items each, and the satisfaction element contains 6 items. Table 4 presents the definitions of these elements based on Keller's ARCS model of motivation [39].

To design effective m-training courses, the content design must be aligned with the characteristics of mobile devices, as shown in Fig. 5. For example, an efficient design incorporates content that is presented in the simplest possible format, has a user-friendly interface, is easy to navigate, includes multimedia tools in an attractive and interactive way, breaks materials into short segments, offers instant feedback, facilitates conversation, and presents quizzes with interactive activities for tests and evaluations [3, 55]. Therefore, conventional learning theories must be revised to align with the characteristics of a mobile environment to enhance the m-training process and facilitate interaction with m-training activities [55].

Recently, various studies have emphasized the lack of a pedagogical approach for designing m-learning content that can be developed as an application on mobile devices. These studies have suggested integrating the pedagogical approach with the affordances and technological features of mobile devices. To stay current with the updates in mobile device technology that have delivered numerous new features, such as MAR technology and new communication tools, many studies have recommended that educators and designers consider

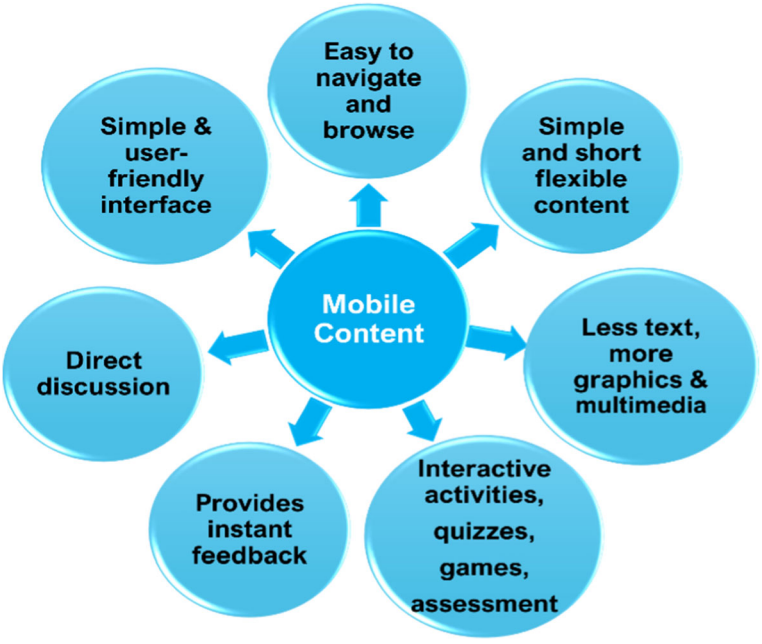

Fig. 5 Mobile content characteristics

the capacities of mobile devices, choose suitable mobile technology for course content, and combine design standards and educational practices while creating mobile applications to design efficient and interactive content for m-training.

3.3 Use MAR to enhance the design of interactive m-training course content

Several studies have demonstrated that the quality of learning and training can be enhanced by using MAR, which merges the artificial with the real world in a virtual setting on a mobile device and enhances learning engagement [56]. Content developers consider different types of AR interactive techniques. These are defined as marker-based, marker-less, outlining, projection and superimposition AR [49]. Studies such as [57] have classified AR techniques into two types: marker-based and marker-less. Marker-based methods depend on camera and visual indicators or markers to produce an image that is easy to recognize and track. This approach uses a mobile camera for reading content, such as through QR codes, and utilizes virtual images to overlay real-world objects. The marker-less method relies on the natural characteristics of an environment, such as location-based AR, using a GPS, an accelerometer, a digital compass or a velocity meter to obtain location data in addition to providing AR visualizations. 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 m-learning started in approximately 2000, when the University of Australia developed AR Quake, whose mobility allows users to engage with the application internally and externally [15]. 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 [15].

When mobile device developers started to introduce MAR environment-authoring tools and MAR applications such as BlippAR, LayAR, and Wikitude, the AR browser affordances were limited. For example, capabilities were limited to overlay objects [35]. However, as mobile technology has evolved, these capabilities have improved [35], and some educational applications have been developed. For instance, Google Sky Map was developed for teaching astronomy, and FETCH! Lunch Rush was designed as an AR app to teach math skills [36]. Most of these applications allow users to utilize 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 leap is expected to occur over subsequent years, reaching over $36 billion by 2026 [8]. As technology has become more cost-effective and publicly available, it has also become a trend in learning and development, opening the door to more opportunities for more interactive and dynamic education.

As a result, AR can be considered one of the best solutions for improving the learning and development process. Therefore, applying AR in 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 was selected as the proposed solution in this study for several reasons [50]:

1. AR increases motivation and engagement in the learning process. According to several studies, AR increases the effectiveness of motivation for learning [17]. MAR technology improves students' motivation and engagement in learning [33].

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 that is presented to them, and the feedback will appear as an image, sound or video that presents the answer. Thus, sharing 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 modeling. The features that are available on new mobile devices, including MAR applications, make this technology easy to access and use for communicating and sharing a social learning experience [50].
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 aims. For example, mobile devices can be used in factories to train workers on how to assemble or install parts and how to repair pieces by 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 will contribute to increased production [50]. Additionally, MAR can be applied as a learning approach. For instance, databases of books in a library are linked with applications on mobile devices such as QR codes. This ability will encourage users to easily find the information they need, such as the locations of books on shelves, show a summary of content or even explain the instructions of the search method, making it easier to access knowledge when needed [52].

It is clear that AR offers enhancement in delivering m-learning content by attracting learners' attention and motivating learners to be involved in the learning and training process. Most studies have shown a positive influence of AR and encouraging outcomes. However, it is recommended 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 based only on its features that are available on mobile devices [56, 75]. Therefore, future studies should concentrate more on MAR technology for educational purposes due to its vast potential implications and benefits in learning, especially in the training environment.

4 Methodology

This study followed a mixed-methods approach of qualitative and quantitative analysis (exploratory sequential design) to benefit from the strength of their combination, which provides a clear and complete integrated solution for a better understanding of the research problem.

It aims to achieve the following objectives:

1. *Identify and propose the key elements to establish an initial framework for designing interactive m-training course content using MAR.*
2. *Validate the initial framework for designing interactive m-training course content using MAR.*
3. *Test the proposed framework by trainees (user evaluation).*

To attain the first objective, the literature was reviewed to identify and propose initial key elements. The second objective was achieved by conducting interviews with experts to validate the initial framework's key elements, which resulted in the establishment of a proposed framework. To accomplish the third objective, an m-training course was designed following the proposed framework steps and guidelines. The designed course was executed to train employees based on their training needs about the communication skills in the workplace. At the end of the course, the trainees evaluated the designed course content using the training evaluation form that was extracted from the design guidelines checklist of the proposed framework.

4.1 Proposing key elements to establish an initial framework

Three essential elements were extracted from the reviewed studies to form the basis for establishing an initial framework. First, several studies have indicated the importance of pedagogical issues, which play the main role in the design of m-training content. These are considered the first key elements of the proposed framework. Second, mobile device physical characteristics, mobile software development and mobile technology infrastructure need to be considered when designing training content on mobile devices, as pointed out in various studies. These mobile technological issues represent the second key element in the proposed framework. Third, to remain current with the revolution of mobile technologies, which include new interactive communication techniques such as MAR, GPS, cameras, multimedia, new communication tools and applications, many studies have suggested integrating these issues with design principles when developing an m-training application that contains interactive and attractive m-training content. Therefore, these interactive communication issues are considered the third key element of the proposed framework.

The elements are categorized as follows:

Pedagogical Such issues are related to the analysis and use of appropriate methods and strategies to facilitate the learning and training process, such as designing learning material [5]. Pedagogical elements include instructional design guidelines for designing m-training course content using appropriate learning theories and strategies that are consistent with MAR technology.

Technological The technological elements of mobile devices facilitate m-learning and enhance training. These crucial elements are described by previous studies emphasizing the transformation requirement for delivering learning via mobile technology to fulfill learners' needs in this digital age [6, 31]. These elements are further classified into three items:

1. *Operating environment*

This item is related to the operating systems to be considered while designing a mobile app to define which platforms can support and be compatible with the app [68].

2. *Mobile applications*

This item considers technical issues and usability guidelines related to the development of mobile applications [42, 46].

3. *Physical specification*

This item is related to physical issues of mobile devices, such as storage capabilities, power, and processor speed [43].

Interactive communication These elements focus on interactivity and communication, which must be considered when designing interactive m-training content. These elements are further divided into three items:

1. *Interactive interface*

This element acts as an interactive gateway for knowledge sharing, discussion, collaboration and specific considerations regarding the design for MAR applications [12].

2. *Mobile AR interactive methods*

This element demonstrates MAR interactive methods such as the use of tools and techniques that are considered when designing interactive content [49].

3. *Multimedia tools*

These tools integrate various elements—such as text, graphics, audio, video and animation—to attract users to the designed content.

All of these key elements and subelements are combined in a list to establish an initial design guideline checklist that helps to verify the recommended items to be considered while designing interactive m-training course content based on the proposed framework.

First, we need to establish a common and systematic instructional design framework as a general approach for the design and development process of m-training course content for various topics according to the training needs. Thus, the generic ADDIE model was proposed for integration with the proposed key elements to guide the application of the three key elements in each phase of the ADDIE model (analysis, design, development, implementation and evaluation) when starting the process of designing content.

The ADDIE model was selected for the initial framework given the following considerations [51, 54]:

- It is an instructional systems design (ISD) model.
- It is one of the most comprehensive instructional design models available.
- It provides a procedural framework to ensure that the outputs are efficient and effective in achieving the objectives.
- It has clear procedural steps and is easy to implement.
- It has the flexibility to meet project requirements.
- It is easily modifiable and can be used with other frameworks and models.

Therefore, the initial framework consists of a combination of the ADDIE model as the main framework and three key elements. The initial framework layout is presented in the results section.

4.2 Validate the initial framework's key elements by interviewing experts

First, a search was conducted for experts through academic sources, university professors' databases, professional associations and social media. We selected experts with good knowledge of instructional design, m-learning and mobile technology who had high levels of experience and shared similar characteristics. The selected experts represent a homogenous group, in which data saturation occurs sooner because of the smaller sample size, as indicated by Bryman [14].

4.2.1 Procedure for collecting data from expert interviews

Seven research interviews were conducted, and research ethical approval was obtained before starting the interviews. No particular answer is available for how many interviews are sufficient for qualitative research, as stated by Creswell & Poth [23] and Creswell, W. & Creswell, D. [22]. Data saturation plays an important role in determining the appropriate number of interviews. Data saturation occurs when the researcher senses that new interview results lead to repeated data that do not offer new ideas to the study. In this study, data saturation occurred after the sixth and seventh interviews. The following points summarize the data collection process:

- Experts were contacted using phone, email and social media to invite them to the interviews. Research interview information was sent via emails clarifying the interview objectives, significance, procedures, expected contributions to the research field, etc.
- Interviews began with an introduction to the research and explained the reason why the interviewees were selected to participate in this study.
- Experts were interviewed individually at time slots convenient for them for approximately 25–30 minutes.
- Interview questions were focused on verifying the extracted key elements and listening to the experts' advice and guidelines about the research topic.
- Initial design guidelines checklist was prepared for validation by adding the experts' assessment portions under each item using a Likert scale that evaluated the extent to which key elements, subelements and items were important and related to each other in the topic. Flexibility was provided to delete or modify any construct and to add comments. The interview contents were discussed with the experts and sent to them by email for validation.
- Interviews ended by summarizing the reported points and discussing whether any other issues should be added to improve the initial framework.

4.2.2 Procedures for analyzing expert interview data

The procedures for analyzing the interviews were executed as indicated by Creswell [22], who stated that the process should follow consecutive steps from a specific to a comprehensive view. This process includes various levels of analysis, as shown in Figure 6.

First, the data were organized and prepared for analysis. This step included transcribing the interviews and sorting and arranging the data. Then, the data were initially coded (open coding) by reading through the interview data to find common or general ideas between the participant responses and writing a brief description.

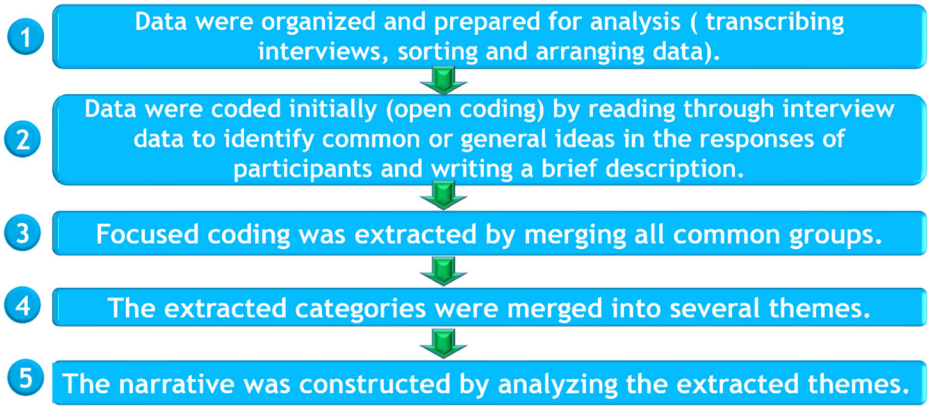

Fig. 6 Steps for analyzing the expert interview data [22]

These preliminary codes were reviewed, and focused coding was conducted by merging each common group of codes together into one related category to ensure greater clarity and specificity, as shown in Table 5:

Then, the extracted categories were merged into several themes and refined to ensure that they were related to the codes and that there were no contradictions or overlaps among them. Table 6 presents the generated themes.

In the final step, the narrative was constructed by analyzing extracted themes, referring to quotes from the interview responses and linking the themes to the initial framework components. The analysis outcome is presented in the results section.

4.2.3 Initial guidelines checklist analysis

Based on the previous studies, the initial guideline checklist was established to verify the recommended elements (*pedagogical, technological and interactive communication*) to be considered while designing the interactive m-training content using MAR based on the proposed framework. To develop the final list consisting of the guidelines checklist, the feedback collected from experts' reviews was reviewed. Their comments were considered and analyzed by extracting the common agreements and differences between the experts' opinions regarding each construct on the list. Then, each group of elements, subelements and

Table 5 Focused coding

No	Focused Codes
1	Using mobile devices as supportive tools for attracting trainees to engage in training courses.
2	Using MAR as an attractive and interactive technology for designing interactive content for mobile training.
3	Steps for designing interactive content for mobile-based training.
4	The importance of pedagogical elements in the design of mobile training content.
5	The importance of technological elements in the design of mobile training content.
6	The importance of interactive communication elements in the design of mobile training content.
7	The importance of the relationship between the three (3) initial key elements to establish an initial framework.
8	Adding the ADDIE Model to be combined with the other key elements for establishing the initial framework for designing the mobile-based training course content.
9	Suggestion for additional information related to improve the research topic.

Table 6 Generated themes

No	Themes
1	Mobile devices as supportive tools.
2	MAR as attractive and interactive technology for designing m-training content.
3	Steps and guidelines for designing interactive content for m-training.
4	Importance of pedagogical, technological and interactive communication elements to establish an initial framework.
5	Combining the ADDIE as a framework with pedagogical, technological and interactive communication elements to establish an initial framework.
6	Initial framework improvements.

items was reviewed again, combined and classified to establish the final list. Figure 7 illustrates the procedures that were followed to collect and analyze the design guideline checklist data. The final design guidelines checklist is explained in the results section.

4.3 Trainee testing of the proposed framework using a training evaluation form

To further validate the proposed framework and offer a better understanding of it, the framework was tested practically by designing a training experience and implementing practical training to train employees based on their actual training needs about communication skills in the workplace.

The steps and procedures were followed of the design guidelines checklist of the proposed framework for designing and developing interactive m-training course content about communication skills in the workplace in an MAR environment using an MAR authoring platform called Metaverse Studio.

The designed m-training course was executed by providing course information to the Oman government institutions for employees' participation based on their actual training needs. Ethical issues were considered. Sixteen employees were nominated randomly from different institutions to participate in the m-training course via mobile devices. The participants were given the flexibility to decide the training timing. However, the training had to be completed within one month considering the participant work circumstances.

At the end of the training, the designed course was evaluated by analyzing the trainees' feedback using a training evaluation form that appeared once the trainee completed the course. The training evaluation form was utilized to measure the trainees' reactions to and perceptions

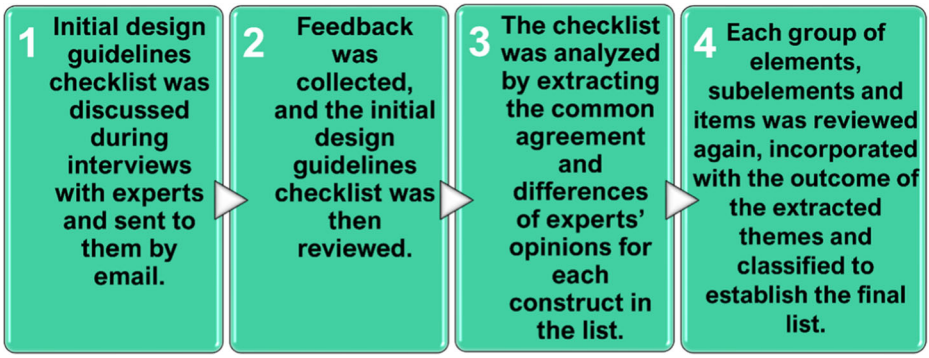

Fig. 7 Procedures for collecting and analyzing the design guideline checklist data

of the designed m-training course. It consisted of the main design elements that were extracted from the design guidelines checklist validated by the experts in addition to trainees' comments and suggestions at the end of the evaluation form. The training evaluation form reflected the extent to which the mobile training course content was designed based on the proposed framework by following the required aspects in the design guidelines checklist.

The evaluation form verified the quality of the designed m-training content by requesting trainees to verify and emphasize the availability of the required items for designing interactive m-training content in the designed course. It also measured the trainees' comments and suggestions for improvement.

The trainees' feedback was analyzed after they completed the training program, and the training evaluation forms were encoded with an anonymous number. Statistical software such as SPSS and Microsoft Excel were used for the data analysis. The training evaluation form was classified into two sections: training design elements and comments and suggestions. Further explanation is offered in the results section pertaining to the training evaluation form and the outcome of the data analysis.

5 Results and discussion

This section presents and discusses the results to clarify the study outcomes.

5.1 The initial framework layout

To achieve the first objective, the initial framework was proposed to consist of a combination of the ADDIE model as the main framework and three key elements (pedagogical, technological, interactive communication), including subelements for designing interactive m-training course content. The layout of the initial framework was conceptualized as illustrated in Fig. 8.

The initial framework showed a collaborative integration between the three key elements guided by the ADDIE model from the analysis to the evaluation phase as an output stage for the designed and developed product. As an initial framework proposed from the literature review needs to be checked and validated, we interviewed experts to validate its components. The next section presents and discusses the analysis of the interview data.

5.2 Analysis of the extracted themes

This section demonstrates and discusses the narrative construction as the outcome of analyzing the generated themes by referring to response quotes.

Theme 1 Mobile devices as supportive tools

The first theme related to the usage of mobile devices as supportive tools to allow trainees to engage in the m-training courses. The interviewed experts considered using mobile devices in the delivery of training courses to be very useful and important. It was described by expert (e2) as "*a good idea to use mobile apps as a platform for learning as you said many people now have more than one device even kids have at least one.*" Another expert (e1) said, "*Therefore, providing this platform where you train people on mobile phones will be an advantage for these people because while waiting for the train or waiting for something on the go you still can attend the training.*" Additionally, another expert (e3) mentioned, "*Using apps is good for learning and it is something new.*" Therefore, using this technology is useful and a good idea. This result supports the findings of the literature.

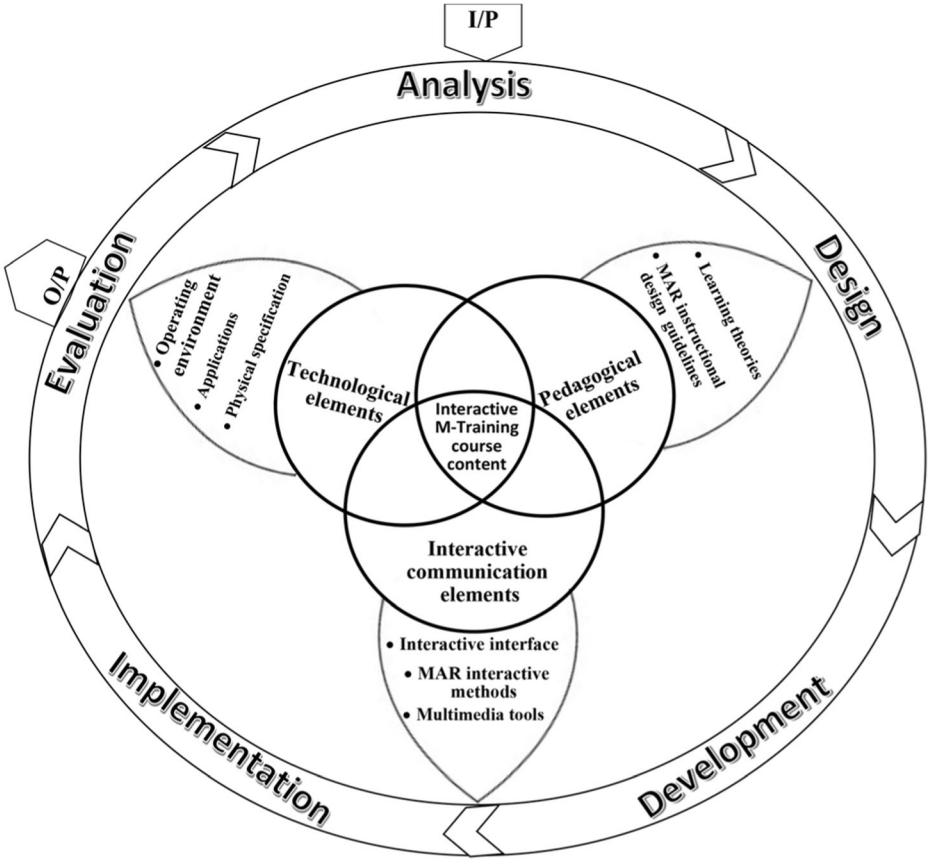

Fig. 8 Initial framework

Theme 2 MAR is an attractive and interactive technology for designing m-training content

Previous studies have indicated that MAR technology enhances learning and entertainment applications. Most of the experts emphasized that it is useful for designing interactive content. One expert (e1) mentioned that "*using MAR is useful for designing some interaction for the content of mobile training*." Additionally, it is an interactive learning tool that assists learners in understanding the training content, as indicated by another expert (e3): "*This is a way of helping them to understand the content.*" Moreover, one expert (e2) described it as a technology that captivates attention and stated, "*The use of augmented reality is like some things captivating attention because it is something new that makes things look real*." The expert added that "*by making it into a mobile application, it is even interesting. It is easier, handy and you do not have to use wearables*" and "*you can capture a lot of learning data there. It is an attractive technology.*" This interview content supports the literature on this issue.

Theme 3 Steps for designing interactive content for m-training courses

Many studies have noted various steps and procedures that can be followed while designing electronic content, such as selecting and following a suitable model from previous instructional design models based on learners' needs and the type of content to be designed and developed. Most of the interviewed experts did not agree about following one specific method to design

interactive content. However, common issues must be considered, such as following a systematic approach that involves analyzing and defining the needs of learners, identifying goals and objectives of training, designing and developing materials related to training topics, and following a process of implementation and evaluation. This process was clearly mentioned by one of the experts (e2), who said, "*It is how to design things starting from A how to do analysis, how to conduct design phase, development, the implementation and evaluation. If I can narrow it down under the implementation part of the ADDIE framework, I can cite Robert Gagne's nine events of instruction.*" Moreover, another expert (e1) described a "*combination of fundamental frameworks or guidelines with the content related to the domain we need to combine them in order to design effective AR mobile training content.*" In contrast, one of the interviewed experts (e3) indicated, "*I will use my own guidance, I call it the ABCDE model. Acronym for A-audience, B-behavior, C-conditions, D-degree, and the main important element: environment.*" The interviewee added, "*Normally, I will use another guidance, my own concept I call KESAN: Knowledge, Experience, Skills, Attitude and Networking. Therefore, either it can be sync with the condition and degree (current situations); it depends on my previous/current KESAN.*"

In addition, other interviewees emphasized the importance of understanding learners' culture and selecting an appropriate environment. Therefore, this outcome confirmed what studies have noted.

Theme 4 Importance of pedagogical, technological and interactive communication elements for establishing an initial framework

With respect to the integration between the three proposed elements (pedagogical, technological, and interactive communication), most experts agreed about the importance of the proposed key elements. Some of the experts, such as (e1), noted that "*pedagogical and technological aspects are very important, as I mentioned earlier, including the interaction aspect.*" Another expert (e2) said, "*Definitely, they have to come all together at the same time.*" However, other experts suggested combining these elements with other elements with the use of clear instruction or guidelines to form a complete framework that explains the entire process. The feedback and suggestions were considered to further explain the integration and interaction between each element and other additional elements.

Theme 5 Combining the ADDIE framework with pedagogical, technological and interactive communication elements to establish an initial framework

The ADDIE was combined as a framework with pedagogical, technological and interactive communication elements to establish an initial framework. Most of the interviewed experts expressed that the proposed framework could be acceptable, and some of them (e1) mentioned, "*I think the ADDIE model shows underlying stages of processes that when you want to deliver some sort of educational kind of materials. Therefore, you have to do analyzing, design...etc. The steps or procedures that you need to follow*." Another expert (e2) said, "*The ADDIE is not a model; it is a framework. There is a difference between the model and the framework. It is a generic one. Therefore, people use many models in the instructional design they mention. There can be thousands of instructional design models. However, they actually use the elements of the ADDIE framework. Therefore, in your case as well as you mentioned you can have each phase of the ADDIE framework guided by the three elements that you have. Therefore, I think that is important*." Additionally, other experts recommended further elaboration and clarification of each of the elements. One (e3) mentioned: "*If you said ADDIE,*

then that is your main framework...from there you elaborate and slot in each of the elements." Some experts suggested using another model in each of the ADDIE phases. For example, (e3) stated that " *in the analysis phase, maybe you will be using another additional specific model in that phase. In the design phase, maybe you will be using another design model.*" In addition, one expert (e2) said that combining ADDIE as a framework with the three key elements with the use of the proposed instructional design guidelines list worked as a design checklist at every phase while designing content and said, *"It is like a checklist. Therefore, every time people design, they will see: Oh, I have this pedagogical element, technological element...etc. and the interactive communication element. Therefore, I think it is important.*"

Therefore, we considered most of these recommendations and suggestions when we improved the framework.

Theme 6 Initial framework improvements

The experts proposed some additional suggestions. For example, (e2) and (e3) suggested including an instructor. For instance, (e2) said, "*I can highlight the instructor presence that I mentioned earlier. I think it will make content more interactive and more beneficial*". This element could be included in the proposed framework with pedagogical or interactive elements by giving trainees the perception that the trainer is with them in the training process, such as by presenting the trainer's photo or avatar or by introducing the course with the trainer and providing related links or email so trainees can communicate with the trainer or ask for further information. Another expert recommended reading a design and development research (DDR) book to gain more knowledge. Additionally, some experts suggested including *ethical and legal* factors, and others (such as e5) suggested adding *managerial elements* into the framework. Furthermore, experts such as (e7) suggested incorporating *mobility* into the proposed framework. Therefore, most of these suggestions were considered as we improved the initial framework.

5.3 Linking the extracted themes to the framework components

Based on the analysis results, the generated themes were classified and linked to the framework components, as shown in Table 7:

Table 7 explains the connection between the themes and framework components by presenting the theme number and the related framework components. The updated framework includes components related to the ADDIE, pedagogical, technological, interactive communication, ethical, legal, managerial and mobility context components.

Table 7 Linking the generated themes to the framework components

Theme No.	Framework components
1	Technological
2	Technological
3	Pedagogical
4	Pedagogical, technological and interactive communication
5	ADDIE (analysis, design, development, implementation and evaluation) model
6	Pedagogical, interactive communication, ethical, legal, managerial, mobility context

5.4 Data analysis outcome summary of expert interviews

The following points summarize the outcome of analyzing expert interviews:

- The experts emphasized the importance of using mobile devices as supportive tools for attracting trainees to engage in training courses.
- Most of the experts emphasized that MAR is an attractive technology that is useful for designing interactive m-training content.
- There is no one specific method for designing interactive content, as pointed out by most of the experts. However, they indicated some common issues that must be considered when designing interactive content for m-training courses, such as selecting instructional/pedagogical design models and following technological design principles, including designing user-friendly interfaces; selecting multimedia that fit with the training content; and ensuring the clarity of the sound, images, shapes and words of the content accompanying the content presentation, color clarity and consistency in the contained content, and scenes that are not cluttered with content. Overall, all of these issues should be considered when following a systematic approach that contains analysis and assessment to define needs, identify goals and objectives, design and develop materials, and follow the process of implementation and evaluation.
- Most of the experts emphasized the importance of including *pedagogical, technological and interactive communication elements* and suggested including additional elements and combining them with a systematic approach.
- The majority of the experts accepted the combination of the ADDIE model with the proposed key elements to form a framework. Some of the experts recommended adding *ethical, legal and managerial elements* as key elements in the initial framework in addition to *including the context of mobility* to show that the design of the course content occurs in a mobility context in this framework.

These findings were considered when forming a validated framework that combines the ADDIE model as the main framework with six key elements (*pedagogical, technological, interactive communication, ethical, legal and managerial*).

5.5 Framework for designing interactive m-training course content using MAR

Validating the initial framework's key elements identified by the experts led to the creation of a framework for designing interactive m-training course content using MAR. Figure 9 shows the layout of the proposed framework as a framework of interactive m-training course content design.

The framework consists of a combination of five phases of the ADDIE model and six key elements: *pedagogical, technological, interactive communication, ethical, legal and managerial* (***PTIELM***). The ***PTIELM*** *framework* shows that the pedagogical, technological and interactive communication elements interact with each other. The ethical and legal elements interact with the elements as an umbrella framing this interaction, while the managerial elements lead the integration by managing the entire process to produce interactive m-training course content on a mobile application in a mobility context.

The interaction between the *pedagogical and technological elements* establishes an *m-learning technology* intersection. This phrase refers to the usage of mobile technologies to

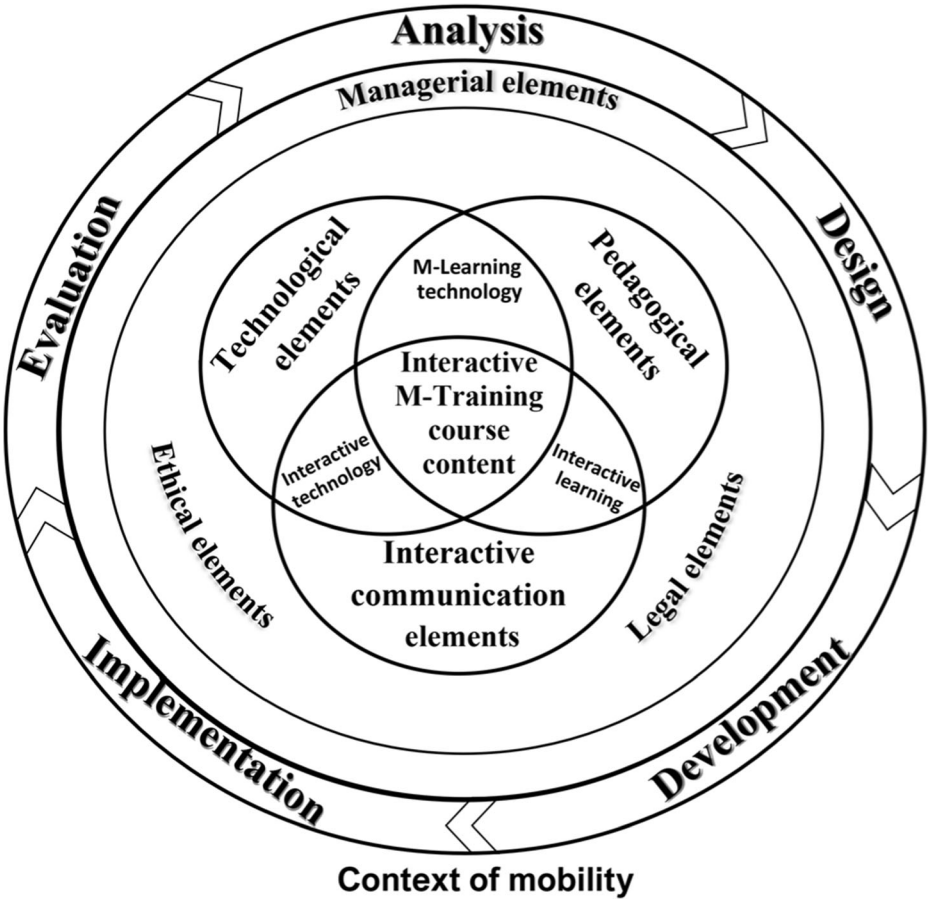

Fig. 9 Proposed framework (***PTIELM*** *framework*)

facilitate the learning process, such as communicating via mobile devices to obtain information and share knowledge [7]. Therefore, this intersection focuses on integrating the technological elements such as the mobile operating environment, mobile applications and physical specifications with the pedagogical elements, which include instructional design guidelines to consider the characteristics of mobile devices while designing m-training content. The recommendations included dividing the content into short sessions; using simple, flexible content; using less text suitable for small screens; using more graphics with multimedia; providing instant feedback; and ensuring the ease of browsing and downloading content.

The *interactive technology* intersection relates to the interaction of *technological* elements such as mobile operating environments, mobile applications and physical specifications with *interactive communication elements,* which include an interactive interface, MAR interactive methods and the use of multimedia tools. This integration facilitates interaction among individuals and enables the creation and manipulation of interactive content [71]. Moreover, it enables communication between the trainer/trainee and the content via an interactive interface that allows the use of MAR technology and multimedia tools as interactive methods for interacting with the content. Therefore, this convergence focuses on facilitating the design of interactive training content with an interactive communication interface taking into account

the technological elements of mobile devices for providing an interactive and motivational environment with the use of MAR technology.

An interactive learning intersection represents an overlap between *pedagogical elements* and *interactive communication elements*. It contains items belonging to both elements. *Interactive learning* is an interactive pedagogical method that involves using interactive tools and styles to motivate learners to interact with each other and with the content to exchange information and share knowledge [62]. *Interactive m-training course content* is an overlap of the main elements in the proposed framework at the primary intersection in the center. This main intersection creates convergence between the key elements and helps achieve the main objective of designing interactive content for m-training courses.

5.5.1 How the proposed framework works

Each phase of the ADDIE model is guided by the six key elements using the *design guidelines checklist* (attached in Appendix 1 Table 9) to verify the required items under each key element. For instance, in the analysis phase, the needs and requirements of the six elements (*pedagogical, technological, interactive communication, ethical, legal and managerial*) will be analyzed and verified with the use of a design guideline checklist. Therefore, these six key elements will also be considered during the design, development, implementation and evaluation phases. The process begins with the analysis phase, as follows:

(1) **Analysis phase**

The analysis phase analyses and identifies the needs of trainees. Initially, the training needs are identified using performance report feedback or interviews or surveys to clarify the instructional issues and determine the requirement as an exploratory method. The collected data are analyzed to specify needs. The analysis phase in the proposed framework determines and clarifies the requirements of the pedagogical, technological, interactive communication, ethical, legal and managerial elements to facilitate the design of the content in the next design phase. The key elements are analyzed as follows:

1. *The pedagogical elements were determined as follows:*

- Identifying the instructional problem (training needs).
- Defining the training solution for the training topic.
- Identifying smart-learning objectives consistent with the proposed training topic.
- Considering designing m-training content to be relevant to the learning objectives and suitable for mobile devices with simple interactive interfaces, dividing sessions into short sessions, being scientifically accurate, linguistically correct, and logically sequenced, and containing instant feedback, less text, and more multimedia and interactive activities running on an MAR environment.
- Defining appropriate learning theories and strategies that are consistent with MAR technology such interactive learning, game-based learning, motivational theory and cognitive theory of multimedia in designing training content.
- Determining appropriate assessment and evaluation methods for achieving learning objectives.

- Determining items of the training evaluation form to measure trainees' reaction to the designed m-training course: Items are extracted from the design guidelines checklist to verify the quality of designing m-training content and measure trainees' comments and suggestions.

2. *The following technological elements were identified as facilitators of m-training enhancement:*

- Operating systems: Specify whether to run the proposed training app on iOS, Android or both operating systems.
- Analyze the need for mobile application development: Consider technical issues such as specifying MAR environment platforms and usability guidelines such as ease of accessing and opening the application after downloading, navigation, provision of appropriate technical support, design of appropriate graphics, and the use of simple and user-friendly interfaces.
- Physical issues of mobile devices: Consider the ability to run the designed content on mobile devices with a standard processing speed to provide acceptable performance to execute the required tasks.

3. *Interactive communication elements*

Focus on interactivity and communication while designing interactive m-training content based on the content design requirements of the scenario.

- Specifying the design of a simple and an interactive interface.
- Identifying the design of activities that use marker-based MAR methods such as image recognition and QR codes.
- Identifying the design of training content using the marker-less MAR method, which is based on locations by GPS, allowing trainees to interact with the course content from specific locations.
- Specifying the use of multimedia tools in the design of content by integrating various items such as text, graphics, audio, video and animation to attract trainees.

4. *Ethical elements*

related to ethical aspects, including accessibility of information and occupational health and safety requirements.

5. *Legal elements*

related to legal aspects, including the copyright of materials, privacy and intellectual property.

6. *Managerial elements*

related to administrative items required for proper project management for producing high-quality course content design and delivering on time.

(2) **Design phase**

In the design phase, the course content is designed based on the actual needs identified in the previous phase. The phase includes a storyboard design that explains the scenario of how the course will be executed. The design phase customizes the course content design to be compatible with utilizing *pedagogical, technological, interactive communication, ethical, legal and managerial elements* during the subsequent phases (development, implementation and evaluation).

Based on the outcomes of the analysis phase, the proposed training in the design phase will be executed as follows:

1. *Pedagogical elements:*

- Writing smart-learning objectives.
- Designing m-training content using learning methods and different learning strategies to deliver the training content. At the beginning of the training, a simple introduction contains instructions and shows the training path, which includes interactive content such as quizzes and activities designed by utilizing MAR techniques and multimedia tools.
- Designing interactive training content: The m-training content is designed to be relevant to the learning objectives with simple, interactive interfaces; sessions divided into shorter sessions; content that is scientifically accurate, linguistically correct, and logically sequenced comprising less text and more multimedia that can be run on an MAR environment.
- Interactive gradual activities and varied evaluation styles and strategies were designed to achieve the learning objectives by using the MAR technique and multimedia tools.

2. *Considering the technological element requirements:*

- Operating environment: The proposed training content application can be developed to be compatible with iOS and Android operating systems.
- Mobile application: The proposed m-training application can be developed by MAR-authoring platforms such as Vuforia, ARToolkit, Metaverse, ZapWorks or Assemblr. These are authoring tools for creating MAR contents. The design must consider issues such as simple, user-friendly application, accessibility, navigation, provision of appropriate technical support, and design of appropriate graphics.
- Physical specification: The proposed m-training application is considered to be designed and developed simply to run at the standard specification of mobile devices.

3. *Interactive communication elements:*

Designing interactive communication content should follow the content design requirements specified in the analysis phase:

- Designing an interactive interface.
- Designing activities that use marker-based MAR methods such as image recognition and QR codes.

- Designing training content implements a marker-less MAR method that is based on locations by GPS to allow trainees to interact with the course content from specific locations.
- Multimedia tools are utilized in content design by integrating various elements, such as text, graphics, audio, video and animation, to offer attractive content for trainees.

4. *Ethical elements*

The training content should be designed considering ethical aspects such as providing information accessibility for all registered trainees. Additionally, instructions should be clearly designed to inform trainees regarding occupational health and safety requirements while moving and interacting with MAR activities.

5. *Legal elements*

M-training content must be designed to consider legal aspects such as the copyright of materials, privacy and intellectual property.

6. *Managerial elements*

The following managerial items must be considered in the design process:

- Assigning the selected designer or course design team based on the required skills.
- Setting up a proper project management plan for course content design and managing the design process among team members by the project manager or course founder.
- Establishing guideline instructions to execute the project plan, such as dividing tasks into stages and small segments in the course content design project to be easily managed.
- Using proper project management techniques to consider the quality control of the course content design.
- Considering a proper project management technique for completing the design and development process and delivering the product on time.

(3) **Development phase**

In the development phase, production begins to develop the training content related to the pedagogical, technological, interactive communication, ethical, legal and managerial issues according to the guidelines identified in the design phase. This phase includes course content development, which consists of executing the previously designed scenario, storyboard, materials, and activities and reviewing the development process. Therefore, the development phase will lead to the production of the prototype of the training application that contains course material content.

(4) **Implementation phase**

This phase involves testing the course content on the mobile application. The developed course must be tested on users with different mobile devices running on iOS, Android or both operating systems based on the course content design requirement. This phase indicates how the application is run with interactive course content on mobile devices and how the

participants interact with the course content. Additionally, this phase addresses the technical challenges that appeared while testing the m-training application. Therefore, this phase includes the execution of the pilot training, the installation and testing of the application, and the management and observation of trainees' activities.

(5) **Evaluation phase**

This phase evaluates the output of the implementation phase. It measures feedback and assesses the outcome from the execution of the pilot training, the installation of the application, and the management and observation of trainees' activities during the implementation phase. It includes instant feedback (textual, oral, and visual), a pre-assessment, a post-assessment, a usability survey and a comparison of outcomes for evaluating trainees' performance and the effectiveness of the designed m-training content, the training delivery method and the m-training application. This phase evaluates pedagogical, technological, interactive communication, ethical, legal and managerial issues according to the outcome of the analysis phase. This phase was outlined and designed in the design phase and developed and implemented in the development and implementation phases. Finally, this phase produces recommendations and modifications to overcome any challenges that occurred and affected the achievement of the training objectives. After the modifications are completed, the m-training course is ready to implement.

5.6 Validated design guidelines checklist

As indicated at the initial stage of this study, an initial guideline checklist was prepared for validation by experts. The following points describe the outcome of analyzing the design guidelines checklist data, which led to the establishment of the final design guidelines checklist (attached in Appendix 1 Table 9) to assist in verifying the recommended items to be considered while designing interactive m-training content using MAR technology based on the proposed framework.

- Regarding pedagogical elements, most of the experts emphasized the importance of these elements, which were combined under subelement titled Instructional design guidelines for mobile training course content in a mobile augmented reality (MAR) environment. This subelement contains several items related to the analysis and use of appropriate methods and strategies to facilitate the learning and training process in an MAR environment.
- The technological elements were considered by the majority of experts as essential elements to be considered when designing m-training content. Some experts suggested revising the operating environment subelement, and the majority of experts recommended expanding the number of items from two to five. One item related to compatibility for operation on different types of mobile devices and two items related to running on iOS and Android operating systems. The other two items relate to support on the previous, current and updated versions of the iOS and Android operating systems. Regarding the mobile application subelement, many experts found that there were too many statements written under one item and recommended separating some items into several items. Under the physical specification subelement, some experts suggested rewriting some items by separating each of the important statements into one item to improve clarity.
- Most of the experts expressed the importance of including interactive communication elements when designing interactive m-training content. The interactive interface was considered by

most experts to be a very important gateway for interactivity for knowledge sharing, discussion and collaboration. Additionally, it represents the trainee's first impression of the m-training application. All experts expressed that the subelement of MAR interactive methods was a very important element that includes tools and techniques to be used for presenting information in interactive and attractive ways, where virtual elements become a part of the real world. Regarding items under the subelement of MAR interactive methods, most of the experts emphasized the importance of all items. However, some experts recommended explaining some items to improve clarity. Most experts indicated that the multimedia tools were an important subelement that makes the designed content attractive, and the majority of experts affirmed the importance of items related to the multimedia tools subelement.

- Ethical elements: These elements were added as the fourth elements to the final guidelines' checklist based on experts' comments and recommendations. These contain one subelement titled ethical aspects. Ethical aspects are related to human principles rights, which must be considered when designing interactive m-training content. These components include social and cultural diversity, anti-discrimination, etiquette, accessibility of information and occupational health and safety requirements.
- Legal elements: These elements were also added as suggested by experts. They consist of legal aspects as a subelement. Legal aspects are related to standards that have been written as laws that must be considered when designing interactive m-training content, such as copyright of materials, privacy, plagiarism and intellectual property.
- Managerial elements were added to play an important role in managing the entire design process. These elements contain a subelement of administrative items for project management of course content design. These are related to administrative items required for proper project management to produce high-quality content and ensure on-time delivery.

Therefore, this validated list, which contains six key elements with subelements, is related to the proposed framework key elements and used as a checklist to verify the requirements under each key element and ensure the quality of the course content design.

These results clearly distinguished and highlighted the proposed framework compared to the previous frameworks in the following ways:

- It is a framework for course content design.
- It focuses on designing interactive m-training course content.
- It utilizes MAR technology as an interactive technology available on most new mobile devices.
- It follows a systematic approach guided by six key elements.
- It provides a clear instructional design guideline checklist to ensure the design quality of interactive m-training course content.

These points represent a considerable contribution supporting the development process in the m-training domain.

This section presents and discusses the findings proposing the initial framework and validating it to establish a framework for designing interactive m-training course content using AR. Overall, the significance of these findings supports the development process of designing interactive m-training course content that attracts more employees to participate in m-training courses. Thus, learner engagement is increased in the m-training domain, and the development of human resources is improved in various fields.

5.7 Analysis of the training evaluation form

The training evaluation form (Appendix 2) was analyzed to measure the trainees' reaction toward the designed m-training course. It was categorized into four aspects: pedagogical, technological, interactive communication, and ethical and legal.

The analysis of the data from the training evaluation form indicates that the trainees strongly agreed with the majority of the items in the designed m-training course content. Most items scored 100%, while the remaining item scores varied from 94% to 98%, as shown in Table 8.

Figure 10 illustrates the scores based on the training evaluation form feedback. It shows that the ethical and legal aspects scored the highest average value of 100%. The pedagogical aspects scored 2.98, which indicates that 99.3% of trainees agreed that the course content considered the pedagogical aspects in the m-training program. Ninety-eight percent of trainees noted that the interactive aspects were considered while designing the m-training course, and 97% agreed that the technological aspects were incorporated into the training program.

According to the trainees' feedback, as shown in Fig. 10, the ethical and legal aspects achieved the highest average value, which indicated that all the trainees supported that the course instructional designer or creator gave these aspects more consideration while designing the m-training course content. These findings show the importance of these aspects in content design. Several studies, such as [5, 53, 67, 69] confirmed the significance of these issues in content design, whereas some designers sometimes ignore these important issues.

The majority of trainees agreed that the pedagogical aspects were given more consideration than the interactive and technological aspects while designing m-training content. This finding was consistent with some previous studies that recommended considering educational aspects more than technologies to attain the best learning enhancement. Therefore, a well-designed mobile-learning content is an important and essential requirement to propel learner achievement.

Table 8 Analyzing the elements of the training evaluation form

Elements	Items	Score
Pedagogical Aspects	1-Contents were relevant to the course objectives.	**100%**
	2-The training course has been aligned to the learning objective.	**100%**
	3-The instruction given during the course was clear and easy to understand.	**98%**
	4-Simple course content delivered using an attractive and interactive style.	**100%**
	5-Appropriate assessment method for achieving the learning objectives.	**100%**
	6-Suitable training duration for each session	**98%**
Interactive Aspects	1-Simple and interactive interface enables easily browsing content.	**100%**
	2-An interactive and motivating training environment.	**100%**
	3-Using MAR techniques facilitate an easy understanding of the topics.	**98%**
	4-Clear and easy-to-control audio and video.	**94%**
	5-Easy to utilize the training content and navigate smoothly between the topics.	**96%**
	6-Interactive and diverse activities that are consistent with the course objectives.	**100%**
Technological Aspects	1-Easy to download and run the application.	**100%**
	2-Clear drawings, fonts and pictures.	**98%**
	3-Easy-to-use buttons that navigate between the contents and easy browsing and exit from the application.	**96%**
	4-Technical support is provided for trainees via email, WhatsApp or direct communication.	**96%**
Ethical and Legal Aspects	1-Access to course information and health and safety requirements were considered in the application design.	**100%**
	2-Issues related to copyright, privacy and intellectual property were considered in the course design.	**100%**

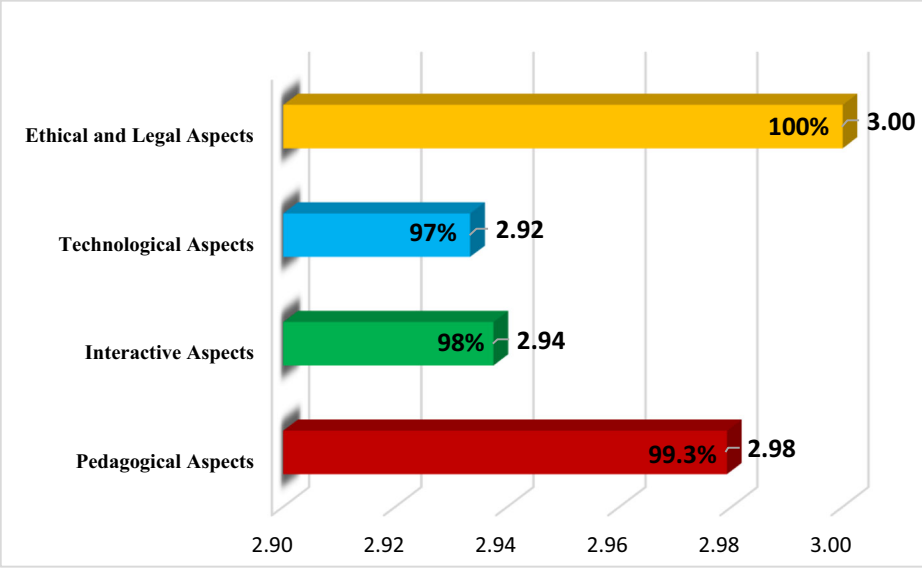

Fig. 10 Average values of the elements of the designed course content based on trainees' feedback

In their comments, most of the trainees expressed that the interactive training experience was excellent and new and captured their attention. It helped them to understand the training topic and gain knowledge in an interesting way. This aspect was clearly indicated by the trainees as follows: "*Excellent experience*" (T1); "*Excellent program*" (T6); "*Excellent and motivating program*" (T8); "*An interactive training program*" (T7); *"New and a great idea for delivering training content" (T2); and "Wonderful and useful training that presents the content in a smooth and attractive way to gain new knowledge and information*" (T5).

These findings emphasize that MAR attracts learners to participate and simplifies the training topic in an attractive manner for better understanding. They also support the literature findings and offer an effective solution for the research problem.

The outcomes showed that the majority of the comments were positive regarding the m-training course. They described as a motivating course and agreed that it contributed to the development of their knowledge and skills for communicating in the workplace. Examples include the following: "*Yes, I agree because it was a motivating course covering important points that every employee needs for effective communication in his work environment*" (T3); "*Yes, I strongly agree it improved my knowledge for good communication in the workplace*" (T10); "*Yes, I strongly agree*" (T8); "*Yes, it contributes to enhancing the knowledge because it helps to enhance knowledge through the easy to understand content (T5)*"; and "*Contributes to knowledge and skills for communicating in the workplace*" (T7). These comments reflected positively on the essential knowledge and skills of trainees with respect to workplace communications.

Most suggestions focused on upgrading the training application by creating more versions and applying the same training experience at an advanced level, covering other skills, using a very high standard for the audio system and providing more time for activities.

All of these comments and suggestions were considered for the improvement of the designed course and for the future design of better m-training course content. This result indicated approval and acceptance from the trainees for designing further courses targeting different areas for developing skills and knowledge.

In general, the outcome of the training evaluation form indicated that the majority of the trainees agreed with most of the items in the design aspects of the designed m-training course content. The overall average value of all aspects was 2.96, or 98.6%. Therefore, this result demonstrates that the designed m-training course was of high quality and was aligned with the proposed framework and design guidelines checklist. The result also showed that the designed m-training course was motivating and had a positive impact on trainees' knowledge. Finally, this outcome verified the outcome of the expert validation and demonstrated the validity of the proposed framework. Thus, this integration resulted in the establishment of an evaluated framework used for designing interactive m-training course content using MAR.

6 Limitations

The limitations of this study were the restrictions and delays in obtaining approval before conducting the interviews and during the execution because the study was conducted during the COVID-19 pandemic period, which included movement restrictions and lockdown. However, this issue was addressed by managing the study plan schedule and adjusting it according to the pandemic updates. This study developed the course content on an MAR environment via the Metaverse Studio as an MAR platform that developed mobile applications with standard features that were suitable for the proposed course content design. Nevertheless, many other MAR authoring tools and platforms can be used to design and develop course content with advanced features and more options for professional purposes. However, the tool must be chosen that best corresponds to the proposed course content design and the development requirements.

7 Conclusion

This study aimed to create a framework for designing interactive m-training course content using augmented reality as an interactive technology available in mobile devices to provide a solution for the research problem indicated by several studies and discussed in the literature. This problem was summarized as the lack of a stable theoretical framework to design interactive m-training course content that could attract and motivate learners to participate effectively in the learning process via mobile devices.

We followed a mixed-methods approach of qualitative and quantitative analyses to offer a clear integrated solution. To accomplish the three objectives of this study, the key elements were extracted from the literature to create an initial framework, which achieved the first objective of the study. Then, we conducted interviews with experts to validate the initial framework. We thus achieved the second objective of this study, which resulted in the establishment of a proposed framework. The framework combines five phases of the ADDIE model and six key elements. Each phase of the ADDIE model was guided by the six key elements using a design guideline checklist to ensure quality content design. To attain the third objective, we tested the proposed framework by designing an m-training course following the framework procedures and guidelines. Then, we conducted an m-training course to train employees and evaluated the designed course by utilizing a training evaluation form to measure trainees' reaction to the designed course.

The outcome of this quantitative analysis verified the outcome of expert validation and demonstrated the validity of the proposed framework.

This study offers an effective solution, validated by experts and evaluated by users, to the problem of establishing a framework as a foundation for designing interactive m-training course content using MAR technology. It contributes to the knowledge by establishing a framework as a theoretical foundation for designing an interactive m-training course content using MAR. We believe that this evaluated framework contributes to developing knowledge and serves as a foundation for further research in this field. Additionally, it contributes to the theory by enhancing the theory related to M-Training course content design using the ADDIE model guided by six key elements and design guidelines. Moreover, it contributes to practice by providing assistance for trainers and designers to produce interactive m-training applications for training employees from different institutions by following and applying the proposed framework procedures with the design guideline checklist. This contribution will contribute to the development process of designing interactive m-training course content that attracts more employees to engage in m-training courses and that offers opportunities for the development of human resources in various fields.

For a future perspective, the design guidelines checklist might be revised and updated in the future as and when required due to the rapid advancement in mobile technology, which affects mobile learning and training. Future studies can be conducted to evaluate the proposed framework by designing courses and measuring the impact on different variables, such as employees' motivation, knowledge or behaviors.

Appendix 1: Design guideline checklist for designing interactive mobile training course content using Mobile Augmented Reality (MAR) technology

No	Construct	Operational Definition
1	**Pedagogical elements:**	These are issues related to the analysis and use of appropriate methods and strategies to facilitate the learning and training process, such as designing learning material.
1.1	**Instructional design guidelines for mobile training course content in aMobile Augmented Reality (MAR) environment**	This represents the proposed criteria for the design of mobile training course content that includes augmented reality technology based on appropriate learning theories to maximize learning via mobile devices.
No	**Items**	**Comments**
1.1.1	Conducting training needs analysis to define appropriate topics for the training content and training solutions that are compatible with the environment of Mobile Augmented Reality (MAR) based on trainees' actual needs.	
1.1.2	Identifying SMART learning objectives (specific, measurable, achievable, relevant, time-bound) consistent with the characteristics of Mobile Augmented Reality (MAR).	
1.1.3	Selecting scientifically accurate, linguistically correct, logically sequenced content that is relevant to the learning objectives.	
1.1.4	Defining appropriate learning theories that are compatible with the selected content and	

No	Construct	Operational Definition
	consistent with mobile augmented reality technology, such as Interactive Learning, Immersive Learning, Inquiry-Based Learning, Game- Based Learning, Motivational Theory, Discovery Theory, Connectivism Theory, Constructivism Theory, Cognitive theory of Multimedia Learning and Behaviorism Theory.	
1.1.5	Identifying suitable training delivery methods.	
1.1.6	Selecting the appropriate learning strategies for designing attractive, interactive and motivational content that is compatible with the level of the trainees.	
1.1.7	Considering the characteristics of mobile devices while designing mobile training content: breaking the content into short sessions; simple, flexible content; easy to access, easy to navigate content; less text (suitable for small screens); more graphics with multimedia; instant feedback; and interactive activities utilizing mobile augmented reality tools.	
1.1.8	Determining appropriate assessment and evaluation methods for achieving learning objectives.	
1.1.9	Designing an interactive interface considering the technical characteristics of mobile devices to provide a motivational environment using a mobile augmented reality environment.	
1.1.10	Designing interactive, gradual and varied activities that develop thinking skills, arouse attention, build knowledge, and achieve learning objectives using mobile augmented reality interactive methods and multimedia tools.	
1.1.11	Designing interactive, gradual and varied evaluation styles and strategies related to achieving learning objectives, such as instant feedback (text, voice, visual).	
1.1.12	Designing an assessment process to include pre-assessments, formative assessments and summative assessments, considering the usage of mobile device features (camera, QR code, GPS, etc.).	
1.1.13	Developing the designed content, activities and various tools of assessment and evaluation with the use of mobile content authoring tools in the mobile augmented reality environment based on the designed scenario.	
1.1.14	Conducting testing for the developed course content by delivering pilot mobile training in the environment of a mobile device.	
1.1.15	Ensuring that the implementation of the mobile training course is executed by following Gagne's nine events of instruction (*Gain the attention of the trainee, Inform the trainee of the objectives, Stimulate recall of prior knowledge, Present the content, Provide trainee guidance, Elicit performance, Provide feedback, Assess performance, Enhance retention and transfer*).	
1.1.16	Evaluating the designed, developed and implemented mobile training content by	

No	Construct	Operational Definition
	measuring feedback and assessing the outcomes from the execution of the pilot training to overcome challenges and come up with recommendations and modifications for improving the prototype so that it will be ready to be an application that runs on mobile devices.	
No	**Construct**	**Operational Definition**
2	**Technological elements:**	The technological elements of mobile devices are used to facilitate mobile learning and training enhancement. These elements represent one of the crucial aspects brought forward in the previous studies, which emphasized the requirement of transformation for delivering learning via mobile technology to fulfill learners' needs in this digital age.
2.1	**Operating environment**	This sub-element is related to the operating systems to be considered while designing a mobile app to define which platforms to support and to be compatible with.
No	**Items**	**Comments**
2.1.1	Compatible with and able to operate on as many different types of mobile devices that contain mobile augmented reality features as possible.	
2.1.2	Running on the iOS operating system.	
2.1.3	Running on the Android operating system.	
2.1.4	Supporting previous, current and updated versions of the iOS operating system.	
2.1.5	Supporting previous, current and updated versions of the Android operating system.	
No	**Construct**	**Operational Definition**
2.2	**Mobile applications**	This takes under consideration the most technical issues and usability guidelines related to the development of mobile applications.
No	**Items**	**Comments**
2.2.1	Developing applications that are easy and fast to download for different types of mobile devices by following consistency in designing mobile applications.	
2.2.2	Developing applications that are easy and fast to download for different types of mobile devices by following standards in designing mobile applications.	
2.2.3	Easy to access applications after downloading.	
2.2.4	Easy to open applications after downloading.	
2.2.5	Using mobile augmented reality technology through the designed applications without downloading additional applications.	
2.2.6	Easy to control for users, making them feel that the application is responding quickly to their actions.	
2.2.7	Designing appropriate graphics elements that illustrate basic components and provide browsing tools with clear instructions.	
2.2.8	Using a clear notification when it is required to ask for permissions, such as accessing the mobile device camera to run an AR experience in the application.	
2.2.9	Availability of simple method to search for content.	
2.2.10		

No	Construct	Operational Definition
	Easy to navigate inside the application, including how to stop, exit and return to accessing the training sessions and activities of the designed content.	
2.2.11	Considering the usage of different styles of interactivity inside the application.	
2.2.12	Avoiding the use of decorative fonts with different colored backgrounds.	
2.2.13	Using simple fonts that show clear text on a light background.	
2.2.14	Using readable fonts that show clear text on a light background.	
2.2.15	Consistency in the use of terms within the application interface menu and terms inside the application's content to prevent and avoid confusion.	
2.2.16	Selecting a small storage size of images in the application with standard formats.	
2.2.17	Choosing images that express the content in the application.	
2.2.18	Providing substitute text labels for images in the application to explain content.	
2.2.19	Selecting comfortable colors so that the eyes can easily focus to highlight the content.	
2.2.20	Using clear, adjustable voices in the application.	
2.2.21	Selecting sounds that require only a small storage capacity.	
2.2.22	Selecting sounds relevant to the presented texts or images for clarifying the content.	
2.2.23	Considering the compatibility of visual clips with mobile device screen sizes.	
2.2.24	Considering short controllable video clips in the application.	
2.2.25	Using video clips with a small storage size with different standard formats.	
2.2.26	Providing appropriate technical support to easily handle, recover from and diagnose errors.	
2.2.27	Conducting a pilot test for the developed application in mobile operating environments.	
No	**Construct**	**Operational Definition**
2.3	**Physical specifications**	This section concentrates on the physical issues of mobile devices, such as storage capabilities, power, processor speed, etc.
No	**Items**	**Comments**
2.3.1	Considering the ability to run the designed content on mobile devices with the standard processing speed to provide acceptable performance in executing the required tasks.	
2.3.2	Compatible with presenting the designed content clearly at the different sizes and resolutions of touch screens.	
2.3.3	Considering that mobile devices having a limited storage capacity.	
2.3.4	Considering the restricted memory size of mobile devices.	
2.3.5	Paying attention to the runtime duration and consumption of battery power.	
2.3.6		

No	Construct	Operational Definition
	Taking into account the bandwidth and wireless network issues.	
2.3.7	Considering the standard configuration of cameras to run on various mobile device types.	
2.3.8	Considering the standard configuration of speakers to run on various mobile device types.	
2.3.9	Considering the standard configuration of microphones to run on various mobile device types.	
No	**Construct**	**Operational Definition**
3	**Interactive communication elements:**	These elements focus on interactivity and communication, which have to be considered while designing interactive mobile training content.
3.1	**Interactive interface**	This is considered a gateway of interactivity for sharing knowledge, discussion and collaboration. Some specific considerations should be taken into account regarding the design for Mobile Augmented Reality (MAR) applications; for example, the user interface design and its content need to be compatible and customized based on the needs of learners.
No	**Items**	**Comments**
3.1.1	Designing a simple interface that illustrates the basic components and offers browsing tools with clear instructions.	
3.1.2	Considering balancing the distribution of the interface components in proportion to empty spaces to increase the visibility.	
3.1.3	Considering balancing the distribution of the interface components in proportion to empty spaces for easy accessibility.	
3.1.4	Each component or group of components should perform a specific function.	
3.1.5	Considering the interconnection of all components of the interactive interface.	
3.1.6	Considering the design of an interactive, user-friendly interface that illustrates basic components and offers clear instructions for guiding the trainee visually by using familiar user interface patterns, visual cues and animation.	
3.1.7	Considering the design of an interactive interface that displays the instructor as an avatar explaining the course instructions to visually guide the trainees to motivate them and facilitate the training process while launching an AR experience.	
3.1.8	Avoiding menus that suddenly pop up, full-screen takeovers, quick transitions and any notifications that distract the trainee and remove them from the AR experience.	
3.1.9	Allowing the trainee to interact individually with components by accessing the training content for self-training.	
3.1.10	Designing an interactive interface that enables trainees to use markers, symbols or icons to display and interact with multimedia objects such as images, videos and 3D models, which simplify the explanation and understanding of the training content.	

No	Construct	Operational Definition
3.1.11	Considering the possibility of establishing synchronous or asynchronous communication, based on the designed training scenario, if required, between the trainer, trainees and training content to facilitate interaction in the training course.	
3.1.12	Demonstrating a map of the topics included in the training that shows the training path to guide the trainees down the path they need to follow to complete the training process.	
3.1.13	Stability in performance while moving between main interface menus.	
3.1.14	Flexibility in interaction by smoothly returning to the previous steps or to the main interface and exiting and entering the program easily.	
No	**Construct**	**Operational Definition**
3.2	**Mobile Augmented Reality(MAR) interactive methods**	This part demonstrates the Mobile Augmented Reality (MAR) interactive methods, such as the use of tools and techniques that are considered when designing interactive content. The usage of one or more than one MAR method depends on the course content design requirements.
No	**Items**	**Comments**
3.2.1	Overlaying virtual images over real-world objects.	
3.2.2	Based on content design requirements, recognizing the features of objects through tracking selected markers on objects and the position and orientation of the object at various angles to recognize it and replace it with a virtual version.	
3.2.3	Based on content design requirements, using the marker-less augmented reality type, which is based on using items such as a digital compass, GPS, accelerometer or velocity meter to obtain location data and the visualizations of augmented reality.	
3.2.4	Considering the possibility of merging virtual 3D objects to allow them to interact with the real environment.	
3.3.5	Considering the possibility of merging shapes to allow them to interact with the real environment.	
3.2.6	Considering the ability to use a mobile camera for reading content using different MAR techniques, such as through QR codes, markers, etc.	
3.2.7	Based on content design requirements, designing AR objects by optimizing the lighting and using shadows, ambient occlusion, the normal mapping technique and reflection to make them look like real objects interacting with the real-world environment.	
No	**Construct**	**Operational Definition**
3.3	**Multimedia tools**	These are related to integrating various elements such as text, graphics, audio, videos and animation to make the designed content attractive.
No	**Items**	**Comments**
3.3.1	Allowing the trainees to control how video clips are displayed at any time through the control bar.	

No	Construct	Operational Definition
3.3.2	Avoiding the use of long video clips as much as possible because this will cause slow downloads. Avoiding the use of long video clips as much as possible because this will require more capacity.	
3.3.3	Minimizing the use of two video clips at the same time on the same page.	
3.3.4	Adjusting window sizes so that they are suitable for showing clear animated content.	
3.3.5	Considering the ratio between the drawing size and page size while creating animated graphics.	
3.3.6	Using voice comments with animated graphics instead of text comments.	
3.3.7	Saving multimedia files with standard formats suitable for a mobile augmented reality environment.	
No	**Construct**	**Operational Definition**
4	**Ethical elements:**	These elements are related to ethical aspects that have to be considered while designing interactive mobile training content.
4.1	**Ethical aspects**	These are related to social and cultural diversity, anti-discrimination, etiquette, the accessibility of information and occupational health and safety requirements.
No	**Items**	**Comments**
4.1.1	Considering social and cultural diversity issues when designing interactive mobile training content.	
4.1.2	Considering anti-discrimination issues when designing interactive mobile training content.	
4.1.3	Considering etiquette issues when designing interactive mobile training content.	
4.1.4	Considering issues related to the accessibility of information when designing interactive mobile training content.	
4.1.5	Considering issues related to health conditions caused by technology when designing interactive mobile training content.	
4.1.6	Considering safety and comfort issues when designing interactive content to keep the trainee safe while interacting with the AR environment; not asking a trainee to go backwards in activities, avoiding activities that take a long time and provide the flexibility for the user to pause and to continue the experience.	
No	**Construct**	**Operational Definition**
5	**Legal elements:**	These elements are related to legal aspects that have to be considered while designing interactive mobile training content.
5.1	**Legal aspects**	These aspects demonstrate the issues related to the copyright of materials, privacy, plagiarism and intellectual property.
No	**Items**	**Comments**
5.1.1	Considering issues related to the copyright of materials when designing interactive mobile training content.	

No	Construct	Operational Definition
5.1.2	Considering issues related to privacy when designing interactive mobile training content.	
5.1.3	Considering issues related to plagiarism when designing interactive mobile training content.	
5.1.4	Considering issues related to intellectual property when designing interactive mobile training content.	
No	**Construct**	**Operational Definition**
6	**Managerial elements:**	These elements are related to administrative items required for proper project management to produce high-quality content and on-time delivery.
6.1	**Administrative items for project management of course content design**	These items are related to proper project management and quality control aspects to produce high-quality content and on-time delivery.
No	**Items**	**Comments**
6.1.1	Selecting a designer, trainer or course design team with professional skills to perform course content design tasks professionally; they should be able to remain current with the evolution of emerging mobile technology for designing and developing content for high-quality interactive mobile training courses.	
6.1.2	Setting up a proper project management plan for course content design, with management of the design process among team members done by the project manager or course creator (trainer or educator).	
6.1.3	Considering establishing guidelines and instructions to execute the project plan, such as dividing tasks into stages and small segments in the course content design project so that they can be easily managed.	
6.1.4	Using the proper techniques of project management to perform quality control on the course content design.	
6.1.5	Considering the use of proper project management techniques for completing the design and development process and delivering the product on time.	

Appendix 2: Training evaluation form

We would like to thank you for participating in this m-training course. We value your feedback. Please complete this evaluation form.

1) Evaluation of m-training course content design elements:

Elements	Items	Agree	Undecided	Disagree
Pedagogical Aspects	**1-Contents were relevant to the course objectives.**			
	2-The training course was aligned with the learning objective.			
	3-The instruction given during the course was clear and easy to understand.			
	4-Simple course content was delivered using an attractive and interactive style.			
	5-Appropriate assessment method for achieving the learning objectives.			
	6-Suitable training duration for each session			
Interactive Aspects	**1-Simple and interactive interface enables easily browsing content.**			
	2-An interactive and motivating training environment.			
	3-Using MAR techniques facilitate an easy understanding of the topics.			
	4- Clear and easy to control audio and video.			
	5- Easy to utilize the training content and navigate smoothly between the topics.			
	6-Interactive and diverse activities that are consistent with the course objectives.			
Technological Aspects	**1-Easy to download and run the application.**			
	2-Clear drawings, fonts and pictures.			
	3- Easy to use buttons that navigate between the contents and easy browsing and exit from the application.			
	4-Technical support is provided for trainees via email, WhatsApp or direct communication.			
Ethical and Legal Aspects	**1- Access to course information and health and safety requirements were considered in the application design.**			
	2-Issues related to copyright, privacy and intellectual property were considered in the course design.			

2) Comments and suggestions:

A) Could you briefly express your point of view about this m-training course?
B) Do you agree that this m-training course has contributed to developing your essential communication skills in the workplace? If so, why?
C) What are your suggestions to improve this m-training course?

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