UX DESIGN EVALUATION OF AN AUGMENTED REALITY SYSTEM FOR HUMAN PHYSICAL TRAINING

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ABSTRACT

Technology advancements has enabled dance to be learnt without mirrors or real dance trainer. Distinctive benefits has been contributed by Augmented Reality (AR) technology. Dance trainers are focusing upon implementing dance analysis systems to enhance dance trainee's artistic skills. AR technology presents new user experience (UX) for learning, instructing, developing and accessing physical dance movements as well as provides scope to expand dance resources and rediscover the learning process. In this research work, we present a novel human physical training system i.e. dance training and analysis that could help individuals in learning selected dance styles which ignites motivation, matches dance steps/body postures and analyzes the performance. This study explored quantitative data by means of statistical tests validation with participants in using the phyisical training system that has facilitated in testing the dance body postures and steps. The work also adopted the user experience (UEQ) questionnaire to perform the UX evaluation. The outcome revealed favaroble results indicating the measurement score of the UEQ six scales to be in the positive range.

Keywords: Augmented reality, dance, gesture user interface posture, steps

1.0 INTRODUCTION

Technological advancements for human physical training has taken a new dimension where previously humans could just see things in the form of imagination. This vision is becoming a reality due to the betterment of specialized hardware and software. In the physical training field in particular, conventional teaching and training is being replaced by virtual instructors where human expertise may be limited particularly in the dance field. Emerging technologies such as AR with specialized equipment and software can be seen as a potential futuristic virtual instructor that not only teaches but has the capability to correct the mistakes made by learners. Generally, this phenomena has given rise to a new mode of educational design both in cutting-edge academia and design practices.

The possibility to extract accurate spatial-depth data of real physical environments-objects and further embed their augmented forms virtually suggest great potential of such technological tools to be included in the educator's standard digital toolbox of educational technologies. However to create high quality teaching and learning environments through AR, we need to understand and explore the potential of AR as an enabling technology for education which include, the fundamental of AR theories, the ability to design and implement certain AR techniques and the capability of applying AR technologies to applications of interest.

AR offers a wide range of uses, including entertainment, gaming, business, education, and medical. Contextual, environmental, interactive, and aesthetic design are all factors to consider while designing AR apps. AR has played a key role in education and training during the last few decades. In such cases, AR is used as a supplement to a normal curriculum, with images, text, audio, and video placed on the student's real-time surroundings. It has been anticipated and expected that new applications would emerge as a result of the probable spread of AR [1].

The system's fundamental user interface and design concerns are designed in line with the Learning Theory (LT) known as constructivism. In comparison to its rivals, such as behaviourism and cognitivism, this class of LT is described as constructive growth of knowledge based on simulation and evaluation of total competency. AR can be classified into four types: marker-based, markerless, superimposition-based, and projection-based.

The purpose of this study is to solve the issue of long-term learning retention and low learning efficiency by developing an interactive AR-based dance training system based on the constructivism learning theory. Following that, the system is verified and assessed using the user experience questionnaire (UEA) to determine user acceptance and usabiliy/user experience aspects.

1.1. Research Gaps and Contributions

Most previous studies focused on different technologies, have examined from different perspectives, and used other evaluation methods. Therefore, the research gaps such as poor learning efficiency, increased learning time, no knowledge on user's acceptance and experience for AR based training systems and lesser self-learning platforms have eventually motivated for the proposed research. This research is aimed to address and fill all the above-mentioned research gaps through distinct and interactive AR based dance training system and find solutions to achieve the objectives and address the corresponding research questions. Therefore, based on the above discussion, the following research objectives (RO) have been formulated:

RO1: To explore and study the relationship between learning theories and AR based training.
RO2: To develop a dynamic pose matching mechanism using skeletal mapping and Dreyfus skill acquisition model.
RO3: To validate the AR based human physical training system using user experience questionnaire (UEA).

This paper is organized as follows, Section 2 presents the background of this study, Section 3 provides an overview of the AR training system, Section 4 explains augmented reality technology, Section 5 describes the UEQ questionnaire used in this study, Section 6 shows the AR human physical system, Section 7 states the research methodology, Section 8 discusses the results and Section 9 concludes the paper.

2.0 BACKGROUND

Tracking, input and output devices (I/O), computers, and screens are the primary AR equipment. The history of augmented reality began in the 1950s, when Heilig proposed that cinema should be able to engage all of the viewers' senses into the onscreen activity in an efficient manner [2]. Researchers have already highlighted significant advantages of AR versus VR, such as the requirement for less power due to the use of fewer pixels. The author [3] discovered the Reality-Virtuality continuum, which is represented in Figure 1 as a depiction of mixed reality. As detailed by [4], who gave an overview of the core ideas of AR as well as a description of the many AR applications, the development that AR has achieved over the last decade has been nothing short of spectacular. AR, as one of the pillars of Computer Mediated Reality Technologies (CMRT), has garnered substantial attention and research focus for the development of technology-based solutions such as in healthcare, engineering and construction systems.

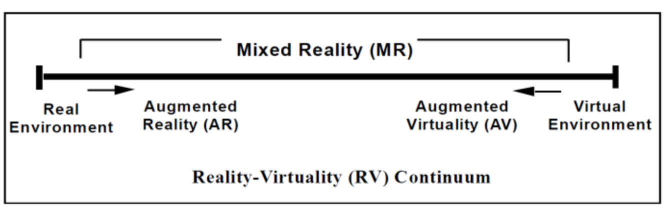


Fig. 1: Reality Virtuality Continnum [3]

A comprehensive literature review, taxonomy, and conceptual framework for state-of-the-art approaches in the field of CMRT research are provided in the article published by [5]. Despite the widespread use of AR and VR technologies in the domains of learning and education, there is still a need to understand the empirical link and variations in educational consequences across both VR and AR technologies. The research given by [6] sheds light on the cognitive and psychological differences between AR and VR in educational settings. Furthermore, the study suggests that both AR and VR can be useful tools for teaching science-based knowledge. On the other side, [7] discusses how diverse activities and technologies assist the younger generation in distinguishing between the digital and real worlds. Other authors [8] suggested a new method for ballet e-learning in which a learner from a remote location can use fuzzy set logic to detect distinct postures for in-home practise and execution.

3.0 OVERVIEW OF THE AR HUMAN PHYSICAL TRAINING SYSTEM

The unique and interactive User Interface (UI) based on the Dreyfus model (five-stage model of adult's skills acquisition i.e. Novice, Advanced Beginner, Competent, proficiency, and expertise), as well as the correlation with constructivism learning theory, are the primary distinctions between the proposed AR human physical training (on dance) system and the existing state-of-the-art methods. These are uncommon in current systems. The system is based on the motor skill acquisition process and posture matching techniques. Figure 2 depicts the many theories of learning.

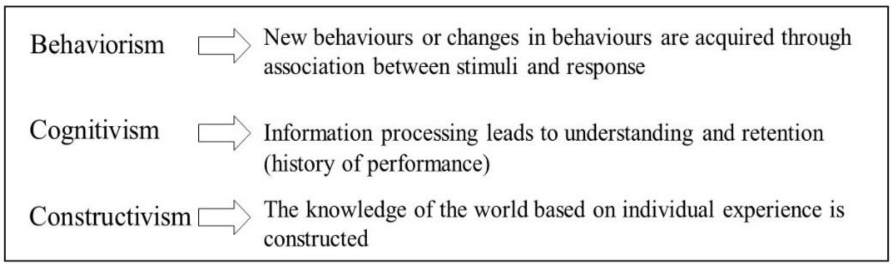


Fig. 2: Theories of learning adapted from [9]

Motor skill learning (MSL) is described as the process of presenting and experimenting with a specific motor skill depending on one's capacity that is carried out in line with practise and experience. Motor skill acquisition is described in the area of dance education as the phase that provides a learning environment for mastering fundamental and high-level abilities that would not otherwise be attainable via human motor development. MSL's major steps are as follows:

(a) Observation or focusing on the demonstration of a skill (UI)

(b) Performance and execution of the observed steps (PM, MSL)

(c) Feedback for the action performed

(d) Repetition-based on the feedback

While prior approaches focused on and achieved the first two phases, this research focuses on the four basic steps of motor skill development using AR technology.

3.1 Technology Assisted Physical Training

The combination of classic fine art forms and modern CMRT techniques has led researchers in the last decade to choose AR-based dance training solutions. As presented by Microsoft, the Cha learn gesture gathers data that is reliant on the user, employs the tiny vocabulary, and uses single shot training based on the Kinect camera [10]. The authors [11] and [12] proposed a technique of visualisation based on the acceleration, speed, and velocity of the dance instructor's movements for the students' clearer and seamless understanding. Other researchers [13] investigated YouMove, an unique framework that allows students to record and understand physical development sequences.

The researches [14] presented a Kinect-based training system for slow motions, with the mechanism of assessment being the similarity of posture and timings between the trainer and the user. The authors [15] study Vietnamese folk dances by analysing the dancer's body component movement through the depiction of an early experimental ontology. The authors created and prototyped the Thai dance training tool system utilising the Kinect motion sensor [16]. Figure 3 depicts the many dancing forms that are now popular.

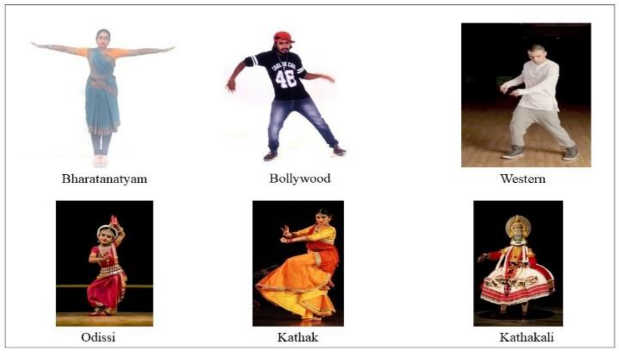


Fig. 3: Different types of Indo-western dance styles [17]

3.2 Physical Training Systems Problem

The Kinect is the most frequently used AR-based dance teaching and training tool. One of the key restrictions of the proposed system, according to the current research contribution [13], is the bone mapping and tracking by the Kinect. The Kinect has the disadvantage of tracking motions with significant occlusions. In this context, occlusions are described as obstructions caused by a hollow space in the body. As a result, combining and positioning several Kinects has been proposed as a possible improvisation to overcome the issue of occlusions. The use of Root Mean Square Error (RMSE) as a learning tool, on the other hand, has the problem of giving incorrect body movement similarities and differences in mapping the coordinates for dynamic motions. As a result of this constraint, correct body motions must be modelled in real time for AR-based dance teaching. Another key drawback of previous AR-based training systems is the use of bigger mirrors and projectors that are necessary for training sessions, which results in less mobility of the system and sounds unfriendly to millennials, dance supporters, and engineers. Due to this limitation, more portable and user-friendly AR-based virtual dance educators have emerged. The most recent study contributions have also suggested the use of social networking platforms and greater gamification elements to give dynamic and motivating feedback for AR-based dance teaching. Nonetheless, based on the research, there is no existing AR-based dance learning system that focuses on self-learning, interactiveness, and long-term retention. Self-learning is an essential component of AR-based in-house dance training systems, which entails studying without the physical presence of a dance teacher (traditional learning). This research gap, on the other hand, leads to the improvisation of the current AR-based dance training system in order to focus and stress the aspects of self-learning and autonomous capabilities.

3.3 Theories of Learning

Learning theories are a collection of principles that are organised to provide a detailed explanation of how people grasp, achieve, recall, retain, and acquire basic knowledge. Knowing and studying various learning theories can provide a clear understanding of how learning occurs. These theories include ideas and recommendations for selecting methods, resources, and instructional techniques that support the learning process. The sections that follow explain the ideas of numerous learning theories as well as a discussion of cutting-edge techniques in the field of learning theories.

3.4 Overview of Learning Theories

Many ideas have been established and refined over the last few decades by psychology educators and research specialists to describe the process of comprehending, learning, organising, and utilising skills and information. Many learning theories are available in the literature, and they are broadly classified into three categories: behavioural, cognitive, and constructive. It was created in early 1913, and the learner generates the output based on the input. Similarly, cognitivism is founded on the translation of data into knowledge. It belongs to the troubleshooting and decision-making learning paradigm and is assessed based on conceptual knowledge through computer-based training, with feedback supplied in the next successive input related to the output.

Constructivism, on the other hand, is focused on the constructive growth of knowledge through simulations and is assessed based on total competency. The information flow paradigm, which was created in 1945, consists of giving feedback to the learner. During 1948, a group of investigators carried out the process of categorising educational aims and goals based on [18]. The goal was to create a method for categorising three domains: emotional, cognitive, and psychomotor. Bloom's taxonomy for cognitive domain was created in 1950, and it was followed by the development of many more taxonomies for psychomotor and affective learning theories. The primary goal of such a taxonomy was to determine what researchers and educators wanted pupils to grasp in terms of educational objectives in relation to hierarchical formalities and the difficulty of learning theories.

3.5 Taxonomy of learning theories

Researchers' discussions on dance learning approaches to date may be divided into learning methods such as MSL, posture matching mechanism, and AR based techniques. The MSL is described as a process that permanently alters a motor skill via practise or experience. Posture matching entails performing a series of actions or steps that correspond to the key data set. Furthermore, the current development in computer vision is AR-based techniques (CV). Because of its low cost, exact matching, lack of wearables, and interactive interface, this AR-based approach, which can be described as learning any skill based on the unique technology of AR, is being regarded as a replacement for motion capture technology.

3.6 Motor Skill Learning

External attention has a better influence on the result of MSL, according to the researchers [19]. The author [20] highlighted the distinction between motor control and motor learning, stating that motor control guides postures and movement, but motor learning assists the body mechanism in acquiring new abilities regardless of an individual's age. Statistically significant improvements in motor skills of students those who are exposed to educational dance lesson compared to the ones not exposed to the dance lesson was discussed by the researchers [21]. Similarly, the authors [22] have discussed several benefits and factors that facilitate the learning of motor skills.

3.7 Posture matching technique

The researchers [23] presented a seven-stage method for recognising 17 essential ballet postures with a single camera. The authors presented a fuzzy discrete membership function-based method for recognising an unknown ballet stance [24]. A creative geometry-based technique for integrating body posture detection collected from multiple perspectives was presented, and a camera network-based system for people re-identification was also explored [25]. Additionally, the study contribution of [26] includes an efficient approach for recovering the human skeleton from a single depth picture using depth data delamination. The authors [27] suggested a string-matching algorithm for gesture identification as a lightweight solution for identifying movements using Kinect. Hence, to achive the objectives of the above study as discussed earlier, the following research questions (RQ) were formulated:

RQ1: How can the existing AR based training systems be categorized based on learning theories?
RQ2: How to improve the existing AR based dance education mechanism for self-learning?
RQ3: What are the factors that influence the user’s experience for AR based dance training system?

4.0 AUGMENTED REALITY

Augmented Reality (AR) is a Computer Vision (CV) field that is described as the integration of the user's environment with digital information in a real-world situation. In contrast to Virtual Reality (VR), which delivers a completely artificially built virtual world, AR uses the existing environment and overlays supporting fresh information on top of it.

4.1 AR based learning

The method of educating a person has progressed from classroom instruction to motor learning to e-learning and, finally, to CV. Technology developments in the 1990s paved the door for computer-based instruction. Following decades saw the spread of information sharing, embedded systems, artificial intelligence, neural networks, and cloud computing. The authors [28] provided a complete set of Kinect-based CV methods and applications. Pre-processing, object tracking, object recognition, human activity analysis, hand gesture analysis, and indoor 3D mapping are among the issues covered in the evaluated techniques. Despite the fact that there are numerous educational prototypes in the present literature, [29] argue that only a few prototypes are produced by multidisciplinary groups and link their work to learning theory. As a result, their study enumerates the benefits of augmented reality for learning and analyses learning theories pertinent to future AR educational content.

4.2 AR in education and training

AR, as previously stated, is a technology that uses CV methods to cooperate computer-generated virtual objects with the real-time environment in order to improve or enhance what the normal human eye can see [30]. AR may be utilised in the educational sector for dance instruction, chemistry, biology, astronomy, mathematics, and computer graphics. Figure 4 highlights the benefits of augmented reality in the education industry. This section provides information on the many advantages of augmented reality applications in the educational setting. As a result, it is possible to assume that better learning curves and greater motivation account for more than 20% of all the benefits of AR in educational aspects reported in the literature to date [31]. Kinect sensors are used in dance education to teach students in physical motions as well as to perfect their abilities.

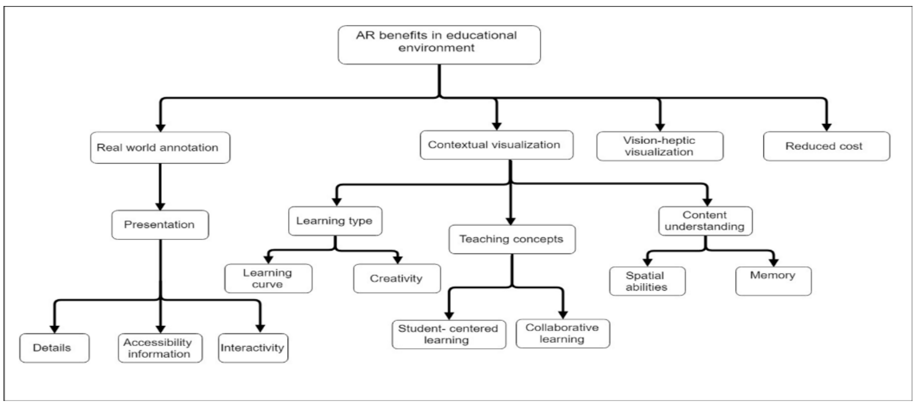


Fig. 4: AR benefits in educational environment

4.3 AR based skill aquisition

Various CV-based systems have been built with the goal of acquiring psychomotor skills through asynchronous training. As an aid to skill learning, such devices capture and repeat the expert's motions. AR technology is currently regarded as a major technology for the learning of psychomotor abilities.

4.4 Pose matching

The technique of obtaining the spatial arrangement of human body components from recorded pictures is referred to as human posture estimation. The researchers [32] developed a method for doing human posture co-estimation using multiple models with varying levels of complexity and an effective inference methodology. As shown in Figure 5, this approach estimates the postures of persons who do the same activity synchronously, such as dancing in a group or undertaking a physical activity.

Fig. 5: Trainees depicting human pose co-estimation

4.5 Gesture recognition

The goal of gesture recognition for skill learning utilising mixed reality is to interpret and analyse human motions using empirical and mathematical methods. The researchers [33] presented a method for matching human motions by applying a methodology that extracts human movement characteristics from silhouette depth images. Figure 6 shows a graphical depiction of the extracted key points silhouette picture. Other techniques like skeletol mapping and emotion analysis have also been used in gesture recognition.

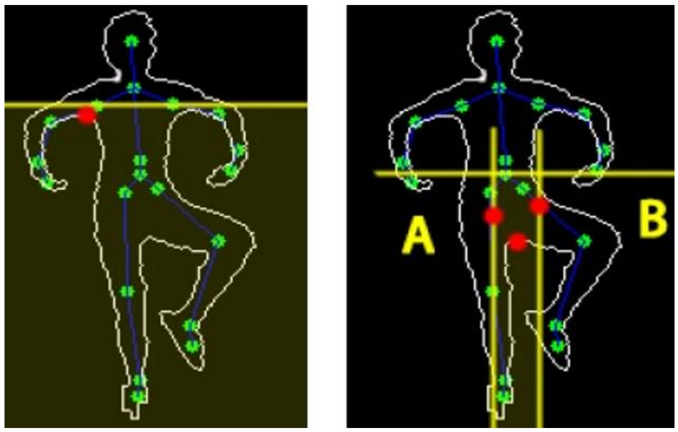


Fig. 6: Key points of the silhouette depth image [34]

Table 1 depicts many types of AR-based dance learning systems. The Kinect has trouble tracking motions that result in a high number of occlusions. This is more user-friendly, but it does not give the same real-time feedback as the mirror. The addition of social elements and more robust game technology integrations might potentially substantially benefit the “YouMove” system. Online yoga, dance, or martial arts lessons with competition from online peer groups are possible, but more work and study is required to achieve this.

Table. 1: AR based dance learning using Kinect

Area or domain topic	References
Movement analysis	[34]
Gesture recognition	[35]
Posture matching	[35]
Skeletal mapping	[13]
Gesture recognition	[12]
Skeletal and gesture recognition	[36]
Skeletal mapping	[37]
Skeletal mapping	[38]
Human computer interaction	[39]
Movement analysis	[40]
Skeletal mapping	[41]

5.0 USER EXPERIENCE QUESTIONNAIRE

There are numerous user experience questionnaires to measure the ease-of-use of the interactive product for example Technology acceptance model (TAM), User experience questionnaires (UEQ), Attrakdiff, Guievaluator, Modular evaluation of components of user experience (Mecue), Visual aesthetics, System usability scale (SUS), Questionnaire for User Interface Satisfaction (QUIS), and Standardized user experience percentile rank questionnaire (SUPR-Q). One goal of employing a UX questionnaire is to generate development suggestions in order to improve the product and provide customer satisfaction. ISO 9241-210 provides a well-known definition of user experience (ISO9241-210) [42]. In this context, user experience is described as "*a person's experiences and views as a result of using or anticipating using a product, system, or service*." Furthermore, user experience is viewed as a cohesive term that incorporates all sorts of emotional, cognitive, or physical reactions produced before to, during, and after the use of a product. The data collection technique provided in this work is based on the User Experience Questionnaire (UEQ) [43] and demonstrates how to evaluate the UEQ results using relavance-performance analysis which is useful in examining user's satisfaction of a system. The UEQ was chosen since it is a well-known UX questionnaire that is offered in over 20 languages. Additionally it is free to use, covers a wide range of areas including pragmatic and hedonic aspects (joy-of-use / creativity of a product) and normative data is available.

The goal of the UEQ is to allow for a fast assessment of user experience by end users, preferably encompassing a full perception of user experience. It enables consumers to communicate thoughts, impressions, and attitudes that develop throughout their experience with the product under consideration in a very easy and rapid manner. It is made up of 26 components and divided into six scales as follows:

1. **Attractiveness:** Overall impression of the product. Do users like or dislike is?
2. **Perspicuity:** Is it easy to get familiar with the product? Is it easy to learn how to use the product?
3. **Efficiency:** Can users solve their tasks with the product without unnecessary effort?
4. **Dependability:** Do the users feel in control of the interactions?
5. **Stimulation:** Is it exciting and motivating to use the product?
6. **Novelty:** Is the product innovative and creative? Does the product interest users?

Each of the scale above reflects a different component of UX excellence. The questionnaire components are implemented as a semantic differential, which means that each item consists of a pair of words having opposing meanings. As an example, consider the following item:

not interesting o o o o o o o *interesting*

The scale of the components ranges from -3 to +3. As a result, -3 indicates the most negative answer, 0 represents a neutral answer, and +3 represents the most positive one. Users have a favourable opinion of this scale if their scale value is greater than +1, and a negative impression if their scale value is less than -1. Because to well-known response effects, such as the avoidance of extremes, observed scale means are often in the -2 to +2 range. A benchmark can be used in addition to this interpretation to compare the findings of a product evaluated with the UEQ to the results of other products.

6.0 THE AR HUMAN PHYSICAL TRAINING SYSTEM DESIGN

The suggested design method is intended for all dance students who want to learn to dance. Furthermore, the system is developed and built with the degree of skill and expertise in mind, which is divided into three levels: novice, intermediate, and advanced [44] based on Dreyfus model.

6.1 The user interface

Usability, visualisation, functionality, and accessibility are the four key components of the AR human physical training system's user interface. The components, (i) Usability is defined as the ease of use and learnability of a software/product. It is a quality measure attribute that assesses an application's usability. (ii) Visualization i.e. visual signals are provided through visualisation in ways that mere text cannot. Visualization easily disseminates information. The suggested system items can be easily visualised by viewing them on the home screen. The system guides us with visual signals and three virtual cubes on the right side of the screen for quick access. This corresponds to an activity comparable to hitting a menu button on the user interface of a web page or an application. When the subject/user picks a particular dance style from the menu, the virtual cubes depicted in Figure 7 begin to rotate in 3D, allowing the subject/user to visualise the effect of the selected options. (iii) Functionality, the key component that allows the system to function as intended. The suggested system meets the functionality requirement by delivering visual signals and feedback to individuals regardless of their height, weight, or body shape. (iv) Accessibility, when building a system, all types of users must be taken into account. Each individual's accessibility and user-friendliness should be taken into account. A new NUI is utilised in the proposed system to facilitate access to items and menus.

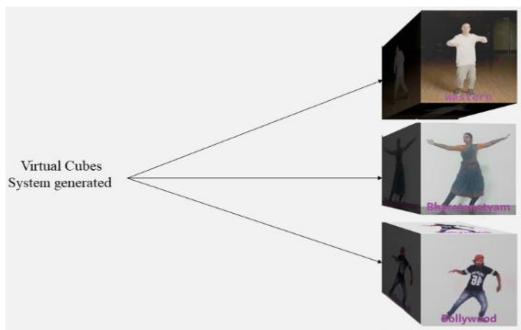


Fig. 7: Visualization of virtual cubes in system

As an example, the novice mode (Figure 8) was created to assist and encourage new dance learners, making it easier for them to grasp the dance routines. The choreographer's video (top left window) pauses after a set of left/right motions and waits for the new student to execute the identical actions. Directional visual signals in the shape of guiding arrows and matching percentage emerge in real-time to aid the new student. In this level, slower moves are also scored, which implies there is no time constraint for the move to be done. The video continues once the motion has been correctly executed. Guidance is a crucial aspect to consider while supporting and assisting new dance learners and improving their dancing talents. A system that lacks direction and feedback is termed non-interactive. Guidance and feedback are offered in the system to make the it more interactive. The types of guidance provided in the system include, match/mismatch in the pose, arrow mark guiding the next move for the new learner and textual information below the choreographer which informs the dancer what should be done for the next move.

Fig. 8: A subject performing western dance (novice level)

6.2 Backend database

The system is a real-time self-learning and evaluation based that gives real-time feedback to the user. If a new dance student wishes to examine his proficiency after a one-week session, the backend database may be accessed. On the other hand, if the dancer wishes to examine how well he or she has improved his or her dance learning skills, the database can also be used to retrieve the performance history. The system is designed to record the whole session with a video recording frame rate of 30fps to assist the dance student and to compare prior performances with recent ones.

7.0 METHODOLOGY

Several research looked at the reliability (i.e., how consistent the scales are) and validity of the UEQ scales (in 11 usability tests with a total number of 144 participants and an online survey with 722 participants). An assessment of all known research revealed that the scales' reliability (Cronbach's Alpha coefficient is typically greater than 0.7 was used to estimate internal consistency) with its components T = .84, .83; Perspicuity = .82, .71; Efficiency = .79, .73; Dependability = .69, .65 [43]. In order to fulfil the study objectives and meet the research goal, an empirical research strategy was devised and applied. The quantitative technique was employed in the research, which helped to address the in-depth difficulties, research questions, and objectives. The overall research methodology is shown in Figure 9. Upon identifying the research framework and domian, the questionnaire was developed using the UEQ framework, and a pilot research test was carried out to validate the questionnaire. The intended respondents were also specified. The questionnaire was filled up by the respondents during the data collection process to measure the UX of the AR physical training system. Furthermore, the data extraction procedure was carried out in order to do data filtering and data coding in order to confirm the results. Following the data extraction procedure, the data analysis process was performed to assess the UX of the AR physical training system and obtain the research result.

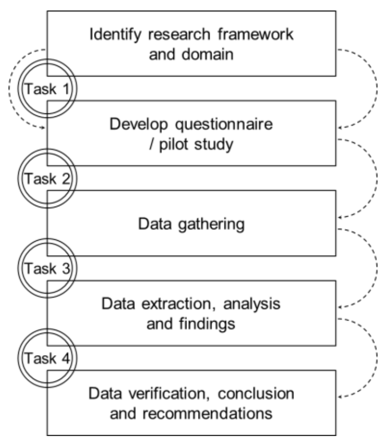


Fig. 9: Research methodology

7.1 Questionnaire design

Two categories of questionnaires were created using the items from each category of the UEQ framework and self-designed about the AR physical training system. The quantitative approach was used in this study to collect data from the questionnaires sent to the consumers. The subjects were carefully chosen, and a pilot research was carried out to fine-tune and improve the robustness of the questionnaire and obtain a better degree of accuracy. The quantitative data are the results of the UEQ questionnaire. These surveys were created with the primary principles behind the current research and literature in mind.

7.2 Research population

The research population consists of people who have been chosen to use the quantitative technique. The current study population for this work comprises of individuals that meet the following criteria:

(i) New dancers - A person who is eager to learn a new dance form.
(ii) The appropriate age for motor skill learning will be between the ages of 12 and 40.

7.3 Sampling, data gathering and analysis

The non-probability convenience sampling approach was used throughout the current study. Convenience sampling is a non-probability sampling approach in which subjects are chosen based on their ease of access and closeness to the study topic. According to preliminary study, this method met the criteria for the target population. Some pilot study participants were also included in the real study since pilot study participants are also users who agreed to test the system. Pearson's Product Moment Correlation Formula was used to conduct the validity assessment and the Cronbach's Alpha formula was used for reliability testing. As part of a pilot research at UNITEN in Malaysia, the AR physical training system was put to the test on 20 individuals. The average age of these respondents was 21 years old, 35% were men, and 75% were interested in dancing. The data was analyzed using SPSS 21.0 (IBM Inc., Chicago USA) statistical software. Approximately 70% of them desire to study diverse dance genres. The UEA which is made up of 26 components and divided into six scales was utilised in this study to assess the acceptability of the newly designed AR physical training system among these 20 individuals. As for the data analysis, the participants' responses were scaled from -3 to +3. If a participant picks 1 on the likert scale for a question in the questionnaire, the question receives a score of -3; on the other hand, if he or she replies 7, the question receives a score of 3. The total score of a question was used to determine the mean score of one question. The mean score of an attribute was calculated based on the mean of all questions in which the attribute appears. The mean of the scores were then used to compute the attribute score by averaging the score means. The most negative response is -3, the most neutral answer is 0, and the most positive answer is +3. Users have a favourable opinion of this scale if their scale value is greater than +1, and a negative impression if their scale value is less than -1. Analysing the data is quite straightforward with the provided excel sheet (the English original version was used for the analysis of this work). Quantitative data (using UEA questionnaire from 60 participants) was collected related to the participant's perception about the AR physical training system. The UEA was analysed by computing the means of the six scales listed in section 5.

8.0 RESULTS AND DISCUSSION

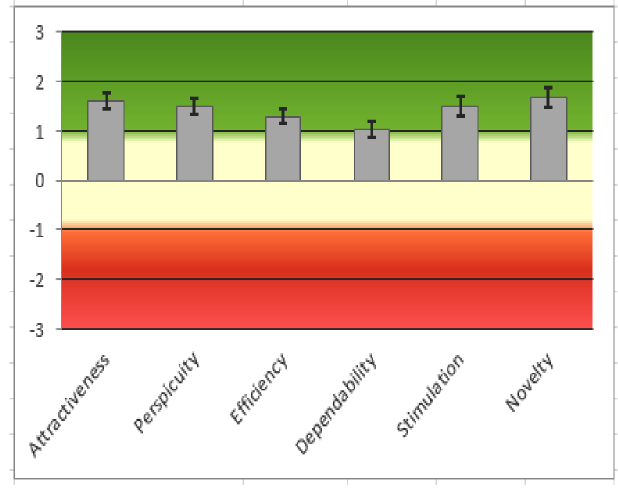
The results of the validity and reliability tests on both the pilot study and the real study are shown in Table 2. All of the validity tests scores are > 0.734. In that scenario, the questionnaire is considered legitimate. In the reliability test, a question from each category is deemed accurate if the score is > 0.6. Since all of the reliability testing scores are > 0.6, it is possible to infer that the surveys are accurate.

Table 2: Validity and reliability results

Scale	Validity and Reliability				
	Question	Validity Result (Pilot study)	Validity Result (Actual study)	Reliability Result (Pilot study)	Reliability Result (Actual study)
Attractiveness	1	.735	.708	.712	.766
	2	.748	.720		
	3	.735	.602		
	4	.766	.756		
	5	.782	.682		
	6	.751	.692		
Perspicuity	1	.738	.724	.675	.685
	2	.724	.721		
	3	.761	.708		
	4	.767	.618		
Efficiency	1	.742	.627	.642	.651
	2	.743	.788		
	3	.782	.734		
	4	.739	.612		
Dependability	1	.743	.626	.746	.782
	2	.768	.614		
	3	.744	.719		
	4	.742	.707		
Stimulation	1	.785	.651	.628	.655
	2	.741	.625		
	3	.847	.629		
	4	.834	.682		
Novelty	1	.785	.745	.824	.790
	2	.902	.900		
	3	.841	.785		
	4	.847	.840		

Figure 9 depicts the findings of the study based on the six UEQ scales. The attractiveness scale obtains a score of 1.600, which falls within the range of positive assessment scores of 0.8 to 3. This implies that the participants had a favourable opinion of the AR physical training system's design. The perspicuity scale receives a positive rating with a score of 1.500. Despite the fact that some participants were inexperienced with AR technology, utilising the AR physical training system for the first time was simple to understand and utilise. The efficiency scale earned a positive evaluation as well, with a score of 1.300. This demonstrates that the participants were able to complete their tasks using the system with minimal effort.

Although the dependability scale earned the lowest score of 1.040, it is still on the border line of the positive assessment zone. This means that the AR physical training system had good virtual animated cube buttons (shown in Section 6.1). It also provides evidence that the system items can be easily visualised by viewing them on the home screen and guides them with visual signals for quick access thus implying that the participants were in control of the interactions. The stimulation scale received a score of 1.500, suggesting that it is in a positive evaluation zone. This shows that the participants were motivated to utilise the augmented reality physical training system. Finally, the novelty scale received the score of 1.678, suggesting that it is in the positive assessment zone as well and atttracted the participants.

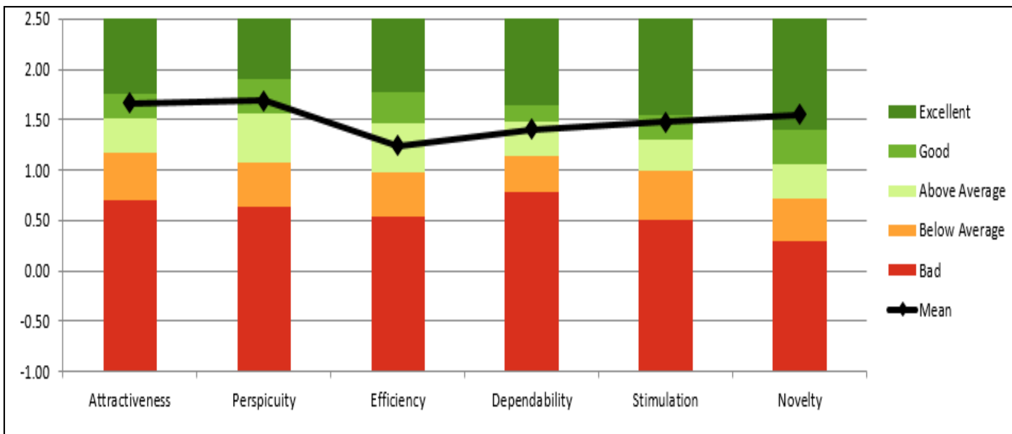


UEQ Scales (Mean and Variance)		
Attractiveness	1.600	0.58
Perspicuity	1.500	0.78
Efficiency	1.300	0.63
Dependability	1.040	0.69
Stimulation	1.500	0.86
Novelty	1.678	1.01

Fig. 9: The UEQ result

The UEQ instrument also includes a benchmarking tool that determines the areas of improvement of a product that incorporates data from more than 163 different product assessments using the UEQ (with a total of more than 4818 participants in all evaluations). The benchmark divides a product into five categories per scale as following [45]:

(i) *Excellent*: In the range of the 10% best results.
(ii) *Good*: 10% of the results in the benchmark data set are better and 75% of the results are worse.
(iii) *Above average*: 25% of the results in the benchmark are better that the result for the evaluated product, 50% of the results are worse.
(iv) *Below everage:* 50% of the results in the benchmark are better that the result for the evaluated product, 25% of the results are worse.
(v) *Bad:* In the range of the 25% worst results.



Mean
1.66
1.69
1.24
1.40
1.48
1.55

Fig. 10: Benchmark graph for the the AR physical traning system

The AR physical training system was categorized as "Excellent" in the novelty category, as shown in Figure 10, indicating that the system is in the top 10% of the best outcomes while attarctiveness, perspicuity and stimulation was categorized as "Good", indicating 10% of the results in the benchmark data set are better and 75% of the results are worse. The efficiency and dependability were rated as “Above average” which indicates 25% of the results in the benchmark are better that the result for the evaluated product, 50% of the results are worse.

9.0 CONCLUSION

The main goal of this work was to use AR technology to tackle the problems of long-term learning retention and low learning efficiency when developing a dance talent. For starters, it offered a thorough knowledge of existing dance learning approaches (both AR and non-AR based) and addressed the research question of how these existing systems are classified based on learning theories. Many factors can have a significant impact on the result of a learning system. Learning theory, kind of learning environment, training tools, technology-based skill acquisition technique, and implications of AR based technology are some of the elements that contribute to the retention and efficient learning result for technology-oriented learning systems. The work also addressed the learning retention rate by developing an AR physical training system based on the Dreyfus skill acquisition model. As a result, this research has generated a two-way research outcome of new interactive feedback and long-term learning retention natural user interface which addressed the second research question of how to improve the existing AR-based dance teaching mechanism for self-learning. Finally, quantitative analysis was used to identify the characteristics that influence user acceptance of the AR physical training system in order to solve the problem of knowledge gaps in the adoption of AR-based systems for dance instruction through self-learning. The key findings of this work's problem analysis are that the retention and learning efficiency of a dance training system is mostly affected by the kind of learning theory used, learning environment, training instruments, skill acquisition technology, and type of AR approach. The UEA questionnaire was adopted in this work to capture the results on the perception of user experience who participated in the evaluation. The result from the analysis of the UX revealed that the general impression from most of the participants of the AR physical training system received positive feedback. The study may be improved further by collecting more qualitative data about the trainees' perspectives and readiness to use the AR physical training system for developing competence and perfecting a dance talent. Additionally, emotion analysis elements may be included into the proposed system to address the relationship between human emotions, gesture detection, and body mapping.

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