THE EFFECTS OF AUGMENTED REALITY APPLICATION ON LEARNERS' PERCEPTION AND TECHNOLOGY ACCEPTANCE IN PHYSICAL EXERCISE

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by

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LIST OF ABBREVIATIONS

3D	3 Dimensional
AI	Artificial Intelligence
AR	Augmented Reality
ASM	Appendicular Muscle Mass
CDC	Centre of Disease Control and Prevention
CIT	Critical Incident Techniques
CITM	Centre of Instructional Technology and Multimedia
H	Research Hypothesis
I	Interview
ID	Identity
iOS	iPhone Operating System
NVIVO 12	Qualitative data analysis software
PE	Physical Exercise
PKS	Selangor Counselling Centre
PTPM	Pusat Teknologi Pengajaran dan Multimedia
PVR	Police Volunteer Reserve
QR Code	Quick-Response Code
RO	Research Objective

RQ	Research Questions
RI	Research Instruments
SDG	Sustainable Development Goal
SMI	Skeletal Muscle Index
SPSS	Statistical Package for the Social Sciences
SUKSIS	Pasukan Simpanan Polis Siswa Siswi
TAM	Technology Acceptance Model
TESOL	Teaching English to Speakers of Other Language
TRA	Theory of Reasoned Action
T-test	Statistical Hypothesis Test
USM	Universiti Sains Malaysia
US	United State
UTAUT	Unified Theory of Acceptance and Use of Technology
VR	Virtual Reality
WHO	World Health Organization
2D/3D	2-Dimensional/3-Dimensional

KESAN APLIKASI REALITI TERIMBUH TERHADAP PENERIMAAN TEKNOLOGI DAN PERSEPSI PELAJAR DALAM SENAMAN FIZIKAL

ABSTRAK

Augmented Reality atau Realiti Terimbuh merupakan salah satu teknologi baru yang sedang giat berkembang dan membangun. Ianya digunakan secara meluas dalam sektor pendidikan sebagai bahan tambahan untuk kurikulum sekolah. Ianya juga telah digunakan dalam bidang kesihatan dan sukan baru-baru ini. Dalam kajian ini, aplikasi AR yang berasaskan penanda untuk senaman fizikal telah dibangunkan. Kandungannya tertumpu kepada empat aktiviti senaman yang berasaskan pengukuhan otot iaitu tekan tubi, bangkit tubi, plank sisi dan turun naik bangku. Kajian ini bertujuan untuk mengkaji persepsi pelajar terhadap aplikasi senaman fizikal dan penerimaan mereka terhadap aplikasi AR untuk senaman fizikal. Bagi menentukan persepsi pelajar terhadap aplikasi senaman fizikal, reka bentuk kajian pra-pasca digunakan kepada dua kumpulan sampel bebas menggunakan aplikasi senaman fizikal Mod A (Presentasi Interaktif 3D PowerPoint) dan Mod B (Aplikasi Senaman AR). Keputusan menunjukkan terdapat perbezaan yang ketara bagi Kumpulan B (Mod B) berbanding Kumpulan A yang menggunakan persembahan Interaktif 3D PowerPoint sebagai aplikasi senaman fizikal. Seterusnya, pendekatan kuantitatif juga digunakan untuk menentukan penerimaan teknologi pelajar bagi yang menggunakan aplikasi senaman fizikal (Mod B). Bagi mendapatkan penjelasan yang lebih lanjut mengenai keputusan kuantitatif, pedekatan kualitatif, temu bual berstruktur telah digunakan. Keputusan penerimaan teknologi mereka juga menunjukkan bahawa majoriti sampel telah menerima penggunaan aplikasi AR bagi senaman fizikal. Selanutnya, pekali korelasi Tau-b Kendall digunakan untuk menentukan kewujudan perkaitan antara

pembolehubah persepsi pelajar dan penerimaan teknologi. Walau bagaimanapun, dari segi perkaitan antara pembolehubah persepsi pelajar dan penerimaan teknologi, dapatan menunjukan bahawa wujud korelasi negative yang sangat lemah antara kedua pembolehubah ini. Ini menunjukkan bahawa penerimaan teknologi aplikasi AR untuk senaman fizikal yang digunakan dalam kajian ini hampir tidak dipengaruhi oleh persepsi pelajar terhadap aplikasi senaman AR. Secara kesimpulannya, aplikasi AR untuk senaman fizikal adalah efektif dan boleh diterima oleh pelajar sebagai bantuan untuk mereka melakukan senaman pengukuhan otot.

THE EFFECTS OF AUGMENTED REALITY APPLICATION ON LEARNERS' PERCEPTION AND TECHNOLOGY ACCEPTANCE IN PHYSICAL EXERCISE

ABSTRACT

Augmented reality is an emerging technology that has rapidly evolved and developed. It was widely used in educational sectors as additional materials for school curricula. It also had been recently used in the health and sports fields. In this study, a marker-based AR application for physical exercise was developed. Its content was focused on four muscle-strengthening activities: push-ups, abdominal crunches, side planks, and step onto chair. This study intended to study the learners' perception toward physical exercise application and their acceptance towards the AR apps for physical exercise. To determine the learners' perception towards the physical exercise application, a quantitative approach, pre-post study design was used on two independent groups of samples using Mode A (3D Interactive PowerPoint presentation) and Mode B (Senaman AR application) physical exercise applications. Hence, the results show a significant difference for the Group B (Mode B) compared to Group A, which utilizes 3D Interactive PowerPoint presentation as their physical exercise application. Next, quantitative approach was also used to determine the learners' technology acceptance for students using Mode B physical exercise application. In order to explain more about the quantitative results, a qualitative approach, a structured interview, was used. The results on their technology acceptance also showed that most of the samples accepted the use of augmented reality application for physical exercise. Furthermore, the Kendall's Tau-b correlation coefficient was used to determine the existence of the association between the variables of learners' perceptions and technology acceptance. Hence, the findings indicated that there were

very weak, negative correlation between the variables. This showed that the technology acceptance of the AR apps for physical exercise used in this study almost did not influence by their perceptions towards the AR application. Overall, it can be concluded that the AR app for physical exercise was effective and can be accepted by the learners as their assistance in doing the muscle-strengthening exercise.

CHAPTER 1

INTRODUCTION

1.1 Introduction

Physical exercise was a great way to improve overall health and well-being. It had been shown to improve moods, decrease stress levels, and help with overall composition. It could also be a great way to relieve anxiety and depression (Mikkelsen et al., 2017). World Health Organization (WHO) (2020) reported that globally, 23% of men and 32% of women of adults aged 18 and over were inactive in 2016. Thus, in 2018, WHO launched a new global action on physical activity, More Active People for a Healthier World, mainly to increase sufficient physical activity among adults and adolescents (Guthold et al., 2020). In Malaysia, the survey done by the National Health and Morbidity Agency in 2019 showed that half of Malaysian adults were 30.4% overweight, and 19.7% were obese (NCCFN, 2021). These phenomena have caused concern, especially among the Malaysian Ministry of Health (MOH), to find various effective ways to overcome these issues.

One of the ways to overcome the issues was taken by the WHO organization which had given a recommendation on the frequency of the physical activity required for every group of individuals, from children under five years old to adults over 65 years old. For adults aged 18 to 64, the recommended physical activity required was at least 150 minutes of moderate-intensity aerobic physical activity and 75 minutes of vigorous physical activity per week (WHO, 2020). This recommendation was very important to note by the working-aged adults and university students at risk of being sedentary due to the proportion of their time spent working and studying (Castro et al., 2018, 2020).

Hence, sufficient physical activity was essential, as stated in the Malaysian Dietary Guidelines 2020; at least 30 minutes per day was significant to gain health benefits (NCCFN, 2021). This recommendation could be applied to the university students, especially undergraduates, as they were one of the groups that were highly exposed to sedentary behavior (S. Lin et al., 2022; Memon et al., 2021). This issue could be seen to become worse since the COVID-19 pandemic, where the majority of universities in Malaysia have moved forward to practice hybrid modes of learning, which only require students to attend the universities when needed (Iskandar & Dawn, 2023).

Consequently, multiple strategies could be employed to promote physical activity. This encompassed the utilization of immersive technologies, such as augmented reality (AR) and virtual reality (VR), as supplementary materials or tools to enhance physical exercise routines. Implementing this technology had the potential to enhance the attractiveness of traditional exercise methods (Ng et al., 2019). However, this study deliberately concentrated on applying AR technology in physical exercise due to its mobile-based nature and affordability, making it accessible to a wide range of individuals.

As a brief introduction towards AR technology, it could be recognized as a technological advancement enabling substituting real-world surroundings with virtual digital information (Vuță, 2020). In contrast to virtual reality (VR) applications that provide users with complete immersion in a virtual environment, AR technology enables the coexistence of both real and virtual spaces simultaneously (Moreno-Guerrero et al., 2020). This allows the users to interact with the virtual objects embedded in the real environment, increasing the realism experience and reaching the aim of using AR applications (Giasiranis & Sofos, 2016). Adopting AR technology in

physical exercise has many advantages. One of its advantages was that it can increase the user's motivation to do physical activity. The impact could be seen while playing the Pokemon-Go game, which used to become world phenomenon and successfully promoted its mass user in physical activities (Khamzina et al., 2020; Yan et al., 2020).

Apart from that, this study specifically addresses the application of augmented reality (AR) technology in the context of physical activity, prompting the researcher to consider some crucial variables. The variables in consideration pertained to the learners' perceptions of the physical exercise application and their acceptance towards this particular technology. The perceptions of learners may encompass their attitudes, beliefs, and subjective experiences pertaining to the physical exercise application. These perceptions hold significant importance in influencing the potential of user acceptance and continued usage of the technology in the future. Therefore, previous studies had demonstrated that the user's beliefs regarding the adoption of AR technology had an impact on the acceptance of this technology (Kristi & Kusumawati, 2021; Oyman et al., 2022).

In a nutshell, it could be concluded from the aforementioned concerns that engaging in regular physical activity was vital for the maintenance of optimal health. Adhering to the recommended levels of physical activity and minimum daily exercise period, as outlined by WHO and MOH organizations, an individual could significantly improve physical and emotional well-being. As quoted by Nelson Mandela, "Exercise is the key not only to physical health, but to peace of mind.". Accordingly, the application of AR technology had been regarded as an innovative approach to promote heightened participation in physical exercise. Hence, the learners' perception towards the used of physical exercise applications and the technological adoption of the learners was taken into consideration to study in this research.

1.2 Background of the Study

Regular physical exercise activity can boost one's stamina and enhance endurance. However, various health issues might occur due to a lack of awareness of the importance of physical exercise. One of the most alarming issues was obesity. Based on the National Health and Morbidity Survey, done every four years, Deputy Health Minister Datuk Dr. Noor Azmi Ghazali said that in 2019, 50.1 percent of Malaysians were overweight, and 19.7 percent were obese (Bernama, 2022).

Moreover, university students, especially those pursuing undergraduate degrees, had various challenges that contributed to inadequate levels of physical exercise. Following the outbreak of the Covid-19 epidemic, the manner of instruction in higher education institutions had transitioned from traditional face-to-face teaching to online platforms and subsequently to a hybrid model, as per the directive of the Higher Education Minister (Iskandar & Dawn, 2023). In accordance with this hybrid model, the majority of university students were required to engage in online classes using digital platforms such as Webex and were only obligated to participate in on-campus lectures during their first and final years, and solely when it was mandatory as per the curriculum. This increased the amount of time individuals spent in front of computers during lectures and while doing their assignments, ultimately leading to excessive screen time, which led to sedentary behavior (Suherman et al., 2021).

Additionally, due to their packed study schedule, the students reported being sedentary on average, spending more than 12 hours daily (Carpenter et al., 2021). It also reported that more than 70% of university students have less than 10,000 steps per day (Memon et al., 2021). This indicated that undergraduates tend to spend too much time seated and become inactive. As a university student, it was crucial to maintain good health. Neglecting their physical and mental health might risk various illnesses

and chronic diseases such as heart disease and cancer. It also might affect their academic performance due to their inability to concentrate, making it harder to stay alert and keep their engagement during class (Pascoe et al., 2020). On that account, it was important for students to set a healthy routine as one of their priorities in their daily routine, even if they just doing a quick workout at their home. This might help them to maintain a healthy mental and physical condition as well as boost their academic performance.

Thus, more awareness of the importance of physical exercise and intervention to enhance the level of physical exercise were needed to overcome these issues. The researcher intended to promote physical exercise by incorporating AR technology in this study. A marker-based AR application named Senaman AR was developed and utilized by undergraduate students as the study's sample. It was believed that AR technology had the potential to facilitate exercise routines, like other AR applications, it could featuring a virtual trainer capable of delivering both verbal and visual demonstrations (Yilmaz, 2021). The AR application was also convenient to be used by its users, enabling them to engage in exercise without the need to allocate significant time for gym visits. This flexibility allows individuals to engage in physical activity at their preferred locations and at any time that suits their schedule.

Consequently, two main variables were raised into the researcher’s concerned to study. These variables were the learners’ perceptions towards the physical exercise application and their technological acceptance of incorporating AR technology in physical exercise context. As proven by past research in different context of study, learners’ perceptions did affect the acceptance of the adoption of AR technology (Taha et al., 2023).

The learners' perceptions towards the physical exercise application would reveal the learners' experienced once they used the physical exercise application that developed by the researcher for the purpose of study. These involved a comparative analysis between the AR app and the Interactive 3D PowerPoint presentation which gives insight into which applications were found more effective and could make them more engaging.

Meanwhile, the technological acceptance was used to assess the learners' acceptance or rejection after their involvement with the AR technology for the physical exercise (Ammenwerth, 2019). This might explain why newly developed technology was accepted or rejected by its users. It was essential to understand the learner's perception of adopting new technology and determine if they would be interested in using that technology in the future (Taherdoost, 2019).

1.3 Problem Statement

The most significant issues related to insufficient physical activity include a lack of awareness regarding the importance of physical exercise and its impact on human well-being. Previous research, as noted by (Fredriksson et al., 2018), had shown that active individuals engaged in regular physical activity tend to be more aware of the health risks associated with physical inactivity. This suggested that the fitter one was, the fewer their health issues might experience by them. Hence, AR apps focused on promoting physical activity were developed as part of this study. It became a supplementary material that could help people keep fit by keeping their engagement and enhancing their interest in physical exercise. It was believed that AR was accessible to be used and could provide an interactive workouts experience by overlaying exercise instructions by virtual trainers in real-world settings.

Furthermore**,** undergraduate students were the focus group in this study. This was because, in their undergraduate years, they will be dealing with various pressures and challenges resulting in experiencing psychological issues like anxiety and depression (N. A. Hassan et al., 2022). These might be due to the transition between high schools and college to the university lifestyle and the demands of academic coursework, assignment and exams that can be overwhelming for undergraduates. In addition, some research also stated that undergraduate students face sedentary behavior due to the proportion of their timetable of study (Carpenter et al., 2021; Moulin et al., 2021). The outbreak of the Covid-19 had worsened this issues as they had to attend their class online through online meeting platforms due to a hybrid mode of learning (Iskandar & Dawn, 2023). Hence, past studies have proven that physical activity could prevent them from having issues especially regarding their mental and physical health. Thus, this points out the need of physical activity among undergraduates, and it could benefit them if the intervention could allow them to do more physical exercise at any place and any time they could.

As undergraduate students became the study's focus group, suitable recommendations for physical exercise appropriate to their age need to be identified. This was because age-appropriated exercise could contribute to optimal overall quality of health and well-being. Typically, undergraduate students are aged around 19 to 24 years old. Hence, according to the Centre for Disease Control and Prevention (CDC), younger adults above 18 were recommended to have moderate-intensity aerobic, vigorous-intensity aerobic, and muscle-strengthening activity. Moderate-intensity and vigorous-intensity aerobics refer to daily physical activities such as brisk walking and jogging. While muscle-strengthening activity refers to any activities that work all

major muscle groups like the abdomen. Thus, muscle-strengthening activities were chosen as physical exercises.

Usually, a typical mobile-based physical exercise app or fitness app that focuses on muscle-strengthening activities uses a 3D model of fitness trainer to demonstrate the movement of the exercise. However, the integration of AR technology was still in its infancy. Not only that, the AR fitness application were mostly focused on specific sports training, such as tennis and basketball (Hegazy et al., 2020; Lin & Singh, 2021a). A gamified AR fitness app also injects entertainment elements to promote physical activity among its users (Wong, 2017).

Next, to understand how learners perceive and interact with the adoption of AR technology, the learners' perception towards the AR physical exercise application needs to be studied. Learners' perceptions reflected their personal experience and preferences towards this application. Based on the previous study, it was stated that the quality of 3D models and objects used in AR apps could give impact on the perception of the AR experience (Blanco-Pons et al., 2019). Hence, a study needs to be done to measure the learners' perceptions of the AR application.

Lastly, technological acceptance must be measured while adopting an interventional approach for physical exercise. This was purposely to know whether the technology that had been used was being accepted or rejected by its user. Assessing learners' technological acceptance is also considered crucial to identifying the barriers or challenges that learners might face while adopting the technology. This could help optimize the user experience by evaluating ease of use and usefulness.

1.4 Purpose of the Study

1.4.1 Research Objectives

General Objective :

This study aims to assess learners' perceptions and get insight into their acceptance of adopting AR technologies for physical exercise.

Specific :

The following are the specific aims of this study:

(i) To investigate learners' perceptions towards the physical exercise application.

(ii) To investigate learners' technological acceptance of the AR application for "Senaman AR" apps.

(iii) To identify the relationship between learners' perceptions and technology acceptance towards the "Senaman AR" apps.

(iv) To explore learners' opinions towards the AR application for "Senaman AR" apps.

1.4.2 Research Questions

As the guideline to conduct this study, the following research questions will be used:

RQ 1: Is there any significant difference between the learners' perceptions of interactive 3D PowerPoint presentations and using Senaman AR apps?

RQ2: What is the learners' technology acceptance towards the AR application for Senaman AR apps?

RQ3: Is there any significant relationship between the learners' perceptions and technology acceptance towards the Senaman AR apps?

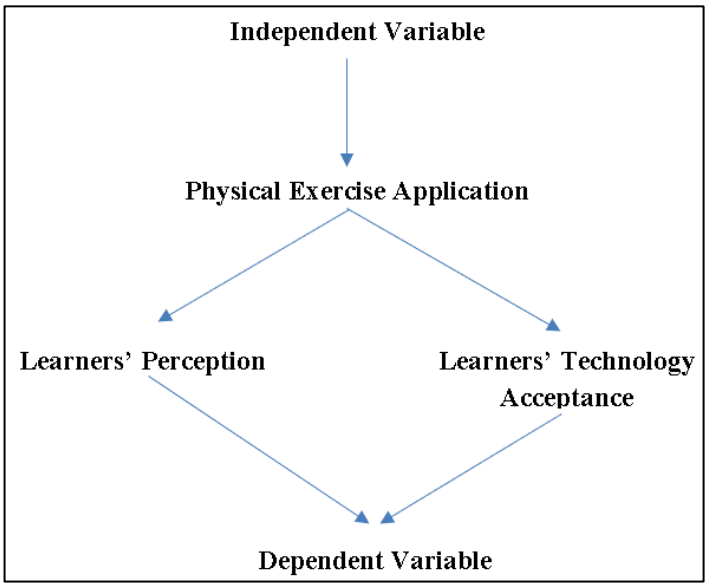
RQ4: What is the learners' opinion towards the AR application for "Senaman AR" apps?

1.5 Conceptual Framework of Study

The independent variable in this study was the Physical Exercise Application. These applications were referred to as Mode A and Mode B, where Mode A referred to Interactive 3D PowerPoint Presentation and Mode B referred to Senaman AR application. At the same time, the dependent variables in this study were (i) learners' perceptions and (ii) learners' technology acceptance. The variable of learners' perceptions in this study was tested on the use of two physical exercise applications developed for this study. As mentioned, these exercise applications were the interactive 3D PowerPoint presentation and the Senaman AR. The variable of technology acceptance would be measured once the learners had used the Senaman AR application. Hence, based on the conceptual framework diagram below, it indicated that the Physical Exercise Application could give an impact towards the learners' perception and their acceptance of the technology. Thus, the following figure shows the conceptual framework of the study.

Figure 1.1

Conceptual Framework of the Study



1.6 Theoretical Framework

This research studied the effects of the AR exercise applications on the learners' perceptions and their acceptance of technology. Hence, two types of physical exercise applications were developed: Interactive 3D PowerPoint presentation and Senaman AR application.

Furthermore, the related theories were utilized as the guidelines for this research. For the variable of learners' perceptions, this study used the cognitive load theory introduced by John Sweller in 1988. As mentioned by John Sweller, the cognitive load theory could explore the impact of the cognitive load placed on learners on the learning process (Sweller, 1988). Thus, in the context of this study, it was important to consider the cognitive demands that users faced, such as the need to process the virtual element in AR application that overlaid while simultaneously participating in physical exercise.

These demands might influence how users perceive the usability and effectiveness of the applications.

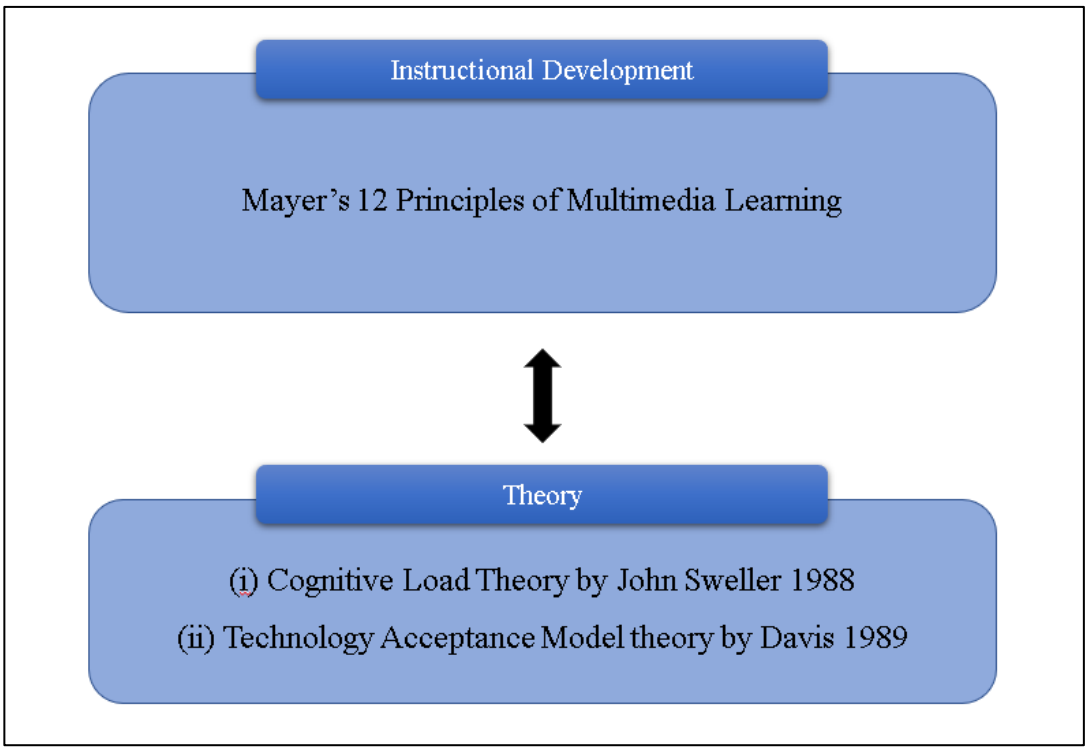
Moreover, while developing the AR materials, all principles except for the modality principle, voice principle and personalization principle from Mayer's 12 Principles of Multimedia Learning introduced by Richard E. Mayer (2001) were considered to be used as the guidelines for producing an effective multimedia learning resource. This was because these principles had provided a basis for developing an AR exercise application that maximized the incorporation of textual and graphic information, enhanced learners' involvement, and adhered to cognitive learning principles. It was believed that implementing these principles could enhance the efficiency and user-friendliness of the AR application, fostering a favorable learning experience for learners participating in physical exercises. However, as the researcher opted to create a straightforward AR application, no voice-over narration was utilized to showcase the workout activity. Instead, the application would utilize a text and animated virtual trainer to effectively demonstrate the workout routine.

Besides that, the other variable used in this study was technology acceptance. To study the technological acceptance of the learners, a theoretical framework by Davis (1989) called the Technology Acceptance Model (TAM) was used. TAM was originally revised from the Theory of Reason Action (TRA), which explained that every action an individual performs was determined by their intention to perform that action. Thus, Davis proposed two factors that became the keys determinants of learners' intentions to use technology. These factors were (i) Perceived Usefulness and (ii) Perceived Ease of Use. In this context of study, learners' perceptions of how useful and easy to use the AR application was likely to influenced their acceptance of the

technology. Hence, the following figure illustrates the theoretical framework of the study.

Figure 1.2

Theoretical Framework of the Study



1.7 Research Hypothesis

Research hypothesis referred to a declarative statement that articulates an expected result or prediction of the study that the research will test. In this study, there were two hypotheses that expected to meet.

The first hypothesis posited that a significant difference in learners' perceptions exists when comparing the utilization of Interactive 3D PowerPoint presentations to the utilization of Senaman AR apps. This hypothesis aimed to ascertain whether there were any notable differences in the learners' perceptions between two groups of samples that employed distinct technologies, namely Interactive 3D PowerPoint

presentations and Senaman AR apps. This was done to achieve research objective 1, which aimed to observe and analyze the aforementioned variations and employed in interpreting the research findings.

Lastly, the second hypothesis posited that there existed no correlation between learners' perceptions and technology acceptance. This hypothesis was employed to deliver research objective 3, which determined whether there existed a correlation between the learners' perceptions and technology acceptance. As research hypothesis 1, this hypothesis was also used to interpret the research findings. Hence, the following were the statements of research hypothesis for the study.

$H_0 1$: There is no significant difference in learners' perceptions between interactive 3D PowerPoint presentations and using Senaman AR apps.

$H_0 2$: There is no correlation between learners' perceptions and technology acceptance.

1.8 Significance of the Study

There were some significances of this study. First and foremost, the score report on Malaysia's 3rd Sustainable Development Goal (SDG), which was good health and well-being, showed Malaysia was in a moderate increase state. It indicated that the score in promoting good health and well-being was still insufficient. Thus, it has become one of the motivations to spread awareness among people to practice a good lifestyle by increasing their physical activity. In order to do this, AR was adopted for physical exercise. It was hoped that AR-enhanced physical exercise could help its users promote more physical exercise.

In addition, the outcomes of this study could be used to highlight the effectiveness of incorporating AR technology for physical exercise. Future researchers

could implement these study findings to develop more flexible and relevant AR applications. It could be a basis for producing new theories in future studies.

Lastly, this study could underline the pros and cons of using marker-based AR in physical exercise. For instance, the utilization of the marker-based AR for physical exercise context might not be practically compared to marker-less AR. The utilization of marker-less AR might help enhance the usability and make the AR apps more user-friendly for its user who wants to do workouts. Thus, this study could be a reference for future researchers in upgrading their design and development related to AR fitness or sports apps.

1.9 Limitations of the Study

Like other research, in this study, some limitations occurred that influenced the interpretation of the findings from the research work.

First of all, as this research activity consisted of physical exercises, the study only considered the participants who had good health and could do physical exercises such as running or jumping. The participants who had critical health problems were not negotiated. This was to ensure the participant's safety and avoid any risk if anything happened to them while joining the experiment.

Moreover, regarding the population sample, this study was limited to Universiti Sains Malaysia (USM) undergraduate students who pursued studies in Bachelor of Education (TESOL) and took a minor in Multimedia. This was to ensure they had a basic knowledge and understanding of the experiments.

In addition, as the study's sample was undergraduates from the Bachelor of Education program, the number of samples based on gender was imbalanced. This was because, among 78 participants, 65 of them were females, and the rest, 13, were male.

As a result, the researcher was unable to compare the result based on their imbalance of gender.

1.10 Operational Definitions

1.10.1 Augmented Reality

Generally, augmented reality (AR) refers to technology that overlays virtually the digital information, visual, audio, or otherwise, onto the real environment (Siriwardhana et al., 2021). In other words, it combined the visual experiences by overlays the computer-generated content onto user's perception of the real-world environment, creating an enhanced or "augmented" view of the physical environment (Farronato et al., 2019). This computer-generated content was typically overlaid on the live camera feed, allowing users to view the merged reality through their device's screen and interact with the virtual content using touch inputs or gestures.

In this study, an AR application referred to the Senaman AR application developed for physical exercise. It combines the real-time use of text, animation, and audio that are integrated with real-world patterns to convey the information to its users. In other words, users typically could view and interact with the virtual trainer once they scanned the AR markers. This AR app focused on muscle-strengthening activities consisting of push-ups, abdominal crunches, step onto chair and side planks. It was used along with a poster of a physical exercise routine that complements the Senaman AR application.

1.10.2 AR Camera

When developing the AR application, it was essential to understand the terms of AR Camera clearly. AR camera plays as important role to ensure the virtual contents in the AR application can exist and being interacted in the real environment. An AR camera

can be defined as the camera objects that had been composed with the device tracker component (House, n.d.). With the device tracker component, the AR camera can now obtain the device's position and rotation. It has become the key component in AR experiences, allowing users to view the blended reality where the virtual elements seamlessly integrated into the real space captured by the camera (House, n.d.).

The AR camera was created while developing the Senaman AR applications on the Unity platform. This embedded camera was specifically intended to view the virtual or AR content in the real-physical world through the smartphone’s screen. The inability to activate this camera on a smartphone could restrict the use of the AR application.

1.10.3 AR Object

An AR object was digital or virtual content superimposed over the real-world environment using AR technology. AR objects could be manifested in diverse formats, encompassing 3D models, animations, textual content, photographs, or interactive components (Herskovitz et al., 2020). These digital creatures seem to live alongside the physical world when observed with AR devices or software (Herskovitz et al., 2020). This AR object or content was often used to address the same concept with the physical object in a virtual way.

In this study context, the AR objects refer to the texts, audio, and the 3D virtual trainer who demonstrated the steps of physical exercise through its animation. This 3D model was the simulation of a fitness trainer, while its animation mimicked the movement of exercise based on which images or AR markers from the poster were tracked. This 3D character will appear once the AR marker from the poster has been scanned using the Senaman AR apps.

1.10.4 AR Marker

An AR marker can refer to any images or objects detected by an AR-enabled mobile application to initiate augmented reality functionalities (Klavins, 2021). AR markers can be present in various forms, such as a QR code, physical image, physical objects, and natural landmarks, to determine which positions of virtual objects need to be displayed (Boonbrahm et al., 2020). These AR markers are trackable by AR camera and contain data information such as the position and rotation of the AR objects. After the AR camera has tracked it, the virtual objects will augment the physical objects in real-time and can be seen on our mobile phone's screen.

In this study, each image in the 'Rutin Senaman Fizikal' poster, or physical exercise routine, worked as the AR marker for the Senaman AR apps. It was enriched with AR in the form of multiple images of a trainer doing a physical exercise routine. It was stored in the Vuforia Target Manager database as the predetermined marker before it could be downloaded and imported into Unity for development. Once the development is done, the learner can scan one of those markers, and the virtual trainer will pop up on the marker.

1.10.5 Image Target

Image target and AR Marker referred to the same concept in the context where both terms referred as reference points for AR systems to anchor virtual content in the real world. AR markers referred to more general terms encompassing various markers that can be used in AR, including QR codes, fiducial markers with distinctive patterns, and barcodes. While image target was the subsets of the AR markers. Image targets were typically images that possess unique characteristics, patterns, or forms identified by the AR system to precisely positioned digital information. These images might consist of photographs, illustrations, or graphics that possess distinctive visual attributes.

The study utilized an image marker as a form of AR marker. This image could be obtained from the Physical Exercise Routine poster. In order to activate the Senaman AR application, after launching the application, point the smartphone's camera toward one of the images on the poster. Now, the animated virtual trainer should emerge on the screen and display the user has scanned activity.

1.10.6 Learners' Perceptions

Learners' perceptions were one of the variables measured in the study. The term perceptions could be defined as the cognitive process by which information was acquired through actions (Ghadirian et al., 2017). In addition, perceived perceptions could be divided into two definitions, positive and negative. Positive perception refers to the understanding and reactions that persist in the pursuit of utilizing knowledge (Siregar et al., 2023). This would be furthered by activating, accepting, and endorsing the perceived object. Meanwhile, negative perception refers to the information and responses that are not in harmony with the object being perceived (Siregar et al., 2023). The response will either be passive acceptance or active rejection and opposition towards the seen thing.

In this study, the learners' perceived perceptions were measured once they had used any of the physical exercise applications that the researcher provided. This physical exercise application could be either the Interactive 3D PowerPoint presentation or Senaman AR application. Then, once they had used one of the applications, they were needed to answer a set of questionnaires that were specifically used to assess their perceived perceptions towards the physical exercise application.

1.10.7 Technology Acceptance

Technology acceptance was one of the variables used in the study. This term often refers to an individual's psychological state on their intention to employ a particular

technology, affecting their favorable decision to either adopt an innovative solution or reject the adoption (Alqudah et al., 2021). Not only that, technology acceptance also posits that the key determinants of the users' intention to use technology were perceived usefulness and perceived ease of use (Elske Ammenwerth, 2019).

In this study, AR technology refers to the Senaman AR application. It was a physical exercise application that was integrated with AR features during its development process. During the study's experiments, the sample, the undergraduate students of USM, needed to use this application to assist them in physical exercise. Once finished, their acceptance of the technology was accessed using a technology acceptance questionnaire. The results indicated whether they successfully accepted the technology or not.

1.11 Summary

The study aims to measure the learner's perceptions towards the physical exercise application and their acceptance towards the technology. Along with the study, several theories like cognitive load theory and technology acceptance model were used to explain more about the learners' perceptions and acceptance once they used the AR technology. Also, the ADDIE model and nine out of twelve principles from Mayer's 12 Principles of Multimedia Learning were used while developing the Senaman AR application and Interactive 3D PowerPoint presentation. This was followed by an explanation of the significance and limitations of the study. At the end of the chapter, the terms' operational definitions were explained generally and in the context of the study.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter reviews various literary works from previous studies. The purpose was to provide a concise explanation of the topics linked to the study and identify the research gaps that need to be addressed. Chapter 2 begins by revealing several classifications of AR technology. It then proceeds to discuss the physical training regimen designed for undergraduate students, past scholarly investigations on AR applications pertaining to fitness, relevant theories, and variables employed in the study.

2.2 Augmented Reality Technology

Augmented Reality (AR) is a digital technology that expands human perception and provides users an interactive experience of the real world (Siriwardhana et al., 2021). It is distinct from virtual reality, where the user is fully submerged in a virtual setting. In addition, by leveraging technologies like image recognition or location recognition, AR can superimpose digital information, including text, images, audio, video, and 3D animation, onto actual physical objects in the real world (Garrett et al., 2018).

Generally, four categories of AR can be distinguished based on how their augmentation works. These groups can be marker-based, marker less, projection-based, and superimposition-based AR (Aggarwal & Singhal, 2019).

A marker-based AR is a vision-based or image tracking that requires real objects to initiate the augmentation process (Edwards-Stewart et al., 2016). These objects can be on paper with a unique pattern, captured by the AR camera, and recognized by AR software (Siriwardhana et al., 2021). Moreover, three fundamental parts make up a marker-based application: a booklet with marker information, a gripper for extracting

data from the booklet and converting it to another sort of data, and an object that adds information to the screen as 3d-rendered information (Lee, 2012).

Next, a marker less AR. Due to some research, instead of predefined markers, a marker-less AR permits the placement of virtual content by tracking and mapping the environment's natural features (Scargill et al., 2021). It used localization technologies such as Global Positioning System (GPS) to determine the users' and virtual objects' relative positions in which the virtual content has been assigned a longitude and latitude coordinate (Cheng et al., 2017). This virtual content will appear on the screen as the difference coordinates value between the device and the virtual content is less than 0.01 degrees.

Projection-based AR also referred to as spatial AR and projection mapping, is a technology that projects computer-generated images onto an undefined or arbitrary shape surface (Iwai, 2019). It employs projection mapping techniques, which use projectors to project the light in the real world and directly overlay AR content over real-world objects (Mewes et al., 2019; Uzun, 2019). Additionally, the forecast light contains data and can sense how humans interact with the light (Joshi et al., 2020).

Lastly, superimposition-based AR. In contrast to marker-based AR, superimposition-based AR technology recognizes the full objects and superimposes the features of the original objects with augmented features (Poghosyan, 2019). It requires object recognition to replace the original with augmented objects (El Filali & Krit, 2018).

The selection of these AR categories might be based on their appropriateness for the product's objectives. Therefore, within the realm of physical activity, numerous studies have commenced investigating the utilization of AR technology in sports and training compared to physical exercise activity. The majority of previous research also

has focused on the use of marker based and marker-less AR in physical activity apps. Meanwhile, in sports training, such as tennis and basketball, numerous researchers had employed marker-less AR technology to identify and track the real environment without the requirement of a physical marker (Hegazy et al., 2020; T. Lin & Singh, 2021b). As an example, past researchers Nair (2019) created Endure, an augmented reality (AR) application that encourages physical fitness through walking without the need for markers. However, there was lack of past studies found that employed the marker-based types of AR in the field of physical exercise. Therefore, the researcher identified these deficiencies and decided to select marker-based AR as the specific form of AR technology to be utilized in this study.

Table 2.1

Type of AR in Physical Activity from Previous Study

Author	Title	Type of AR Technology Used
(Hegazy et al., 2020)	Usability Study of a Comprehensive Table Tennis AR-Based Training System with The Focus on Players' Strokes	Marker-less AR
(T. Lin & Singh, 2021b)	Towards An Understanding of Situated AR Visualization for Basketball Free-Throw Training	Marker-less AR

(Nair et al., 2019)	Endure: Augmented Reality Fitness Mobile Application	Marker-less AR
(Jeon & Kim, 2020)	Effects of augmented-reality-based exercise on muscle parameters, physical performance, and exercise self-efficacy for older adults	Marker-less AR
(Chang et al., 2020)	Applying augmented reality in physical education on motor skills learning	Marker-based AR

2.3 Physical Exercise Among Undergraduate

Physical Exercise (PE) is essential among undergraduate students to enhance their physical health and reduce the risk of severe health problems. This is because, compared to their earlier phase of life, undergraduate students are in a vital transitional period where they are coping with various pressures and challenges as well as a lack of external control and supervision (S. Lin et al., 2022). These might lead to psychiatric problems and a low level of well-being. Thus, due to these phenomena, undergraduate or university students often face depression and anxiety issues (Fauzi et al., 2021; Hassan et al., 2022).

Generally, physical exercise and physical education are two distinct concepts. Physical exercise can refer to any planned, structured, repetitive activities that individuals do to enhance their physical well-being and fitness (Siscovick et al., 1985). Physical activity includes activities to enhance fitness, such as strength training,