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Patient Perspective towards the Usage of Augmented Reality in Aiding Healthcare Consultation

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ABSTRACT: Augmented Reality (AR) technology and its applications in various industries and sectors has been increasingly popular and on-demand as the world approaches IR4.0. With its enormous and continuously progressive advancements in the healthcare industry, basic yet vital services like consultations can be further improved with the integration of technologies. This study proposed a TAM derived conceptual framework using the constructs Perceived Enjoyment, Perceived Usefulness and Perceived Ease of Use towards patient's actual use of AR technology application in aiding their consultations withtheir healthcare professionals. A survey questionnaire was developed and distributed via social media platforms to 539 respondents. All hypothesis proposed in this study's conceptual framework has been found significantly positive in influencing patient's eventual usage of AR technology application in facilitating consultations. These results revealed the interrelationships of the constructs involved, thus enhancing our understanding on the factors of AR to be used in aiding consultations sessions. The findings of this study have some important practical implications for the improvement of conventional healthcare consultation methods to improve patients' understanding which has an impact on their overall health compliance and outcome.

KEYWORDS: Industrial Revolution 4.0, Augmented Reality, Perceived Enjoyment, Perceived Ease of Use, Perceived Usefulness

I. INTRODUCTION

Augmented Reality (AR) have been around for many decades. The technology has only garnered its popularity in the 21st century, but mainly in the advertising and gaming industry. The first AR technology, called 'The sword of Damocles', was first developed in 1968 at Harvard by computer scientist Ivan Sutherland who is also known as the father of computer graphics. From its first creation of head-mounted display system, the technologies have been further expanded by laboratories, universities, tech companies and national agencies to the advanced AR wearable, portable devices we see and use today.

The advancement of AR technology has allowed the development of innovative products and applications using the technology, improving and advancing many aspects of every life. With every industry picking up pace to integrate AR technology into their field, the healthcare industry was one of the first to embrace the innovation. AR applications have been used to improve medical education amongst medical students, nurses, specialist trainees; and beyond that, it is also being used to provide better patient care and patient education. The technology allows medical professionals to help patients understand surgical procedures and the way medicines work as the AR technology applications allow patients to visualise and interact with three dimensional (3D) representations of their bodies. Therefore, patient can understand better about their conditions and how certain medical procedures or medications work, which ultimately can promote better compliance and hopefully, better health outcomes.

Although AR technology application relatively new to the Malaysian healthcare industry, but with the advancement towards industrial revolution 4.0 (IR 4.0), we can expect to see more and more of the innovation being integrated into the various aspects of healthcare, in particular patient

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education via consultations. Numerous researchers have shown that through the usage of AR, learning is made better as information and knowledge is absorbed and retained better than using traditional forms of teaching (Carlson & Gagnon, 2016; Moro,Stromberga, Raikos, & Stirling, 2017; Wang, HungYuan, Duh, Li, Lin, & Tsai, 2014).Manyinstitutions and even training programs in bothmedical and non-medical fields have started toimplement AR technology into their teaching andlearning programs due to its proven efficacy,efficiency and reliability when compared to itstraditional counterparts.

Therefore, the objective of this paper is to identify factors that determine patient's behavioural intention and the actual usage of AR technology in healthcare consultation session. Specifically, this paper intends to evaluate the link between perceived ease of use, perceived usefulness, perceived enjoyment, behavioural intention usage on the actual usage of augmented reality in aiding healthcare consultations from patient's perspective. The result of this study can be used to improve the healthcare consultation methods and patients' understanding, which could affect their overall health compliance and outcome.

II. LITERATURE REVIEW

Augmented Reality in Healthcare

In healthcare, AR allows its users to have immediate access to the information that is not naturally present in the actual environment, and permits computer interface to map the information into the current environment the user is in. In medical education, this has helped students and healthcare workers in understanding and absorbing information better. In the other words, AR provides many benefits to both undergraduate and postgraduate students in their medical studies. A study by Moro et al. (2017) found that AR has provided the students learning enjoyment, ease of understanding anatomy, effectiveness as a learning tool and with clear instructions and labels. Meanwhile, a study on AR system called Augmented Reality Integrated Simulation Education (ARISE) fount that the system gave learners an authentic experience, provided engaging interaction, enhanced the simulation, enhanced learning, encouraged critical thinking decision making, inspired dialogue during debriefing and assisted learner to understand a concept or skill (Carlson & Gagnon, 2016).

In another study, Wang, HungYuan, Duh, Li, Lin, and Tsai (2014) have conducted a randomized controlled trial (RCT) method to compare between the conventional two-dimension (2-D) learning experience and AR. The pre- and post-test were used to evaluate participants overall knowledge before and after intervention. The t-test score of their post-test result showed that students in the AR group have a significantly improved knowledge compared to the students using traditional 2D method. The authors concluded that AR is an effective teaching method, but its use is not widely adopted due to the lack of financial support and awareness of the technology and its benefits in education.

Providing accurate information is a major clinical responsibility of all healthcare workers in order to provide better quality patient care and achieve better health outcomes (Street, Makoul, Arora, & Epstein, 2009). In an effort to increase patients' understanding, healthcare workers have to use various interventions and strategies alongside with their verbal consultations in order to help patients understand better. This included written material, telephone helplines, teaching and audio-visual aids. A study found that the interventions had a positive effect on several aspects of patient health outcomes such as knowledge and recall, symptom management, satisfaction, preferences, health care utilization and affective states (McPherson, Higginson, & Hearn, 2001). Meanwhile, another study showed that the use of audio-visual information in consent taking for invasive procedures on patients has improved the immediate recall of informed consent, indicating better information and knowledge retention and possibly better understanding of the procedure they are subjected to (Farrell et al., 2014).

Healthcare professionals have been trying different strategies in hopes to produce more effective ways of communication to enhance the value of consultations which ultimately can benefit to better patient health outcomes. There are many conventional ways healthcare professionals have used to enhance communication and consultation to patients, one of which is called the teach-back method. Schillinger et al. (2003) described teach-back as a "multi-step cycle which commences with the clinician explaining a new concept, the clinician then assessing patient recall and comprehension, the clinician clarifying and tailoring the explanation, the clinician reassessing patient recall and comprehension, and repeating the cycle if required" (Schillinger et al., 2003).

Other techniques like speaking more slowly and not using medical jargons are widely encouraged by all healthcare professionals when communicating with patients. Providing tools like question prompt list on patient question asking during consultation helps facilitates patients to ask a

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broader range of questions which impacts positively on doctor-patient communication (Amundsen et al., 2018). Ultimately, determining the patients' ideas, concerns and expectations from their condition and management should be the main goal for all healthcare professionals in improving patient health outcomes while keeping with current notions of patient's autonomy and empowerment of adequate medical knowledge to make appropriate informed decisions for their own health (Gaston & Mitchell, 2005; Köpke, Solari, Khan, Heesen, & Giordano, 2014).

With the emergence and growth of telemedicine in the recent decade, which was further expedited by the Covid-19 pandemic in the year 2020, we can see the integrationofARtechnologyanditsrelated applicationintoremoteortelemedicine consultations during times of worldwide quarantine and travel ban.For instance, in a study done in China in 2019, mixed reality (MR) technology, which is a combination of virtual and AR technology, were used in remote preoperative discussion, doctor-patient communication, and remote surgical guidance and these teleconsultations were proven possible and successful in three hospitals in China with the use of MR technology (Zhang, Gao, & Ye, 2020). Such integration of technology makes the real-time transmission, visual expression, and accurate understanding of 3D spatial information possible for effective communication and consultation between healthcare professionals and patients.

Another use of MR technology tool which includes AR application is the "Virtual Surgery Intelligence (VSI) Patient Education" tool. House et al. (2020) found that the intervention group had better understand of their condition, better visual imagination of the procedure, hence reduced fear and worries they had due to poor understanding and uncertainties of the brain surgery (House et al., 2020). The authors suggested that such technological tool might strengthening patient's commitment and influencing their decisions in favour of medically indicated surgical operations.

Another recent promising use of AR technology in healthcare is the project known as SOULMATE ("Secure Old people's Ultimate Lifestyle Mobility by offering Augmented reality Training Experiences") (Neven et al., 2018). SOULMATE is a customizable smartphone-based mobility support application aimed for the elderly population. The technological application not only aims to help the elderly with their mobility and allowing them to live a more healthy, active and meaningful life, it also helps caregivers by improving the quality, effectiveness and efficiency of the care they provide reduces stress and leads to a lower care burden (Neven et al., 2018).

In summary, from these literatures, we can understand that having interventions and strategies as an adjunct to verbal consultation can make a difference in patient's understanding and provide effective and valuable consultation which can eventually lead to better health outcomes for the patient.

Perceived Ease of Use (PEOU)

PEOU is defined as "the degree to which a person believes that using a particular system would be free of effort" (Davis, 1989). It describes the perception of user-friendliness of a technology and how it requires little to no physical or cognitive effort in understanding and using the innovation. In the TAM theory by Davis (Davis, 1985), it is stated in the model that users' who the technology to be easy to use and interact with will be more useful for them. In other words, the easier it is to use the system, the more useful the system will be perceived. In the context of AR technology, if the AR system requires minimal cognitive effort to function, it is perceived to be more beneficial to the user compared to when more effort is required use a system. When it comes to technology-based learning systems, the ease-of-use component refers to the interface of the system and how user-friendly it is while delivering educational contents (Leue et al., 2014). The usefulness component of the system refers to the quality of the educational content and how beneficial it is for the user (Leue et al., 2014). With this, we can deduce the following hypothesis on the relationship between PEOU and PU for the present study:

H1: The perceived ease of use of augmented realitytechnology in aidinghealthcare consultation willhave a significant and positive effect on itsperceived usefulness.

Perceived Usefulness (PU)

PU describes the perception of benefits a user is able to gain from using the technological innovation, allowing individuals to complete tasks, increase their productivity, while also enhancing their performance and efficiency (McLean, 2018). It can also mean how the user gains on improving their workflow or daily processes from the usage of the technology. It is another main predictor of consumer behaviour of TAM. The perceived usefulness of a technological system is often referred to as an important construct in influencing the adoption of new technologies through determining the

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user'sbehavioural intention to use the technology (Kim, H.Y., Lee, Mun, & Johnson, 2017). Previous studieshave justified the direct association between users'perceived usefulness and their behaviouralintentions towards a new technology (Ayeh, Au, &Law, 2013; Rauniar, RAwski, Yang, & Johnson,2014). In addition, results from a study by Alalwanet al (Alalwan, Dwivedi, Rana, & Williams, 2015)also show significant results between PU ontechnology adoption and behaviour. These studieshave further validated the significance of therelationship in analysing users PU and their usageintention of various technologies.

H2: The perceived usefulness of augmented reality technology has a significant and positive effect on the behavioural intention usage of AR in aiding healthcare consultation.

Perceived Enjoyment (PE)

PE has been recognised as an important attribute of TAM. PE is defined as "the extent to which the activity of using the computer is perceived to be enjoyable in its own right, apart from any performance consequences that may be anticipated" (Venkatesh et al., 2012). Enjoyment from system usage has been identified in several previous studies as an important variable influencing the attitude and intention to use innovative technologies (Chen & Tan, 2004; Hausman &Siepke, 2009). For example, Davis et al. (1992) and Igbaria, Guimaraes, and Davis (1995) found that enjoyment was a significant determinant of behavioural intention. Meanwhile, Olsson et al. (2013) stated that AR apps were "expected to offer playful and entertaining momentary experiences". Alongside with previous TAM constructs of PEOU and PU, PE have been introduced into the model as one of the major antecedents to influence a user's intention to use an innovative technological system (Childers, Carr, Peck, & Carson, 2002; Davis et al., 1992; Van der Heijden, 2004). Therefore, PE has become an important variable in understanding the adoption and use of new technology. As such, we can deduce the following hypothesis on the relationship between PE and ITU for the present study:

H3: The perceived enjoyment of augmented reality technology has a significant and positive effect on the behavioural intention usage of AR in aiding healthcare consultation.

Behavioural Intention to Use (ITU)

ITU predicts the possible future intentions of individuals. The intention construct is central to Theory Planned Behaviour (TPB). Intentions are assumed to capture the motivational factors that influence a behaviour and to indicate how hard people are willing to try or how much effort they would exert to perform the behaviour (Armitage & Conner, 2001). In researching on technological application acceptance, individuals' behavioural acceptance is commonly investigated through the willingness of consumers to use, spend on or repurchase and willingness to recommend. Therefore, we regard behavioural intention as a target construct that encompasses intention to repeat the AR experience and as a predictive factor towards its actual usage (AU) of the technology. AU refers to the prediction of a consumer's true utilization of the innovative technology or system (Davis, 1985). Actual behaviour commonly refers to the way the people decide to spend their time, money and effort on consuming products or services they are interested in or have intention (Liu, Segev, & Villar, 2017). Based on TAM, we hypothesize that intent to use AR technology will positively influence actual usage of AR technology in consultation, thereby predicting actual use by investigating intent to use.

In the TAM framework, ITU is followed by AU when analysing consumer's level of acceptance of a new technology and towards their likelihood of using the technology in the future. Ajzen (2005) reported behavioural intentions of individuals' readiness to engage in a given behaviour is an immediate antecedent of actual usage of the studied technology or system. Besides, intentions are the outcome of a mental deliberation procedure and commitment that possibly requires a significant amount of time. Studies have defined actual usage of a technological system as the frequency of using the system for information search and decision-making processes (Rauniar et al., 2014). Studies also confirmed a positive relationship between behavioural intentions and actual use of the new technology or system (Rauniar et al., 2014). Based on this, the following hypothesis is proposed for the present study:

H4: Behavioural intention of using augmentedreality technology have a significant and positiveeffect on the actual usage of augmented reality inaidingconsultations.

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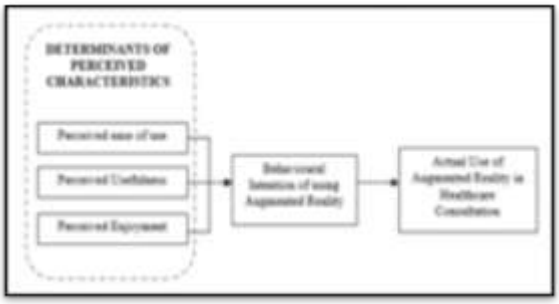

Figure 1 Conceptual Framework

III. RESEARCH METHODOLOGY

This is a quantitative study where data were gathered using adopted questionnaire to empirically test the proposed study framework. The data has been collected through online survey distribution (google form) that were randomly distributed for four weeks. The design of the survey instrument started with a cover letter for the respondents. After reading the cover letter, respondents gave their consent to participate in the study. They answered a few demographic questions and filtering questions such as "What was the reason for your visit to the doctor?" and "Did you have any problems in understanding what was being told to you?" In the next sections, respondents then assessed their awareness of augmented reality technology, followed by perceived ease of use, perceived usefulness, perceived enjoyment, intention to use, and actual usage of augmented reality.

This paper adopted several items which combined attitudinal items from Davis (1985), Venkatesh and Davis (2000), and Kim and Forsythe (2008) to create the eight items for perceived ease of use and perceived usefulness, seven items for perceived enjoyment, six items for intention to use, and 5 items for actual usage of augmented reality. All items were measured using a five-point Likert scale; 1 for strongly disagree to 5 strongly agree. The internal consistency of the items in measuring the respective construct has been evaluated using Cronbach Alpha. The results from the reliability tests show that the Cronbach Alpha values are ranging between 0.828 to 0.912, indicating high degree of internal consistency of the items used for the construct.

IV. DATA ANALYSIS

A total of 539 participants were eligible to be used in final analysis of this study as they fit theinclusion criteria. Out of 539 respondents, 48.2% of them are in the range of18 and 25 years old, making them the majority. Majority of the respondents were females, and most of them were Chinese ethnicity.Table 1 summarise the respondent profiles.

Nonresponse rate bias (Armstrong and Overton, 1977) was assessed using t-test comparing early and late respondents of selected variables such as age, gender, ethnicity, education, AR awareness and AR usage. Table 2 displays the comparison of means for each of these key variables. The results showed that the differences between early and late responses on any key measures are generally equal which can be implied that there is no significant between early and late responders ($p > .05$). Thus, non-response bias is not the case to significantly affect the result in this study.

Table 1 Respondents' demographic profile

Demographic	Items	Frequency	Percentages
Age	18 - 25	260	48.2
	26 – 35	93	17.3
	36 - 45	60	11.1
	46 – 55	67	12.4
	56 - 65	44	8.2
	Above 65	15	2.8
Gender	Female	327	60.7
	Male	212	39.3
Ethnicity	Chinese	336	62.3
	Indian	98	18.2
	Malay	64	11.9

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	Others	41	7.6
Education level	Pre-school	1	0.2
	Primary school	1	0.2
	Secondary school	8	1.5
	College	59	10.9
	University	470	87.2
Heard of AR	Yes	372	69.0
	No	136	25.2
	Not sure	31	5.8
Used AR	Yes	329	61.0
	No	194	36.0
	Not sure	16	3.0

Table 2 T-test for Non-response Bias

Items	**Early response (n=276)**		**Late response (n=263)**		**P value**
	Mean	**Std. Dev**	**Mean**	**Std. Dev**	
Age	2.36	1.53	2.09	1.43	0.82
Gender	1.34	0.48	1.44	0.50	0.17
Ethnicity	1.68	0.99	1.61	0.93	0.33
Education	4.83	0.49	4.87	0.38	0.17
AR awareness	1.43	0.62	1.30	0.55	0.44
AR usage	1.50	0.57	1.33	0.52	0.11
Variables					
PEOU	3.23	0.49	4.29	0.39	0.36
PU	3.71	0.60	4.36	0.54	0.36
PE	3.78	0.62	4.38	0.50	0.33
ITU	3.78	0.67	4.44	0.54	0.32
AU	3.71	0.63	4.37	0.53	0.35

Table 3 Hypothesis testing result

Hypothesis	Path	Path Coefficient	Standard Error	t-Value	Decision
H1	PEOU → ITU	0.100	0.030	3.334	Supported
H2	PU → ITU	0.448	0.041	11.040	Supported
H3	PE → ITU	0.423	0.042	9.965	Supported
H4	ITU → AU	0.803	0.024	33.810	Supported

Hypothesis testing was done to determine the significance of the relationship between each variable in the framework presented in Figure 1. Hypothesis testing is used to assess the plausibility of the derived hypothesis using the data collected to see if meaningful results were produce.

Table 3 displays the results of the regression analysis of all the proposed hypothesis of this study. The results show that perceived ease of use, perceived usefulness and perceived enjoyment significantly influence the behavioural intention usage of AR in aiding healthcare consultation. Thus, the study proves the acceptance of H1, H2 and H3. H4 which stated that behavioural intention of using augmented reality technology influence the actual usage of augmented reality in aiding consultations is also supported.

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V. DISCUSSION AND CONCLUSION

The purpose of this study is to establish whether perceived ease of use (PEOU), perceived usefulness (PU) and perceived enjoyment (PE) determine patient's behavioural intention to use (ITU) the augmented reality (AR) technology application in the consultation session with a healthcare professional. The findings show that all three variables (PEOU, PU and PE) are significant and positively related with patient's intention to use the AR technology during consultation sessions. This suggest that the perceived ease to use, usefulness and enjoyment of the AR technology must be established by the patients before they can decide to adopt and use the AR in healthcare consultation. The results from this study are in line with Kamal et al. (2020) that used the same TAM constructs on telemedicine and found the relationship of PEOU and PU on usage intention are also positive and significant.

The significance of PEOU and PU towards usage intention of the technology can also be seen beyond healthcare context. For example, Lee (2009) found that PU significantly impacts the people's intention to use internet banking services. Similar results can be seen in Rafique et al.'s (2018) study on acceptance of mobile library application amongst university students which found both PEOU and PU have a significant influence towards usage intentions. In addition, they also found both PEOU and PU are strong interpreter towards behavioural ITU.This indicates that PEOU and PU are important drivers for people's usage intention and acceptance of technologies into various services.

A plausible explanation to this is that if patients find AR technology application an easy technology to utilize and navigate, more patients will be convinced and motivated to use. Moreover, easier handling and operating of AR technology applications are better for the elderly patients and those who have poorer technology literacy. They will perceive the ease of use of the technological platform as user friendly which will motivate them further to use the technology, hence promoting further inclusivity for all age groups rather than just the younger generation.

The findings of this study also in line with the concept of using technology in facilitating the learning experience. In the case of AR technology application in healthcare consultation session, the application would help patients to know more about their conditions, and the related treatment. Therefore, the AR technology could effectively and efficiently replace conventional ways of learning and also can become the ideal learning's tool for patients.

In this present study, behavioural intention has been used as a predicting reference point in assessing actual usage. Analysis on hypothesis testing shows that the intention to use the AR technology have a direct relationship with their actual usage of the given technology in aiding their consultation sessions. This relationship between the two TAM constructs is in line with (Sakshi, Tandon, Ertz, & Bansal, 2020) whose findings affirmed that behavioural intention positively influences the actual use of technological application. The significance of this relationship may suggest that the actual behaviour of using the AR technology application in the context of facilitating healthcare consultations may not be so difficult to perform ornavigate through and does not require excessiveeffort or commitment especially since most peoplethat exposed to AR now for a variety of reasons maybe using it for various purpose.

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