# EFFECTS OF HANDHELD AUGMENTED REALITY ANTECEDENTS, EXPERIENCE, AND CONSEQUENCES ON STUDENTS' AWARENESS OF STROKE

RIYAD AYYAD

UNIVERSITI SAINS MALAYSIA

2016

# EFFECTS OF HANDHELD AUGMENTED REALITY ANTECEDENTS, EXPERIENCE, AND CONSEQUENCES ON STUDENTS' AWARENESS OF STROKE

**by**

**RIYAD AYYAD**

**Thesis submitted in fulfillment of the requirements for the degree of Doctor of philosophy**

**September 2016**

# ACKNOWLEDGEMENT

I would like to express my sincere appreciation to my principal supervisor, DR. Hosam Al-Samarraie and Co-supervisor, Prof. Dr. Merza Abbas, for their constant guidance and encouragement, without which this work would not have been possible. For their unwavering support, I am truly grateful. I am also grateful to all the lecturers in the Centre for Instructional Technology & Multimedia.

I would like to acknowledge and thank YAYASAN KHAZANAH for providing a financial support, and I appreciate their motivation during my study.

Most importantly, none of this would have been possible without the love and patience of my family. My immediate family to whom this dissertation is dedicated to, has been a constant source of love, concern, support and strength all these years. I would like to express my heart-felt gratitude to my mother, the soul of my father, my sisters, my brothers, my wife, my daughters and my son for their support and tolerance of the unremitting unsocial behavior caused by the days and months that this thesis consumed, I will be home more – soon.

I am also thankful to my friend Heng Kok Hoe for his encouragement and moral support which made my stay and study more enjoyable. For Him I say “we meet to part, but more importantly we part to meet.”

# TABLE OF CONTENTS

# LIST OF TABLES

# LIST OF FIGURES

**Page**

**KESAN FAKTOR-FAKTOR AWAL, PENGALAMAN DAN SUSULAN DALAM REALITI MAYA TERTAMBAH TERHADAP KESEDARAN PELAJAR TENTANG STROK**

## ABSTRAK


Strok atau angin ahmar adalah penyebab utama kehilangan upaya dalam kalangan orang dewasa dan adalah salah satu faktor penyebab kematian dan kehilangan upaya yang besar di dunia. Strok dapat dicegah dan pengenalpastian awal gejala-gejalanya dapat memastikan rawatan yang lebih efektif. Kajian ini meninjau penggunaan realiti maya tertambah berasaskan alat bimbit pintar di dalam menyampaikan maklumat tentang strok, gejala serta kesannya terhadap kesedaran terhadap strok dalam kalangan pelajar universiti. Penyelidik telah membangunkan sebuah aplikasi bertajuk *AugStroke* yang terdiri daripada dua bahagian, iaitu bahagian pertama yang menyampaikan fakta-fakta berkaitan strok dan dikuti oleh bahagian kedua tentang latihan untuk mengenal dan mengesan tanda-tanda awal dan gejala strok. Bahagian latihan ini menggunakan unjuran langsung imej-mej video dari kamera alat bimbit pintar tersebut ke dalam bentuk realiti maya tertambah. Semasa sedang dirakam, subjek diberi beberapa tugas spesifik untuk dilaksanakan dan pelajar akan menilai pergerakan-pergerakan tersebut dengan memilih jawapan-jawapan yang tertera di skrin. Satu laporan diagnosis dihasilkan selepas subjek dan pelajar menyempurnakan kesemua tugas. Pemboleh ubah kajian ini ialah faktor-faktor awal realiti maya tertambah, iaitu interaktiviti, tumpuan perhatian, dan tanggapan kawalan; faktor pengalamam dalam realiti maya tertambah, iaitu keseronokan dan kehadiran

maya; faktor susulan dalam realiti maya tertambah, iaitu kecenderungan meneroka dan pengalaman positif; serta kesedaran terhadap petanda-petanda awal serta gejala strok. Kajian ini menggunakan kaedah tinjauan dan persampelan berstrata. Sejumlah 170 pelajar universiti telah dijemput menggunakan aplikasi *AugStroke* selama enam hari dan mereka telah dipinta untuk mengulangi latihan-latihan ini dengan seramai subjek yang boleh dengan berfokuskan pada orang dewasa dan orang tua. Sejumlah 149 soalselidik lengkap telah diterima di akhir tempoh kajian. Data telah dianalisis menggunakan permodelan persamaan berstruktur dalam SmartPLS. Dapatan menunjukkan bahawa aplikasi *AugStroke* menyediakan faktor-faktor awal yang diperlukan dan faktor-faktor ini menghasilkan pengalaman yang bermakna dalam kalangan pelajar dan ini seterusnya mencetuskan hasil susulan yang positif serta meningkatkan kesedaran mereka terhadap strok. Semua hubungan yang dihipotesiskan adalah signifikan dan positif dengan pekali-pekali laluan dan saiz kesan yang kecil dan sederhana, kecuali hubungan faktor tanggapan kawalan terhadap keseronokan yang tidak melaporkan kesan yang signifikan. Dapatan-dapatan in menunjukkan bahawa untuk aplikasi yang dibangunkan, faktor-faktor awal memacu faktor-faktor pengalaman yang seterusnya memacu faktor-faktor susulan dan kesedaran terhadap strok.

# EFFECTS OF HANDHELD AUGMENTED REALITY ANTECEDENTS, EXPERIENCE, AND CONSEQUENCES ON STUDENTS' AWARENESS OF STROKE

## ABSTRACT

Stroke is the main cause of permanent disability in adults and one of the primary causes of death and disability worldwide. It is preventable and early detection of its symptoms lead to more effective treatment. This study investigated the use of handheld Augmented Reality (AR) application to instruct and increase awareness stroke and its symptoms among university students. The researcher developed an application called *AugStroke* that comprised a section that presented facts regarding stroke and followed by an exercise section to detect warning signs and symptoms of stroke. The exercise section employed the projection of augmented objects onto real-time videos of a subject as generated by the handheld devices. While on camera, the subjects were given specific tasks to perform and the learners would evaluate the performance by tapping on the corresponding answers provided on-screen. A diagnosis is generated after the subjects and the learners have completed all the tasks. The variables of this study were AR antecedents, namely, Interactivity, Focused Attention, and Perceived Control; Experience with AR, namely, enjoyment and telepresence; Consequences of using AR, namely, exploratory behavior and positive behavior; and Awareness of warning signs and symptoms of stroke. The survey method and stratified sampling were employed for this study. A total of 170 university students were asked to use *AugStroke* for six days and the participants were asked to repeat the exercises with as many subjects as possible, focusing on older adults and the elderly. A total of 149 questionnaires were completed at the end of the study. Data was analysed using structural equation modeling in SmartPLS. The results showed that *AugStroke* provided the learners with the necessary antecedents that brought about meaningful experiences which then resulted in positive learning consequences that increased their awareness towards stroke. All the hypothesized relationships were significant and positive with small to medium path coefficients and effect sizes except for Perceived Control which reported no significant effect on Enjoyment. These findings indicated that in the AR environment the antecedent factors drove the experience factors that in turn drove the consequent factors and awareness towards stroke.

# CHAPTER ONE

# INTRODUCTION

This chapter presents the motivation for conducting this research and discusses various aspects associated with the utilization of augmented reality (AR) in the health awareness domain. Further, it outlines the challenges and limitations faced by students learning about stroke via the current AR designs. The research problem and the proposed solution are summarized and supported, respectively, with the aid of a conceptual model. Finally, the significance of the research and operational definitions are given at the end of the chapter.

## 1.1 Introduction

The latest advances in interface visualization offer the potential to extend the awareness of users in various learning domains. One such example is AR, which has the underlying aim of promoting user visualization of aspects associated with real situations by bringing multimedia elements into the immediate surroundings of users. These aspects help to enhance users' perception of, and interaction with, the real world. In addition, the main principles underlying the design of AR applications place primary emphasis on characterization of experiences when a user engages in an exploratory task (Bower, Howe, McCredie, Robinson, & Grover, 2014). An indirect view of the real-world environment, which includes two-dimensional (2D) and three-dimensional (3D) displays, is also projected. Such implication in the learning field was found to enrich and enhance learners' perceptions and interactions with the learning context (Specht, Ternier, & Greller, 2011). This can be related to its capabilities in reducing the complexity of the learning process by guiding users in a synthetic world while also allowing them to see the real world (Liu, Huot, Diehl, Mackay, & Beaudouin-Lafon, 2012). Therefore, the potential of AR in enriching a person's knowledge of complex contexts can be described as the process of supplying a contextual and situational learning experience (Zhu, Hadadgar, Masiello, and Zary (2014). It is also known to be a powerful aid in exploration-related research, especially in aspects related to complex interconnections in information found in the real world (Ridel et al., 2014).

The design of AR applications usually involves the integration of different aspects of ubiquitous computing (White, Schmidt, & Golparvar-Fard, 2014) in order to help individuals to use both their own skills and the power of networked computing when interacting with the physical world. Ultimately, AR can be considered an invaluable means by which the information being displayed can be absorbed. In addition, the materials incorporated into AR are assumed to maintain the mental state of a person while engaging in a certain learning task (Mihaly Csikszentmihalyi, 1991).

A considerable amount of research and body of knowledge offer an alternative design aided by the utilization of AR in different contexts, which often demonstrates visualization of complex situations in a realistic manner. It is evident from previous observations that providing an augmented presentation via mobile AR can help to improve stroke awareness (Chi, Kang, & Wang, 2013; Yoon & Wang, 2014). However, the design and development of AR apps for health awareness requires considerable attention in order to meet users' demands (de Sá & Churchill, 2012), which may affect users' expectations and, as a result, influence their ability to understand given information. This study focused on improving students' knowledge of stroke through the use of handheld AR with the underlying objective of increasing students' awareness of stroke to such a level that they are able to recognize stroke symptoms when they or someone else is experiencing such symptoms. To provide further clarification and also address the current gap in AR utilization in health awareness, a review of the state-of-the art related to mobile AR applications is provided in the next chapter.

## 1.2 Research background

Stroke refers to the “sudden onset of a focal neurologic deficit lasting at least 24 hours” (Lopes et al., 2010) due to the disruption of the supply of blood to the brain. It is caused by a compound disorder resulting from genetic and environmental factors but it is preventable and treatable (National Institute of Neurological Disorders and Stroke, 2016). Stroke is the main cause of permanent disability in adults and one of the primary causes of death and disability worldwide. It has been estimated that by 2020 stroke will be the leading cause of lost healthy life-years, including in the youth population (Hilton-Jones & Warlow, 1985; Jones, Jenkinson, Leathley, & Watkins, 2009). Hilton-Jones and Warlow (1985) reported that the possible and probable causes of stroke are trauma, migraine, atheroma, hypertension, diabetes, and various other unknown factors. Despite the recent growth in programs geared toward educating the youth population about stroke prevention and improvements in medical care, there is still a need for efficient ways to keep the youth population informed about stroke prevention and treatment techniques, at least in part among the community (Silver, Rubini, Black, & Hodgson, 2003). In addition, community education among young people specifically aimed at stroke is critical. In the literature, it can be seen that whereas much effort has been devoted to large community education projects related to cardiovascular disease in general cardiovascular knowledge, attitudes, and behavior, only a few educational studies have specifically targeted education regarding stroke risk factors, stroke symptoms, and the appropriate response to the signs and symptoms of stroke (Stern, Berman, Thomas, & Klassen, 1999).

Most researchers who have conducted studies in the area agree that the main cause of patient death and disability is delay in acting to hospitalize patients with serious stroke (Addo et al., 2012; Hong, Kim, Kim, Ahn, & Hong, 2011; Jin et al., 2012; Kim et al., 2011; McKinney et al., 2013). This delay in recognizing stroke symptoms is attributed to the lack of awareness of the symptoms associated with stroke attacks (Lundelin et al., 2012; Williams, Bruno, Rouch, & Marriott, 1997). Thus, concentrating on educating the youth population to immediately and correctly act at the beginning of a stroke is crucial to improving stroke outcomes. Such a practice can help to prevent early death and disability. This can be achieved by getting the youth population to recognize the early symptoms of stroke onset; for example, to call an ambulance as soon as possible. Despite the importance of recognizing early symptoms, in general youth and young populations worldwide, and university students in particular, are not well informed about how to act when confronted with the early symptoms of stroke (Becker et al., 2001; Pandian et al., 2005).

Multimedia and augmented applications can help to increase people's ability to recognize stroke and change health behavior because they can reach large target audiences with behaviorally focused messages. This is in contrast to the learning materials available on the web, which require persons to perform their own research about stroke in order to gain some knowledge that can be used in real-life situations (Mellon, Hickey, Doyle, Dolan, & Williams, 2014). However, such a practice is not commonly devoted to the youth population. Therefore, many previous studies emphasized the potential role of mobile devices in inducing changes in the delivery of health services (Chen et al., 2012; Klasnja & Pratt, 2012; Kumar & Anderson, 2015; Sun, Wang, Guo, & Peng, 2013).

The foundation of user-centered design emphasizes that both users' expectations and needs must be achieved in order to boost the development of effective and engaging learning experiences (Sinatra, Holden, Ososky, & Berkey, 2015). With this in mind, the presentation of complex behavior (usually involving learning about unfamiliar topics) must satisfy the needs of users in order to facilitate positive learning experiences (Buxton, 2010). Having users interact with an interface could result in a state of isolation from the real world based on various interface design properties (Laurillard, 2013). Such changes may influence the overall experience of users, which, in turn, may regulate their perceptions of its value and effectiveness (Olsson, Kärkkäinen, Lagerstam, & Ventä-Olkkonen, 2012).

Ultimately, providing effective visualization that increases university students' awareness of stroke requires an appropriate interactive presentation of stroke elements. Failure to provide such a mechanism may negatively affect learning transfer among users (Salomon & Perkins, 1989). Jonassen, Howland, Marra, and Crismond (2008) stated that interaction "learning by doing" is the main aspect that draws a user's attention for better control of learning activities; this requires having new experiences merged into the user's existing knowledge by considering the complexity of the context. When the user has a positive behavior of certain design elements, he/she may also engage in exploratory behavior while immersed in the activity. This can be reasoned to be the impact of the learning environment characteristics on the flow of activity (Chen, Wigand, & Nilan, 2000b; Chen, 2007; Pace, 2004).

In this study, a handheld AR called "AugStroke" was proposed and developed with the objective of improving the awareness of stroke warning signs and symptoms among university students. AugStroke may provide youth with the necessary antecedents to effectively engage in the flow experience (feeling of being engaged with the task) to achieve a positive outcome. Acquiring positive learning experiences requires incorporating appropriate sequences of learning tasks along with interactive elements that provide the basis for enjoyment. A number of researchers, such as Kamphuis, Barsom, Schijven, and Christoph (2014), have also suggested using alternative techniques to reduce the complexity factor while learning unfamiliar topics. Inspired by this line of thinking, this study developed the AugStroke app as an interactive, appropriate, and cost-effective setting to educate university students about stroke.

### 1.3 Problem statement

One of the keys to preventing and treating stroke is to be aware of the risk factors and the warning signs of a stroke. The principal outcome of increasing stroke awareness is reduction in prehospital delay, which is the main cause of patient death and disability. With many studies concluding that effective methods of increasing stroke awareness among people are lacking (Deeny & McFetridge, 2005; Srinivasan, Miller, Phan, & Mackay, 2009), media-driven stroke awareness movements (involving advertisements, TV programs, radio announcements, etc.) have not had a demonstrable effect on user knowledge (Slark, Bentley, Majeed, & Sharma, 2012). Evidence of this is clear in the inability of most people to recognize stroke symptoms appropriately and to act accordingly.

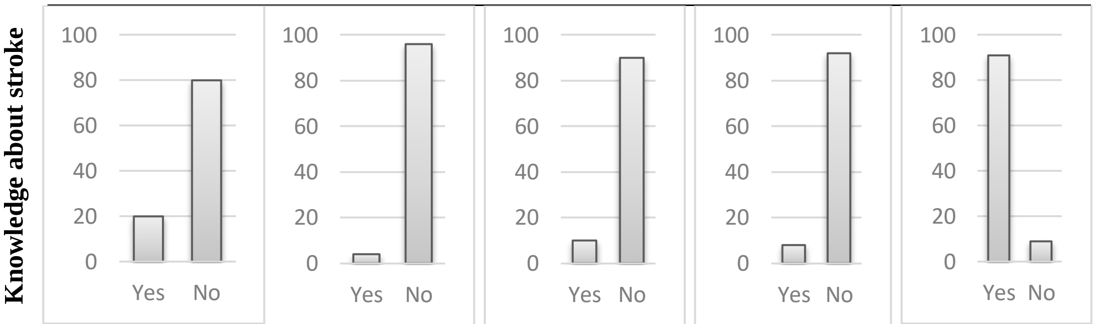
The literature also shows that most studies on awareness primarily focused on healthcare professionals and placed less emphasis on the public. Pandian et al. (2005) stated that the public remains uninformed about strokes, and only a few stroke patients are presented to hospital in time to receive treatment. This state of affairs is true even in developed countries such as the United States, Australia, and Canada, where there is a recognized lack of knowledge in the community about established stroke risk factors and warning signs.

Loo and Gan (2012) reported that stroke is one of the top five leading causes of death after ischemic heart disease, septicemia, malignant neoplasms, and pneumonia in Malaysia. The common health aids in Malaysia is generally provided by the public and private sectors where both work as two parallel systems and are complemented by nongovernmental organizations. Furthermore, there is an apparent lack of evidence on how people manage and learn about stroke in their community (Mohamed, 2010). Hence, Mohamed asserted the importance for providing the educational needs to enable Malaysian to learn about stroke in a flexible manner.

In this study, the researcher has further examined youth knowledge about stroke warning signs and symptoms in a preliminary study conducted on 77 university students (from Universiti Sains Malaysia). The results, listed in Table 1.1, showed that 80% of the students had no knowledge about stroke. In addition, majority of them (96%) had no idea about the main types of stroke whereas 90% of them were unable to distinguish the symptoms of stroke. The result also showed that 92% of the students were unaware of how to spot stroke in which 91% of them promoted the idea of using handheld device to learn about stroke related aspects. From these, it can be concluded that students' knowledge about stroke is extremely poor. This can be reasoned to that current efforts to raise awareness of stroke face formidable challenges among youth worldwide in general, and among Malaysians in particular.

Table 1. 1: Preliminary study on knowledge of Malaysia’s youth about stroke

| | What is stroke? | What are the types of stroke? | What are the symptoms of stroke? | How can you spot stroke? | Do you prefer to use your handheld to learn about stroke? |
|---|---|---|---|---|---|
| Yes | 20% | 4% | 10% | 8% | 91% |
| No | 80% | 96% | 90% | 92% | 9% |




Although many studies have examined the effects of media-rich content in raising awareness, the accumulated evidence from other domains suggests that methods used to educate youth should be more interactive in order to be effective (Niederdeppe, Bu, Borah, Kindig, & Robert, 2008). Some researchers reason that a lack of tools for providing accurate representations of stroke onset symptoms has dominated the process of providing intuitive visualization and control of content. However, improving procedural presentation with the correct perception of depth, relative position, and layout of objects from a person's point of view is a major issue (Azuma et al., 2001; Furmanski, Azuma, & Daily, 2002). This has led to the current focus on the potential of handheld AR in providing generalizations, suggesting causal interpretations, highlighting contrasts, and providing detailed information about stroke.

### 1.4 Research objectives

With limited mechanisms to increase students’ awareness of stroke, it became necessary to determine the potential of advanced technologies to supplement live visualization in real time. Thus, this study is a first step that investigates the potential of AR antecedents, experiences, and consequences for promoting students' awareness of stroke warning signs and symptoms. The following are the core goals of this study:

1. To investigate the effects of handheld AR antecedents in terms of focused attention, interactivity, and perceived control on students' enjoyment and telepresence when learning about stroke warning signs and symptoms.
2. To investigate the effects of handheld AR experiences in terms of telepresence on students' feeling of enjoyment when learning about stroke warning signs and symptoms.
3. To investigate the effects of handheld AR experiences in terms of enjoyment and telepresence on students' exploratory behavior and positive behavior.
4. To investigate the effects of handheld AR consequences in terms of exploratory behavior and positive behavior on students' awareness of stroke warning signs and symptoms.

## 1.5 Research questions

The following are the research questions for which answers were sought in this study:

1. What are the effects of handheld AR antecedents in terms of focused attention, interactivity, and perceived control on students' enjoyment and telepresence when learning about stroke warning signs and symptoms?
2. What are the effects of handheld AR experiences in terms of telepresence on students' feeling of enjoyment when learning about stroke warning signs and symptoms?

3. What are the effects of handheld AR experiences in terms of enjoyment and telepresence on students' exploratory behavior and positive behavior?
4. What are the effects of handheld AR consequences in terms of exploratory behavior and positive behavior on students' awareness of stroke warning signs and symptoms?

### 1.6 Research model

The potential of handheld AR to promote community-based awareness has not been extensively studied. This potential includes its use in improving youth awareness about certain health-related events. Therefore, learning how stroke works in AR can allow for incremental interaction and heighten their motivation to spot potential symptoms (Bohil, Alicea, & Biocca, 2011). It is believed that the resultant interaction can simulate necessary behaviors to sustain a person's attention while learning with a system (Decety & Grezes, 2006). Such processes can be facilitated by providing an augmented display of aspects related to stroke. This can be achieved by using 3D geometries to stimulate the stages and symptoms of stroke. In addition, AugStroke can provide a detailed navigational experience that may optimize the user's experience.

Csikszentmihalyi (1988) stated that while processing a particular exploratory behavior individuals can experience the feeling of flow when they have clear goals, exercise control, lose their self-consciousness, and experience a distortion of time. The driver of such experiences was found to be associated with one's capacity to experience autotelic nature. This autotelic nature was explained by Csikszentmihalyi (1988) as the self-goal that an individual sets to ensure his/her concentration on the process of the activity rather than the end result.

Csikszentmihalyi stated that a person's control of the process in an activity demands a definite level of attention in order to overcome possible confusion during the process. As such, subsequent studies about flow created or proposed their own factors that can contribute to the flow experience based on the nature of the task. In terms of AR design, some studies emphasize the potential for providing a richer interface and control to the user, in which the interface components can act as a tangible interface control (Poupyrev et al., 2002). Having one's attention and interaction focused on the task can contribute to one's experience if one feels appropriately engaged (Finneran & Zhang, 2002; Finneran & Zhang, 2003; Mathieson & Keil, 1998).

The approach taken in this study was developed from various empirical studies on flow in computer-mediated environments (Finneran & Zhang, 2005). The formation of the present research model shown in Figure 1.1 is discussed in the next chapter.

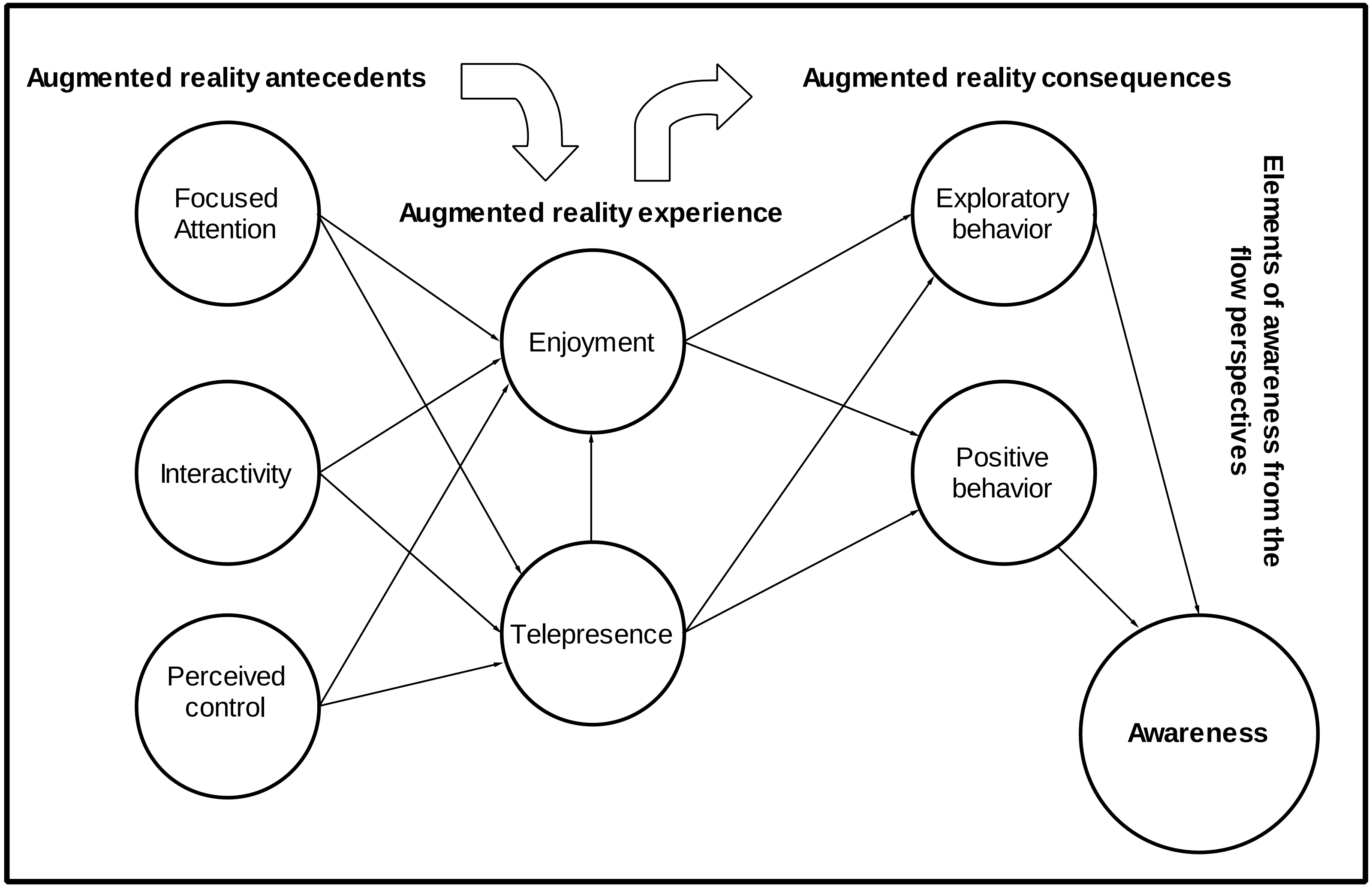



Figure 1.1: Proposed model

## 1.7 Research significance and contribution

The significance of providing interactive visualization using a handheld AR mobile app is primarily to increase and promote youth awareness of stroke risk factors; youth (and the wider population) can benefit from this service as it can be used as an interactive channel for stimulating understanding of a complex situation. In addition, this study contributes to the current body of knowledge about the potential of mixed reality in providing the necessary antecedents for promoting awareness in healthcare, especially within the Malaysian context. It also contributes to the current theory on flow in which the role of handheld AR in fostering positive behavior and exploratory behavior is yet to be explored.

## 1.8 Operational definitions

1. Augmented Reality (AR) is an interface technology that enable users to manipulate information and displays with handheld devices such as mobile phones, browsing their environment visually anywhere and at any time (Ifenthaler and Eseryel, 2013).
2. AugStroke is a mobile handheld AR developed to help youth in Malaysia gains the necessary knowledge about stroke risk factors and symptoms. It also allows them to spot stroke symptoms using FAST (Facial, Arm, Speech, and Time).
3. Youths are persons between the ages of 15 and 24 years and includes undergraduate students.
4. AR antecedents are factors that contribute to the flow state and should be considered in awareness research. These are:
    - Focused attention: An important factor that contributes to the flow experience, which is defined as the degree of concentration on the activities

that regulates the perception of time (Abuhamdeh & Csikszentmihalyi, 2012). In this regard, the individual has the perception that time passes very quickly and is often surprised at how quickly it passes (Chen, Wigand, & Nilan, 2000a). In this study, focused attention refer to the state in which a student concentrates on certain object to the exclusion of all others. It is measured using Ghani's and Deshpande (1994) 5-items instrument.

- Interactivity: The extent to which users can participate in modifying the form and content of the mediated environment in real time (Steuer, Biocca, & Levy, 1995). In this study, interactivity refer to the capability of AugStroke to allow students to modify and process information related to stroke. It is measured using 5-items from Novak et al. (2000) and Novak et al. (1999).
- Perceived control: Defined by Ajzen (1991) as "people's perception of the ease or difficulty of performing the behavior of interest" (p. 183). Perceived control reflects the internal and external constraints on behavior. In this study, perceived control is a more important antecedent of intention to use AugStroke to increase students' awareness of stroke warning signs and symptoms. Ghani and Deshpande (1994) considered perceived control as the core antecedent of flow. It is measured using the Novak's et al. (2000) 4-items instrument.

5. AR experience refers to the levels of involvement in a task and these are:
   - Enjoyment: The extent of computer usage being perceived as enjoyable, regardless of the consequences that may come out (Davis et al., 1992). In this study, enjoyment refer to the level of intrinsic pleasure and interest

derived from using AugStroke. It is measured using Ghani's (1995) 4-item instrument.

- Telepresence: The mediated perception of an environment, where "presence" is the natural perception of the immediate physical environment (Sheridan, 1992). In this study, telepresence refer to the extent to which students when using AugStroke feel present in the mediated environment, rather than in the immediate physical environment. It is measured using Novak's et al. (1999) 7-item instrument.

6. AR consequences are the outcomes of one's efficacy beliefs. These are:
   - Exploratory behavior: An important and valuable consequence of the flow experience that refers to the state of mind in which a user focuses on new experiences (Ghani and Deshpande, 1994). It is measured using Novak's et al. (1999) 7-items instrument.
   - Positive behavior: The delivery of intrinsic value as escapism and enjoyment experienced by the user from the surrounding environment (Ghani and Deshpande, 1994). It is measured using 4 items from Havlena and Holbrook (1986).
7. Awareness is active knowledge and attention towards stroke and its risk factors as measured using the adapted Fu's et al. (2009) 4-item instrument.

## 1.9 Summary

This chapter introduced the main aspects related to the use of handheld AR in increasing youth awareness of stroke warning signs and symptoms. The study problem was formed based on the current evidence that an effective medium to facilitate youth awareness of stroke is lacking. The preliminary investigation showed that the majority of youths (university students) in Malaysia are ignorant of stroke symptoms and other related information owing to limited resources and visualization enhancements. Consequently, this study proposed the utilization of AR as a way for presenting live information related to stroke warning signs and symptoms. A conceptual model was also presented based on the theoretical foundation to be discussed in the next chapter.

# CHAPTER TWO

# LITERATURE REVIEW

## 2.1 Introduction

There are many different ways for people to be educated and trained with regard to specific information and skills they need. These methods include classroom lectures with textbooks, computers, handheld devices, and other electronic appliances. The choice of learning innovation is dependent on an individual's access to various technologies and the infrastructure environment of a person's surrounding. In a rapidly changing society where there is a great deal of available information and knowledge, adopting and applying information at the right time and the right place is needed to main efficiency in both school and business settings. Augmented Reality (AR) is one technology that dramatically shifts the location and timing of education and training (Lee, 2012).

With the evolution of mobile computer systems, there is a tighter and more ubiquitous integration of the virtual information space with physical space. For example, the use tagging (markers) and mobile displays to enable potential integration of virtual information and physical assets. AR systems allow users to be aware of perfectly spatial registered information from simple Two-Dimensional (2D) labels to Three-Dimensional (3D) labels or virtual markers. AR techniques allow users to see buildings, objects, and tools superimposed with computer-generated virtual annotations. Unlike Virtual Reality (VR), AR enhances the real environment rather than replacing it with computer-generated imagery. Graphics are superimposed on the user's view of the real environment.

Studies of user performance in AR-based information systems indicate that they can provide unique human factors benefits—as compared to approaches using traditional printed manuals or other computer-based approaches—such as improved task performance, decreased error rates, and decreased mental workload. Information objects such as labels, overlays, 3D objects, and other information are integrated into the physical environment (Wu, et al., 2013). Objects, tasks, and locations can be cued when appropriate to support navigation and mobile active user tasks.

## 2.2 Augmented Reality (AR)

AR is identified by many researchers as the combination of real and virtual imagery. Milgram and Kishino (1994) defined the main concept of reality-virtuality continuum as the belief of a person in a virtual immersed situation in real environment without direct interaction between user and the virtual component. On the other hand, Mixed Reality (MR) is identified as one's impression of the environment which includes the full range of VR and the real environment. Based on this, AR systems is typically embedded into the design of MR through which information used to guide user is reflected from the environment with the presence of some virtual elements which included as a supplements of that environment. With this in mind, it can be summated that AR characteristics can offer the following:

- A combination of real and virtual elements
- An interactive real time display
- and 3-D supported

Azuma (1997) stated that the potential of these characteristics can be used to determine the independently of AR in a certain context. Thus, using AR can offer a rich and interactive display of 2D and 3D materials that can be designed with different metaphors of Human-Computer Interaction (HCI), such as Head-Mounted Displays (HMD), projection displays and handheld devices. AR and mobile computing are often mentioned together, as many mobile computing platforms rely on some kind of head-up or HMD to provide continuous access to information, often coupled with hands-free operation. AR as a user interface is particularly powerful when the computer has access to information on location and situation, so that it can provide contextual information. Recent developments focus on applying mobile AR interfaces to real-time applications to be deployed to end users (Chi, Kang and Wang, 2013).

From the literature, it appears that AR applications have been widely utilized in the context of geography, archeology, entertainment, science education, assembly assessment, etc. However, few studies considered the use of AR in increasing community-based awareness of health related knowledge. For example, Yoon, Elinich, Wang, Steinmeier, and Tucker (2012) and Yoon and Wang (2014) showed the benefits of using AR for increased interest and engagement of a person in science museum that may positively drive the development of conceptual knowledge and cognitive skills. Ifenthaler and Eseryel (2013) explicitly addressed the implication of mobile AR in simplifying one’s understanding of complex situation. The authors added that users’ interaction with the AR elements can help them compare the augmented process in a real life situation. Peng and Li (2013) proposed the use of AR in commerce by using the interaction model for engaging users in an interactive experience with the goods and services information. In healthcare, Ma, Jain, and Anderson (2014) highlighted the importance of AR in providing the substantial support for medical education, and rehabilitation due to its ease of use and accessibility. According to de Ribaupierre et al. (2014), AR can offer a training opportunity of different health related matters. Despite these studies, there appears to be a little understanding about the use of AR in community-based knowledge. With the rapid shifting from the PC to mobile, one can easily access and learn about health related matters at anytime and anywhere. This led the researcher to consider the potential of handheld AR in promoting young population to learn about stroke warning signs and symptoms.

### 2.2.1 Display solutions for merging visual realities

In order to ensure a realistic display of the augmented materials into the real world, there are two ways that are currently used for merging real and virtual worlds in real time; these are video see-through and optic see through (Cutolo, Parchi and Ferrari, 2014; Hua & Javidi, 2014). Both types of systems were developed for HMDs, which are displays that located directly in front of the users eyes. Then, a new display has recently emerged known as marker which relay on certain target to display the visual elements of AR.

#### *2.2.1.(a) Optic see-through AR*

In optic see through AR, the user has a head mounted see-through optical display which allows the user to see the real world as if through a glass lens (Kiyokawa, 2007). The virtual information is then overlaid on the see-through display. Although the technique of blending virtual and real information optically is simple and cheap compared to other alternatives, this technique is known to cause some problems. For example, it may be difficult to obscure the image projected virtually into the real world. This means that real objects are augmented in a way that reduces its details due to the elimination some of the objects' characteristics. The concept of this type is illustrated in Figure 2.1. This type of display requires several hardware component which not all users can afford to buy and use. Therefore, the researcher did not consider this type of display in the present work.

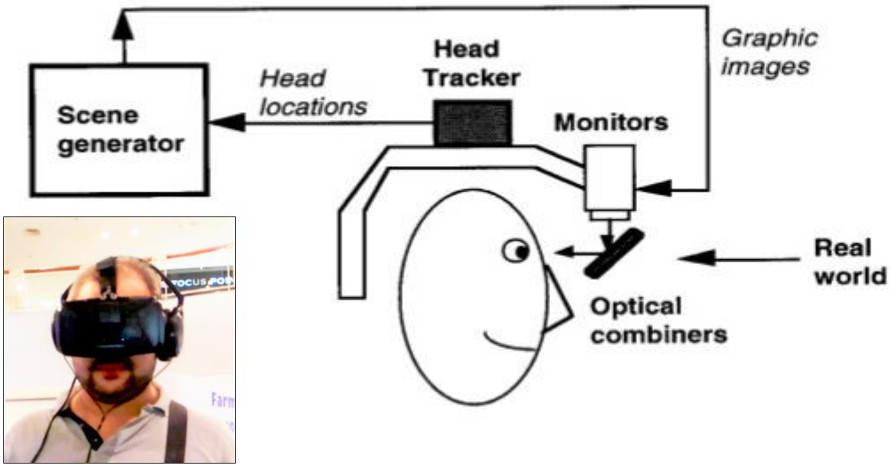



Figure 2.1: Optic see-through augmented reality

*2.2.1.(b) Video see-through AR*

Another method of AR display the can be used as an alternative for optic see-through is video see-through AR, where a camera is placed in front of the users' eyes, see Figure 2.2. The captured camera image is then projected to a small display in front of the users' eyes (Hahn, 2012). Furthermore, this type of display deals with integrating the virtual images to the real image without effecting the characteristics of the objects which solves the problem with the semitransparent virtual images described above. Still, this type of display also requires certain hardware equipment and prior configuration of the environment. Therefore, the researcher did not consider this type of display.

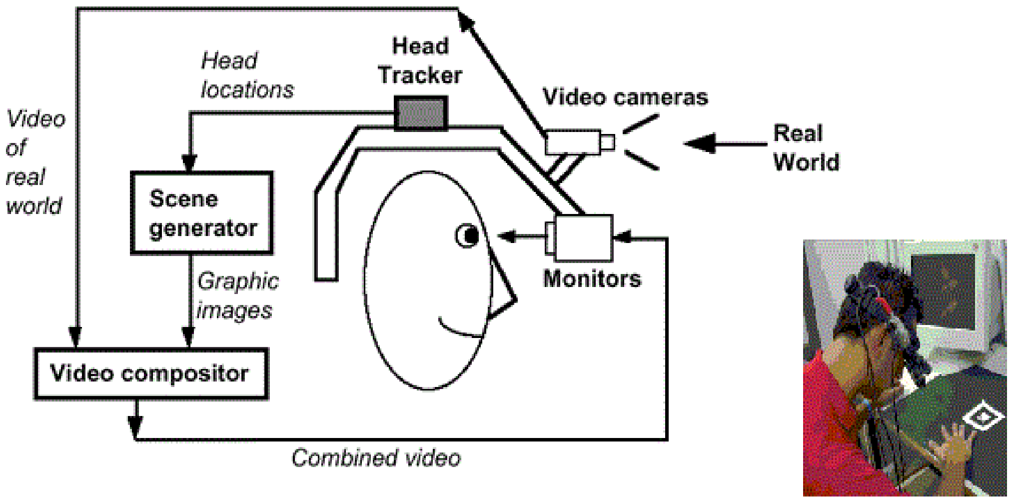



Figure 2.2: An illustration of see-through AR solution

*2.2.1.(c) Visually based marker tracking*

Marker-based solution can offer a realistic and convenience to the users by simply presenting the augmented objects in the real world when processing a predefined reference. For this to happen, users need to read the code on the marker using the camera on their devices (computer or mobile) in order to augment the objects to the surrounding environment. This can be illustrated in Figure 2.3 whereas a device identifies the reference points for the system to stimulate the virtual elements into the real world display. This type of display known as "tracking" which is currently used in different areas.

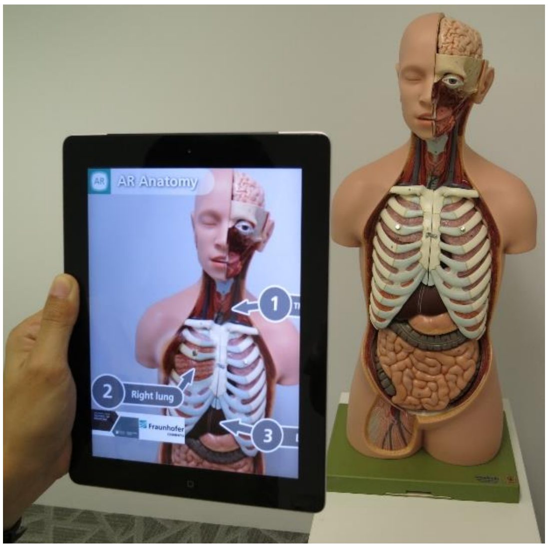



Figure 2.3: Free AR

By tracking and identifying markers placed in the environment the position of the camera in relation to the marker can be calculated, and hence the virtual information can be placed in the display relative to the marker position (Behzadan and Kamat, 2013; Benbelkacem, et al., 2013). When using a camera based AR system (video see-through AR) the visual tracker is already there embedded within the video camera (Chen and Tsai, 2012). In optic see-through systems the tracker system must be added, either in the shape of cameras for visual marker tracking or some other kind of tracking devices (Carmigniani et al., 2011). An example is shown in Figure 2.4 where the virtual element is embedded into the display of environment based on the position of the marker.


Figure 2.4: AR based marker

Generally, there are two types of tracking, marker and free-marker. The only different between these types is the use of marker. Since the aim of this study is to enable students to learn about stroke warning signs and symptoms, then a free-marker technique is used in this study. In addition, the use of this method enable the users to use their mobile devices to simply project the 2D and 3D objects in a real world without a need to have a fixed marker. This is assumed to offer a realistic way for students to use AR with no restrictions. On the other hand, the feasibility of running AR applications on mobile devices make it more feasible and easier for users to control and be telepresenced with the context (Liu et al., 2012; Olsson et al., 2012; Olsson, et al., 2013). Although AR mobile systems can offer an interactive display, designer of a system need to consider user ability to navigate through its display by breaking down the materials into sub elements. According to Mavrikis, et al. (2013), user may develop positive perception and attitude when engage in positive and exploratory behaviors with minimal cognitive capacity. After all, it can be summated that handheld AR for promoting students' awareness of stroke warning signs and symptoms is promising.