Conceptualising Mobile Augmented Reality (MAR) and E-Learning to Enhance Library Wayfinding

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Mobile augmented reality (MAR) applications represent a profound opportunity to enhance user experiences on library accessibility into modern and interactive learning environment. Mobile Augmented Reality (MAR) aids library visitors to simplify the complexity of comprehending unfamiliar library territories – say it building, structure, department, facilities, services and collection through the navigation with their own smartphones. E-learning has been studied and used in various domains including library and information science (LIS). Many libraries have incorporated E-learning with education programmes in the library environment. It is worth noting that, from the literature, limited studies used both platforms to improve library wayfinding. Also, inadequate studies suggested conceptual framework for the usage of AR in library navigation although system architecture is usually demonstrated in project-based studies. Realising AR potential, the intention of this paper is to suggest a conceptual framework for MAR and E-learning to enhance user experiences on library navigation.

Keywords*:* Library Accessibility, Library Navigation, Mobile Augmented Reality (MAR), E-learning

1. INTRODUCTION

Mobile augmented reality (MAR) applications represent a profound opportunity to enhance user experiences on library accessibility into modern and interactive learning environment[1]. Mobile Augmented Reality (MAR) aids library visitors to simplify the complexity of comprehending unfamiliar library territories – say it building, structure, department, facilities, services and collection through the navigation with their own smartphones [2]–[5]. Conventional alternatives in library wayfinding such as signs and asking directional question to library personnel are very convenient, but less exciting to the smartphone and tablet alike generation.

Mobile Augmented Reality (MAR) is relatively a growing technology in today's world. MAR can be understood as a technology that combine virtual and overlaid information such as text, images, video clips, sounds and 3D models with real world objects[6], [7]. The fundamental idea of MAR is to complement real world objects with digital information. The blend of virtual and real world information through smartphone camera for instance, enhances users' familiarity and learning capacity on library navigation in a self-guided and interactive manner. In this respect, users can navigate themselves to any of the designated areas in the library building through smartphone camera. To do so, AR smartphone application must be downloaded and used throughout navigating process.

Augmented Reality (AR) was introduced to the scientific literature as early as 1960s by a number of researchers such as Sutherland [8], Azuma [9] and Feiner [10]. AR is known as an environment along Reality-Virtuality (RV) Continuum[11]. Since its inception, Augmented Reality has evolved and used in various areas such as education[12]–[16], medicine [9], [17], engineering [18], forestry, dentistry, entertainment, navigation[7], [8], [17], tourism[19], architecture and marketing[12]. The rapid progress of enabling technologies has allowed researchers to extend AR world in mobile settings. However, the expansion of such technology is gradually escalating in Library and Information Science[1], [4], [20]. It is worth noting that, from the literature, limited studies used both platforms to improve library wayfinding[20][6]. Also, inadequate studies suggested conceptual framework for the usage of AR in library navigation although system architecture is usually shown in project-based studies. Realising AR potential, the intention of this paper is to suggest a conceptual framework for MAR and E-learning to enhance user experiences on library navigation.

This paper is organised into several sections. In section II, a brief introduction is given on mobile technology and industry. Section III explains on AR applications in libraries. In this section, certain amount of studies will be taken to exemplify AR applications in the library. After that, section IV proposes the E-learning and MAR conceptual framework to enhance user experiences on library wayfinding.

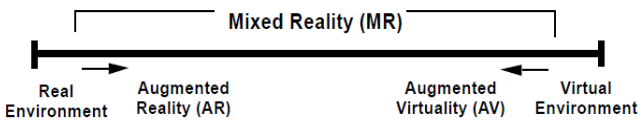

Fig. 1: Reality-Virtuality Continuum

2. MOBILE TECHNOLOGY

The world today is seeing a fast migration from desktop-based machines to increase adoption of smartphones and other hand-held devices. In 2014 alone, it is estimated that the mobile technology and communication industry globally has created over $3 trillion in revenue and responsible for millions of jobs

worldwide [21], [22]. Over the past 20 years, many interests and extensive studies have taken place to investigate mobile technologies. This development has triggered information agencies to apply such application into information industry to remain relevant in fulfilling users' demands.

3. AUGMENTED REALITY APPLICATIONS IN LIBRARY

3.1. Integration with Library Instruction

Library instruction focuses primarily on teaching users how to utilise effectively library materials. This involves teaching users at different level such as at school and higher institutions. Delivering library instructions to users is challenging as it involves technology, economic, and organisational commitment. Clearly, libraries are meeting these challenges by adapting technological changes such as embedding instruction with Computer-assisted instruction (CAI), podcasted tours and online tutorials. Recently, a number of libraries integrated AR with library instructions to enrich user experiences on using the library collection, services and facilities[2], [23]. In this aspect, AR can be integrated with teaching approaches and exercises to familiarise users with the library. Several studies indicated that such usage is applicable especially for young children to improve learning performance and motivation[3], [4]. One example of such implementation is to simplify library classification system with AR so that library users can understand on how library materials are being organised. Another instance is to integrate Information literacy (IL) exercises with AR. By doing so, library users can use their smartphones to play scavenger hunt game[24]. In [24], it was found that AR increased learners' participation, user experience (UX), retention rates and positive attitude among new students.

3.2. Marketing Library Resources with AR

Developing AR materials demands a certain degree of expertise depending on the computational complexity and environment. However, immediate marketing materials through AR can be generated by using mobile applications such as Layar, Argon, Wikitude, Aurasma, Blippar and Junaio. Each of these mobile applications may only work in several operating systems. For instance, Layar works only on smartphones with iOS, Andriod and Symbians devices. Through these mobile applications, developer can develop simple and effective AR materials and incorporate these materials in marketing library resources. By doing so, AR developer can integrate 3D images, models, videos, links and background music with any marketing materials such as poster and pamphlet. When library users flash their smartphone to any of these materials, they come alive and linked with the digital information attached to them. Few examples of such application, including bringing rare books to life without exposing them to dangerous handling or attach book reviews on AR poster and on library website.

3.3. Location-based Application

One of the advantages of AR is it provides information on library resources whereabouts. In a library, resources are arranged according to call number and classification system. Not only that, these materials are frequently moved, loaned and misplaced. Finding a book in a large library is difficult especially for first-time users. AR can be used as a searching assistance in libraries [2], [5], [25]. For librarians, AR can be applied to visualise shelf-reading and inventory such as ShelvAR application in Google Apps.

4. E-LEARNING ADOPTION AND LIBRARY NAVIGATION

E-learning has been studied and used in various domains including library and information science (LIS). Many libraries have incorporated E-learning with education programmes in the library environment. For example, it is used to enhance information literacy programmes for new library users and academics. Apart from that, E-learning is used to support information access and discovery in digital library[26]. Earlier studies have revealed that E-learning adoption improve students' understanding and performance. In this study, E-learning refers to an online program that is used for assisting users in library wayfinding[27]. E-learning program integration with interactive map and visual elements help users to learn about library navigations.

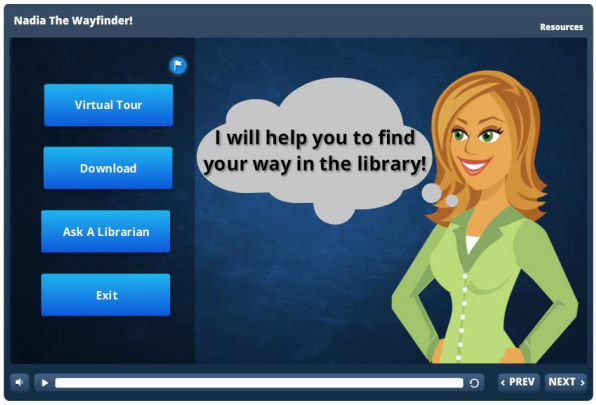

Fig. 2: Interactive Wayfinding

5. METHODOLOGY

Proposing a conceptual framework on MAR and E-Learning requires an extensive reading of the past and recent literature. In this study, the first step towards realising this objective is to explore the abundance of literature on both areas. Web of Science which is one of the largest indexing databases is used to identify relevant and contextual information on the proposing topic[28]. Three indexes were selected, namely i) Science Citation Index, ii) Social Sciences Citation Index (SSCI) and iii) Arts & Humanities Citation Index (A&HCI). These indexes were the foundation to discover scientific literature that deals with MAR and E-Learning in the context of library wayfinding. After that, a series of keywords were

used primarily to locate relevant studies. Example of keywords includes *"Mobile Augmented Reality in Library"*, *"Library wayfinding", "E-learning in Library", "Mobile Augmented Reality Applications", "Augmented Reality Framework"*, and *"E-Learning in Library education"*. Other information resources were referred to such as online databases and books subscribed by the academic library. Subsequently, these literatures were read and used to propose a conceptual framework.

6. CONCEPTUAL FRAMEWORK

Given the preceding considerations, we propose a conceptual framework in figure 2 consisting technological context, organisational context and environmental context in MAR and E-learning adoptions particularly in library wayfinding.

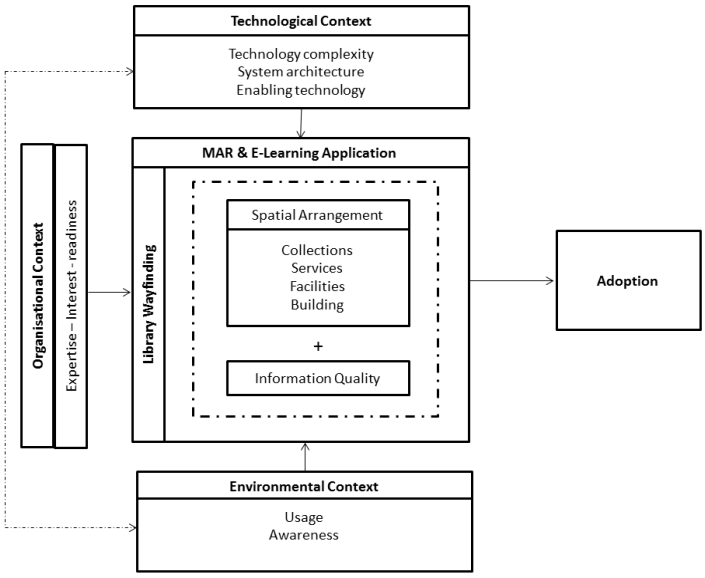

Fig. 3: Conceptual Framework

6.1. TECHNOLOGICAL CONTEXT

Technological context refers to the challenges on developing MAR and E-learning innovations. Literature suggests that numerous challenges faced by developers to use and apply these technologies such as technological complexity, system architecture and availability of enabling technology.

6.1.1. Technological complexity

In developing AR and E-learning application, technology complexity often faced by many developers. In this study, the term "technology complexity" relates to technological innovation and challenges on developing AR and E-learning projects[29]. These projects can be developed with simple or advanced on system architecture and technological terms. Less-advanced projects usually used mature technologies with great level of understanding. Example of simple adoption of AR technology includes developing AR content by using web-based tools. For instance, QR codes can be generated for free on the internet[30]–[32]. QR codes can link library users to limited digital information such as website, online map and library instructions. Contrary, developing complex AR content involves expertise, fund allocation and time[2], [23], [25]. Advanced projects involve adopting emerging or new platforms of which its understanding is low. Lesser amount of understanding or knowledge means greater challenges on design, product delivery and implementation[33]. The term used is consistent with other scholars [34]–[36].

6.1.2. System architecture

System architecture relates to the construction, functionality and inter-relationship of software and hardware components or subsystems in relation to human interaction[37]–[39]. The literature suggests various system designs used to develop AR collected from the past studies. These design patterns share some similar components such as application, communication, presentation, tracking, context and world model subsystem[40], [41]. "Gateway" and "platform" architecture were also used in some AR system architecture[42]. In [40], nearly 50 patterns were used for AR systems.

6.1.3. Enabling technology

Development of AR and E-learning is influenced by the progress of other related technologies. According to [43], example of these enabling technologies including global tracking technologies, storage, wireless communication, display technology and interaction technology. Apart from that, hardware, content and software-related technologies enabled the massive Augmented Reality (AR) and E-learning applications[16].

6.2. ENVIRONMENTAL CONTEXT

6.2.1. Usage & Awareness

The success of AR & E-learning platforms depend on the awareness and usage of such technologies by users. However, introducing MAR experiences does not automatically warrant positive experiences. To this end, and motivation theories, Technology Acceptance Model (TAM) and Expectation Confirmation Model (ECM) are used by scholars to understand the factors and intentions of using IS from the user perspective[44]. For instance, TAM suggests two determinants, perceived ease of use and usefulness as the fundamental elements in behavioural intention. In another study to examine users' continuation intention and reasons to use Augmented Reality (AR) applications, [44] found that Information quality and visual quality are essential elements on AR applications. Furthermore, [45] suggests that MAR developers need to take into account designing socially acceptable and fashionably accepted MAR application for users. Therefore, designing MAR and E-learning must centralised on user needs and experiences to enhance awareness and usage of these applications[20].

6.3. ORGANISATIONAL CONTEXT

Organisational context refers to organisational commitment towards the application of MAR and E-learning. Organisational readiness is paramount in creating appropriate augmented reality solutions. Not only that, expertise and interest are equally important to safeguard any success on IT applications. There are a number of existing platforms for building desktop AR applications. These can be broadly organised into two types: 1) authoring tools for programmers, and 2) authoring tools for non-programmers [18]. Any of these platforms require expertise, readiness, interest, and organisational commitment to ascertain the success and sustainability of MAR projects. Example of MAR project is shown at figure 4[47].

Fig. 4: Navigation with Mobile Augmented Reality (MAR)

7. MAR & E-LEARNING APPLICATIONS

Library wayfinding has a dynamic correlation with space. In library building, information materials are kept on shelves and library layout is usually filled with rows of desks and chairs. In large multi-floor libraries, finding a collection or deciding on a route choice is difficult as it involve personal spatial skills and strategies. These set of skills is vary from one user to the other. Indoor wayfinding and spatial problem-solving involve three major steps such as decision making, decision executing and information processing[46]. In this aspect, MAR and E-learning can be used to help users in spatial-related matters.

Spatial arrangement is the library layout in general. This includes the arrangement of collections, shelves, departments, services and facilities in the library building. Interactive map and virtual tour is an example on how E-learning can be used in library wayfinding. Such application of navigation is seen across public facility such as airports and hospitals. Interestingly, MAR can be applied with real-time locations of the library user in the library building. This will help users to locate library collections and identify shelves. Google Indoor Maps is an example of such application. Understanding library layout and spatial arrangement is pivotal to drive users' success in retrieving desired information. Therefore, department locations, collections, services, and facilities indoor data can be integrated with MAR and E-learning. Information quality refers to the quality of navigational information within MAR and E-learning programs. Information quality is regarded as one of the most significant components in AR mobile application. Apart from that, interactivity and visual quality is equally vital for Mobile Augmented Reality (MAR) applications.

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10. BIOGRAPHY

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