The Feasibility of Implementing Augmented Reality Technology for Delivering Library Services:
A Case Study at the University of Bahrain

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Abstract: Engaging new mobile technology tools, which deliver information and knowledge, become part of our daily life. One of these tools is Augmented Reality (AR), a technology that blends the real world with computer-generated media. Through in-depth analysis, this study investigated the researchers' (academics and students) behavioral intention to use mobile AR technology to access special library services: current awareness service (CAS) and selective dissemination of information service (SDI), provided by University of Bahrain (UOB) library as an example. Technology Acceptance Model (TAM) was used and focused on Perceived Ease of Use and Perceived Usefulness together with Attitude toward using and Behavioral Intention to use new technologies, together with Perceived Behavioral Control to test the factors of using AR technology in accessing UOB library services. A questionnaire was distributed to collect data from targeted sample researchers. Findings revealed that AR technology was accepted by UOB library users in receiving through their mobile an instant and frequent information of the two important tested library services. Results showed that perceived usefulness, perceived behavioral control and attitude toward using AR technology had positive significant effects on the researcher's intention to receive library service using AR technology.

Keywords: Library services, Augmented Reality, Current Awareness Service (CAS), Selective Dissemination of Information (SDI), Technology Acceptance Model, Perceived Behavioral Control

1. INTRODUCTION

Mobile devices are considered as a hugely productive tool. They became the central hub for education. According to [1] smartphones can create an effective learning environment for instructors and students. Using mobile devices with new technologies like Augmented Reality (AR) which blends the real world with computer-generated media became a truth. Augmented Reality system was defined by Azuma, et al. [2] as "supplements the real world with virtual (computer-generated) objects that appear to coexist in the same space as the real world. AR can potentially apply to all sense, including hearing, touch, and smell."

UOB pays millions of dollars per year to encourage and keep its researchers up to date with the latest publications and through enhancement of the library services. However, students and academics often face challenges in utilizing, accessing, and benefiting of some special services for full advantage [3]. Consequently, librarians need to utilize the new technologies in a way that deliver the best user experience and gateway to library services.

In this study, the prototype of AR system proposed by Abdulrazzaq and Al-Ani [4] is adopted to provide the UOB researchers (academics and students) with two of important library services, Current Awareness Service (CAS) and Selective Dissemination of Information Service (SDI).

The remainder of the study was organized as follows: Section two highlighted previous studies and technology applications in AR used in the field of information and library services. Objective of the study was described in section three. Section four covered research hypotheses while section five presented the data and the procedure of collecting the data. Results and analysis discussed in section six. Finally, the study enclosed in section seven the conclusions and future work.

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2. LITERATURE REVIEW

EBSCO had released an infographic that illustrates their findings from a 2015 survey of 208 students about how college students conduct research. how research start, as well as the experience gained. Results indicated that while students are largely receiving library instruction and using library resources, they were often challenged by or were under-utilizing certain services, 68% started their research process using Google and Wikipedia and 41% found evaluating the best resources to their paper was the major difficulty in conducting research [30]. This created needs for integrating new technologies with library services to help students invest the treasures of library resources. Moreover, many research studies examined the impact of adopting mobile applications to deliver library services e.g., [5], [6], [7] and [3]. Avila provided some examples that depicted how librarians can enhance library usability and marketing by creating AR content using free and low-cost applications [8].

Many researchers showed that integrating education and AR enhances user learning performance and motivation. Radu in [9] showed in his analyzed studies, the positive impact of augmented reality on the performance of the learning tasks and users' satisfaction compared to traditional methods of learning. Based on our research and knowledge, few researchers used AR technological innovation to convey library services to the users.

In 2003, Reitmayr and Schmalstieg investigated building indoor location-based applications for a mobile augmented reality system. ARLib was a sample application [10]. It was a book-location system for users of any library, as it was used to help searching and returning books from and to the right shelves.

In 2011, Miami University researchers developed ShelvAR application based on augmented reality as a tool for shelf-reading and inventory management in libraries. The application was implemented to be used with any iOS or Android device with a camera. ShelvAR application was up to four times faster than manual shelf-reading and up to 40% more accurate [11]. The application scans tagged library materials and overlays a red X over the item in the wrong location or a green check mark on items in the right place. It also generates lists of missing books and identifies sections with high patron activity.

Another university engaged AR technology to deliver library services was University of Houston Downtown [12]. The library orientation material was provided using Aurasma application to the students with on-line and in-person AR tour introducing new students to the library services and how they can find more information about the library [13].

In 2014, Pradeep Siddappa, an Indian developer, implemented an augmented reality application called librARi. The application allowed users to search for books with AR interaction. Users find book locations by pointing tablet's or smartphone's camera on the physical books' shelves. The application displays sections of books and new books arrivals in different sections. However, librARi had never been used by any library [14].

In 2018, Abdulrazzaq and Al-Ani [4] proposed AR system prototype using HP Reveal augmented reality platform as a tool to provide library services to the University of Bahrain users. The users would create an HP Reveal account then followed the library AR account to start getting information about the library services through scanning the Quick Response (QR) code. Once QR code scanned the overlay video or text appear showing up-to-date information about this service.

3. OBJECTIVES OF THE STUDY

This study investigates users' perceptions and acceptance of the special services provided and delivered through AR technology system by UOB library. The adopted AR prototype proposed by Abdulrazzaq and Al-Ani [4] was used to investigate and answer the following questions:

- What are the users' behavioral intention (BI) toward using AR technology, based on the constructs of perceived ease of use (PEOU), perceived usefulness (PU), attitude toward using (ATU) the technology, and perceived behavioral control (PBC)?

- What are the relationships between the constructs?

- How perceived ease of use, perceived behavioral control, and attitude impact the behavioral intention to use AR technology?

4. RESEARCH HYPOTHESES

Technology Acceptance Model (TAM) has an excellent reputation in terms of robustness and explanatory power [15], [16], [17]. It is widely used to illustrate the positive influences of both perceived ease of use and usefulness on the learners' attitudes toward using AR technology [18]. PEOU measures users' acceptance of using AR technology would be with no effort while PU measures users' acceptance of using AR technology would improve their performance. Furthermore, ATU measures the users' feelings about applying the target behavior. ATU directly impacts behavioral intention to use AR technology which measures the strength of learners' intension to perform AR technology to access the library services.

In this study, an external variable was added to TAM factors, Perceived Behavioral Control. PBC refers to users' confidence in their abilities to correctly do a behavior [19].

Learner's behavior indirectly impacted by PEOU through PU [20]. Ease of use has an indirect effect on intentions to use new technology [21]. If an AR system is not perceived as useful, then the system will not be used, even though it may be easy to use, or people enjoy using it [22]. On the contrary, PU has direct and indirect effect on the ATU the new technology [23].

When PBC reflects actual control, it is positively strengthening the intentions impact. As Fishbein and Ajzen stated in their study [24], PBC has a direct impact on behavior.

Hence, PEOU, PU, PBC, ATU and BI to use AR technology are the constructors that are used in this study model, and are shown in Fig. 1, to depict the effects of these factors while engaging AR technology in delivering the UOB library services.

The following hypotheses are tested depending on TAM and PBC:

H1: PEOU has a significant positive effect on the PU to deliver UOB library services using AR technology.

H2: PEOU has a significant positive effect on ATU to deliver UOB library services using AR technology.

H3: PU has a significant positive effect on ATU to deliver UOB library services using AR technology.

H4: PBC has a significant positive effect on BI to use AR technology to deliver UOB library services.

H5: PU has a significant positive effect on BI to use AR technology to deliver UOB library services.

H6: ATU AR technology has a significant positive effect on BI to use AR technology to deliver UOB library services.

5. METHODOLOGY

Focusing on UOB Library researchers' behavioral intention to use AR technology in receiving delivered special services. The participants were voluntarily answered an online questionnaire, the instrument of the data collection. A link to the questionnaire with video showing how to use AR application were sent by email to 98 researchers and only 58 participated. The questionnaire was included demographic data and 17 items testing PEOU, PU, ATU, PBC and BI (three items for PEOU, three items for PU, five items for ATU, three items for PBC and three for BI). The questionnaire measured participants' perspectives with 5-point Likert scales ranging from strongly disagree to strongly agree.
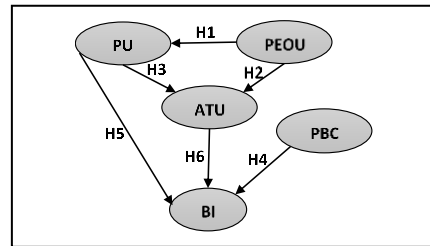

Figure 1.   The Study Model

The proposed AR prototype by Abdulrazzaq and Al-Ani [4] was adopted for this study as shown in Fig. 2. The AR simulation includes two main elements, trigger and overlay. QR code was used as trigger to activate the overlay. Overlay on the other hand was an animation, created by PowerPoint, to be played within mobile camera view.   A UOB HP reveal studio account was created, and the brochure was designed to include two online created QR code, one for CAS and the other for SDI services as shown in Fig. 2a. Overlay media for each QR code was created and added to UOB account. After linking QR codes with overlay media, a video was created to show the participants of this study how to use AR system (see Fig. 2c).

6. RESULTS AND ANALYSIS

Data analysis and model validation were performed using statistical description, reliability, validity, and predictability analysis. Descriptive statistics were used to describe and understand the features of the collected data measured by frequency and percent. Table 1 shows the respondents' demographic items with the descriptive statistics. Based on the collected data the percentage of respondents' gender, 51.72% females and 48.28% males. In terms of respondents' age, 36.21% are 18-24 years old followed by 35-44 years old with 31.03%. More than 56% hold a post-graduate degree, 32.76% hold master's degree while 24.14% hold doctorate degree. Respondents with bachelor's degree are 27.59% while 15.51% undergraduates or associate degrees. Faculty members represent the highest percentage among the respondents, 48.28%. Followed by undergraduate students completed 0-29 hours with 27.59%. Other undergraduate students completed 30 hours or more with 18.97%. MSc students with 5.17% only among the rest.
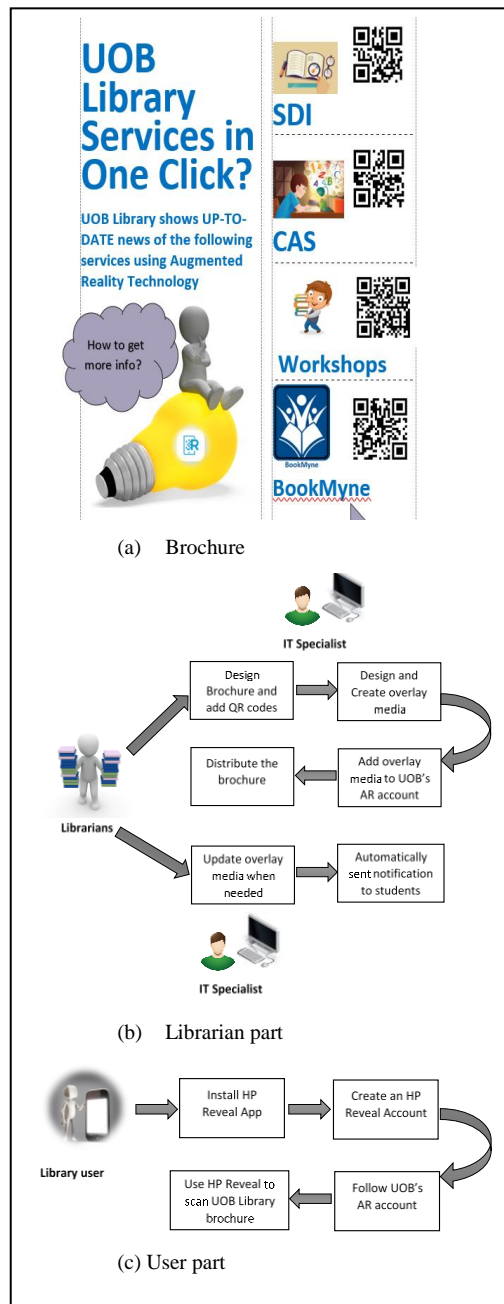
(a)   Brochure

(b)   Librarian part

(c) User part

Figure 2.   The AR Application Parts [4]

TABLE I.   DEMOGRAPHIC PROFILE OF RESPONDENTS

	Characteristics	Frequency	%
Gender	Female	30	51.72
	Male	28	48.28
Age	18-24 years old	21	36.21
	25-34 years old	7	12.07
	35-44 years old	18	31.03
	45-54 years old	5	8.62
	55 and above	7	12.07
Education	Undergraduates	6	10.34
	Associate degree	3	5.17
	Bachelor's degree	16	27.59
	Master's degree	19	32.76
	Doctorate	14	24.14
Class standing	0-29 hours completed	16	27.59
	30-59 hours completed	5	8.62
	60-89 hours completed	1	1.72
	More than 90 hours completed	5	8.62
	MSc Student	2	3.45
	MSc Student - completed all courses except thesis	1	1.72
	Faculty member	28	48.28

TABLE II.   THE DESCRIPTIVE STATISTICS

	Yes	No
Have you ever tried to access any of the library services using your mobile device?	**24**	**34**
0-29 hours completed	4	12
30-59 hours completed	1	4
60-89 hours completed	1	0
more than 90 hours completed	1	4
MSc Students	0	3
Faculty members	17	11

In addition to the demographic statistics shown in table 1, the use of mobile devices to access UOB library services was investigated. Results reveal in table 2, only 25% of the respondents who completed 0-29 hours use mobile devices to access library services. While the same percentage (20%) of both respondents who completed 30-59 hours or more than 90 hours use mobile devices to access library services. Faculty members represent the highest respondents (61.7%) to library services using mobile devices.

Cronbach's Alpha coefficient was used to measure questionnaire reliability and test the internal consistency of latent constructs. Based on Nunnally study, the acceptable Cronbach's Alpha values are normally above 0.70 [26]. Also, values near 0.6 can be accepted when the construct has only few items [27], [28]. Table 3 shows PEOU, PU, ATU, and BI Cronbach's Alpha values are above 0.85 while PBC Cronbach's Alpha value is above 0.68 which mean the questionnaire has a high reliability and the constructs' items were internally consistent. Hence, further analysis of the data is proceeded.

TABLE III.   CORRELATIONS BETWEEN THE CONSTRUCTS

Construct	Cronbach's Alpha	Number of Items
PEOU	0.87	3
PU	0.91	3
PBC	0.69	3
ATU	0.92	5
BI	0.85	3

To determine the validity of the measurement model (relationship between constructs), Pearson's correlation was calculated based on items average scores of the constructs. Referring to Cohen study, correlation value between 0.5 and 1.0 means constructs have a strong relationship [29]. As shown in Figure 3, Pearson's correlation results show that PEOU has strong positive impact on the PU with r value of 0.784 (p (one-tailed) < 0.001). PU and PEOU have direct positive effect on the ATU with r value of 0.819 and 0.7711, respectively (p (one-tailed) < 0.001). On the other side, PU, ATU and PBC have direct positive impact on BI with r value of 0.824, 0.805 and 0.677, respectively (p-value (one-tailed) < 0.001).
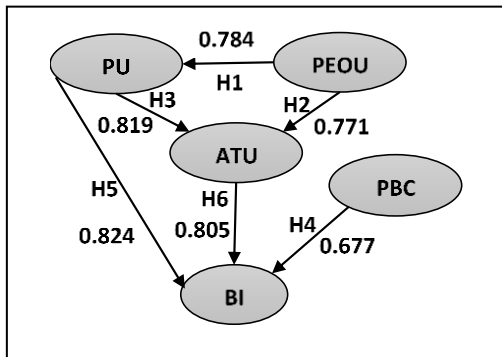

Figure 3.   Pearson's correlation

In addition to Pearson's correlation, regression analysis was applied to determine the predictability potential of predictor variables (independent variables) on the response variable (dependent variable).

The linear regression results shown in Table 4 support all hypotheses. Regression results show that PEOU significantly effects PU supporting the first research hypothesis H1. The analysis also reveals that PEOU and PU have an excellent positive relationship with ATU (Multiple R= 0.847355) and approximately 70% (R-square) of the model variation is explained by the two predictor variables, PEOU and PU which provide a good fit to predict ATU. The significance level (Significance F < 0.05 and p-value of each variable < 0.05) show that both predictor variables, PEOU and PU, are significantly related to the ATU thus supporting H2 and H3.

TABLE IV.   REGRESSION RESULTS

Response Variable	R^2	F-value (p-value)	Predictor variable	t-value (p-value)	Beta	Hypothesis is (Supported?)
PU	0.6160	88.22960 (<.0001)	PEOU	9.3931 (<0.00001)	0.8445	H1 (Yes)
ATU	0.7078	70.02111 (<.0001)	PEOU	2.6736 (0.00986)	0.2854	H2 (Yes)
			PU	4.9049 (<0.00001)	0.4900	H3 (Yes)
BI	0.7700	64.61896 (<.0001)	PBC	3.5822 (0.000731)	0.2956	H4 (Yes)
			PU	3.4320 (0.00115)	0.3424	H5 (Yes)
			ATU	3.5822 (0.0007)	0.3441	H6 (Yes)

Then, multiple regression was performed with PU, PEOU, ATU and PBC as predictor variables and BI as response variable. The results indicate that the variables in the study model move toward perfect tandem and in the same direction. The multiple R value is 0.89 with significant equal to 0.000. However, the research model shows that PEOU's p-value is greater than 0.3 that means PEOU is not a direct 'significant variable' that impacts behavioral intention to use AR technology in receiving library services. This matches with Lai study [31] that ease of use has an indirect effect on intentions to use new technology. For this reason, PEOU is excluded from the predictor variables and regression analysis is repeated with PU, ATU and PBC as predictor variables. The results reveal that PU, ATU and PBC have an excellent positive relationship with BI (Multiple R= 0.884). In addition, approximately 77% (R-square) of the model variation is explained by the three predictor variables, PU, ATU and PBC i.e., predictor variables provide a good fit to predict BI. Based on the significance level (Significance F < 0.05 and p-value of each variable < 0.05), the research model is valid, and the predictor variables are significantly related to the BI. Consequently, the hypotheses H4, H5 and H6 are supported.

7.   CONCLUSION AND FUTURE WORKS

The main purpose of this study was to investigate the perceptions and acceptance of UOB researchers to special library services delivered through AR technology. Findings show that PEOU, PU, ATU and PBC influence the users' intentions to use AR system to receive library services. PU also among the factors that has the most impact on researchers' behavioral intention to use AR technology. This finding matches with participants' comments, "It is good", "good keep it up" and "I am looking forward to use this".

It is important to highlight some considerations that might be useful for future studies. Firstly, the study could be replicated including more participants. Secondly, qualitative data might be included to support research data. Moreover, advanced analysis could be applied to enhance the research findings.

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