Examining subjective involvement on Arabic Alphabet Augmented Reality application

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Abstract: It is still an open argument that many AR applications in education which require some text on their interfaces impact learning positively. Even though the majority of AR educational tools in public domain contain English-based text, very few Arabic AR tools were adopted for use in teaching and learning, (rephrase the last part, it is not clear). It's not clear whether user's and end-user's adoption of Arabic AR tools for use in teaching and learning is influenced by the system or the environment. That is why this study developed an Arabic alphabet-based AR and examined the subjective involvement on its adoption based on the Technology Acceptance Model (TAM) approach. An interactive experimental evaluation was carried out with the developed app. A sample of 51 participants have participated in the experiment and responded to the structured questionnaire. The analysis of the gathered data indicates that the measures of acceptance and adoption of Arabic Alphabet lies within the Perceived Ease of Use (PEOU), Perceived Usefulness (PU), Attitude toward usage (AT) and Behavioral Intention (BI). These are indicators which were used in the Technology Acceptance Model (TAM). Hence the findings of this study indicate that PEOU had the strongest impact on PU and both of them influence AT which impact BI of using Arabic Alphabet AR app.

Keywords: Augmented Reality, Edutainment, User experience, Arabic Alphabet.

1. Introduction

Hedonic and Affective experience on the Augmented Reality application is expected to improve interactive experience of the real-world. With respect to the Arabic alphabet across multiple users, a combination of text-based and AR can improve and create an educational environment that is more attractive, interactive and efficient. This enhanced method can improve Arabic learning. People will be able to examine Arabic words and check its appearance in various forms.

Although virtual and augmented reality (VR and AR) technologies can help providing a three-dimensional experience that mimics physical world, the bulk of educational applications usually present two-dimensional media. The utility of AR in education can develop an improved educational environment that is more attractive, interactive, and efficient. It combines physical and virtual worlds in user – centric interactive scenarios. In such environments, virtual content is presented as an overlay on top of real-world feeds from a real-time camera. This combines education and entertainment to provide a new notion known as / referred to as "edutainment" (Colace et al., 2006).

Nowadays children are part of a digital era. They grew up in a technology – surrounded world, and they are using mobile phones, tablets, e-readers and computers on a daily basis. However, despite the disadvantages that burden parents, technology also has a bright side and can bring many benefits for children. That is why it is important to provide applications that help children to develop new skills while having fun. Mobile devices allow children to access a wide range of educational applications packaged in the attractive form of games that can improve their skills (Hsin-Kai et al., 2013; Sommerauer and Müller, 2014; Aksakal, 2015). AR technology can enrich children's experience as it utilizes mobile devices' built-in cameras, GPS sensors, and Internet access to embed real-world environments with dynamic, context-aware, and interactive digital content (Kesim and Ozarslan, 2012). These capabilities have created an interest in using AR applications for educational purposes in the field of mobile learning, and the new possibilities for

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teaching and learning have increasingly been recognized by educational researchers (Hsieh and Lee, 2008). According to (Hsieh and Lee, 2008; Chatzidimitris *e*t al., 2013; Hsin-Kai et al., 2013; Sommerauer and Müller, 2014; Aksakal, 2015), AR technologies and edutainment have achieved an increase in students' success levels, knowledge transfer, and skill acquisition.

Edutainment was applied first in1970s when the educational computer games were being produced based on learning theories (Mayer, 2009). One of the promising new technologies in this field is Augmented Reality (AR), that has been developed for use in a creative way to promote educational tools. In order to merge Arabic text with visual description, the AR technology joins the text content on top of the visual based description. The crucial function of the system depends on the user satisfaction towards its usage. This kind of application is more suitable for children.

This paper proposes an application based on augmented reality edutainment. The application is intended to teach Arabic language alphabets to children aged from 2 to 5 years. The educational content was designed based on educational theories such as Piaget's theory of cognitive development, multimedia learning theory and child language acquisition theory.

2. Background Review

This study uses TAM in order to investigate subjective involvement on Arabic alphabet AR. This is crucial to examining how users and end-users adopt Arabic AR tools for education purposes. The justification for choosing TAM lies with the ongoing technological advancement that led to various reforms in educational technology. The development of TAM comes from the general views of Information Systems (IS). Although there are there are many theories for the adoption of new technologies, TAM remains one the most influential information system theory adopted for widespread use. However, it also faces a lot of criticism, that's why other forms of TAM were established and many other IS emerge for specific use cases by virtue of their design choices from preceding social, psychological, and cognitive theories (Mayer, 2009). TAM is based on the Theory of Reasoned Action (TRA) and the Theory of Planned Behavior (TPB). The main views of TAM entail that the usage of technology is determined by four variables, namely: Perceived usefulness (PU), Perceived ease of use (PEOU), Attitude toward usage (AT) and Behavioral Intention (BI) respectively (Davis, 1989). The first three variables determine the user acceptance of technology/system in terms of behavioral change. This is in consistence with the previous acceptance models that also asserted that "the best predictor of a person's behavior is his intention to perform the behavior" (Straub, 2017). The new acceptance models that come after TAM: TAM2, TAM3 and Unified Theory of Acceptance and Use of Technology (UTAUT) also agree that "behavior is the best predictor of a person's intention". Therefore, both TAM and UTAUT emphasize the need to understand technology and Information Systems (IS) adoption (Davis, 1989).

In education, it is crucial for learners to use Arabic Alphabet Augmented Reality Application, especially to the non-Arabic natives, who are willing to learn Arabic language. AR technology can help a lot in teaching and learning for non-Arabic speakers as well as to encourage them to study Arabic language. Therefore, using the TAM model will enable this study to evaluate the acceptance of Arabic Alphabet Augmented Reality System.

A. Related Work

There are many related works on AR and its application, both practical and theoretical. Among the common AR apps found in public domain for use in Education there is the Augmented Reality English Learning System (ARELS). ARELS is a web-based AR edutainment application to help children to learn English by playing (Hsieh and Lee, 2008). ARELS basically targets preschool children in Hong Kong to learn English by giving the letter and a word of something that starts with the same letter. The research of using AR technologies to support edutainment applications has witnessed huge interest. Rohaya et. al. (Rohaya et al., 2012) developed an engaging method for learning via an interactive story book for preschool children. AR edutainment

systems were developed to be used as support for teaching different student levels and various contents (Lai and Wang, 2012) such as science (Beng Keat et al., 2018) and physics (Buchanan et al., 2008). The increasing interest in edutainment has led to the emergence of commercial mobile-based applications such as: AR Flashcards, a web-based application that is used to teach English language for preschool children up to 5 years. ABC TRANSPORT, which teaches children alphabetical letters using the names of different means of transportation, Chromville Science Application, a mobile-based application that uses AR for education. The latter can be used to create AR (augmented reality) classrooms that enliven science learning.

Research studies on AR and its uses in educations mainly highlight the effects and benefits of its uses for higher level students (Hashim et al., 2017; Garzón and Acevedo, 2019). The use of AR applications with the idea of making them an edutainment platform has been outlined in (Hashim et al., 2017). This is consistent with the perceived views for the future of AR, dominating human social activities (Chowdhury et al., 2013). There is a need to bring education and AR technology together, in order to enable students to gain the experience of combining learning with engagement (Lee and Lee, 2008). This is an attempt to bring learning into reality in order to maximize the effectiveness of education. Thus, various AR tools like Handheld English Language Learning Organization (Liu, Tan and Chu, 2007), Augmented Reality English Learning System (Hsieh and Lee, 2008) and Augmented Reality English Vocabulary Learning System (Hsieh and Lin, 2010) emerged. AR tries to make reality as it exists. It does that by either combining virtual and real-world elements or real-time interaction in a virtual world (Billinghurst, Clark and Lee, 2014). A study of AR involving primary and secondary school students has shown that it can improve learning experience (Billinghurst and Dünser, 2012). This shows that AR-based education allows students to better understand the material, similar to the findings of (Majid, Mohammed and Sulaiman, 2015). This allows researchers to develop more system, especially with the combination of different technologies (Solak and Cakır, 2015). Specifically, it has been found that there is high degree of motivation for students when using learning materials designed with AR (Santos *et al.*, 2016). Another study reveals that the use of AR in learning provides pleasure, motivation, and confidence (Sytw and Wang, 2016).

B. Proposed System Design

The proposed application aims to provide an AR-based edutainment environment for teaching Arabic alphabet to the preschool children. We can classify the main requirements of the application in functional and non-functional requirements.

a) The functional requirements include:

1- The child should be able to learn the Arabic alphabets.

2- The child should be able to see a visualized model of the flashcard he chooses.

3- The application should include Augmented Reality features for educational purposes

b) The non-functional requirements and constraints include:

1- user-friendly Interface

2- The application interface should be easy-to-use for a young audience

3- Application should be fast and accurate.

Those requirements were basically taken into consideration when designing the proposed system architecture. The application enables the child to position the mobile device's camera in front of the flash card, the camera module then being responsible for capturing the flash card image. The captured image is fed into the Vuforia engine, which identifies pre-configured targets (letters and objects). Each target has a unique ID that is used to query the database for the target-related 3D model, content and metadata (i.e. video to display and/or pronunciation sounds to play). The rendering module then generates the augmented scene using both the real time camera image

and the retrieved content. The augmented scene matches the concept derived from the multimedia learning theory which states that children's education must be built on using multimedia such as graphs, animation videos and 3D objects as shown in system architecture Figure 1. To illustrate this concept, a scenario is shown in Figure 1. A 3D object of a tree is displayed after detecting the card.

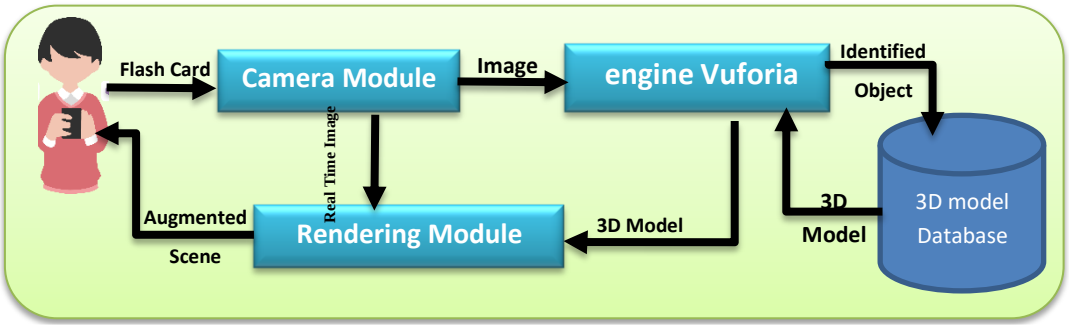

Figure 1. system architecture of Arabic Alphabet Augmented Reality Application

3. Methodology

This study relies on examining the user's involvement with Arabic alphabet AR application. An interactive experimental evaluation was carried out with an Arabic alphabet AR developed as part of this study. This methodology chosen for this study is purposely to come into consensus with what AR apps offer, what people perceives they do, and what Arabic alphabet-based AR actually do / are supposed to do. That is why observation/involvement, experiment and subjective evaluation are necessary. These will alleviate any discrepancies between what people do with what the AR app provided for the users. Therefore, two phases were involved in the study: the development of the App phase and the Subjective evaluation of the Arabic Alphabet Augmented Reality Application.

The subjective evaluation uses the developed Arabic alphabet-based AR to examine the user's involvement on its adoption based on the TAM approach. This approach is primarily concerned with the subjective assessment, and relies on the views of the participants that emerge from their interactive engagement with the application. This is aimed at reflecting the user behavior in terms of using the application by examining how their intention to use the Arabic alphabet AR application is influenced by their PU, PEOU, AT and BI. The interrelationship with PU, PEOU and AT on the first round of analysis together with interrelationship PU, PEOU, AT and BI are set to answer the question regarding to user's acceptance of Arabic alphabet-based AR. This can be practically achieved by observing the relevant details in an experimental setting. Despite the fact that observation may alter behavior during experiment, it will help in highlighting incidents of environmental engagement and disengagement while using Arabic alphabet-based AR.

The subjective experiment involves few tasks that beginning with the application to get started, performing the functional tasks involved in the application and closing the application at the end. The functional tasks start with the initial loading of the AR app, which enables the user to position mobile device's camera in front of the flash card. The real time animation videos render the content of the task. Thus, the interaction continues until the end of the task.

The target-population for this study consisted in children accompanied by their parents. A sample of 51 participants was involved in the study. The participants' age ranged from 3 to 5 years, accompanied by their parents. The first step in data collection is experiment followed by answering some structures questions. A survey was conducted using a set of questionnaire was developed with intention to elicit what the kids' feels about their engagement. They either completely disagrees from the left side range to completely agree on the right side in a Likert scale fashion.

4. Result and discussion

This section discusses the result of this study. The reliability analysis was conducted to check the internal items' validity and consistency that were used in each factor by using the SPSS analysis tool. The reliability analysis result is shown in Table 1.

Table 1. Validity test result

Factor	Items	Cronbach's alpha
PU	4	.792
PEOU	4	.785
AT	4	.635
BI	4	0.833

As presented in Table 2, inter-correlations among PEOU, PU, AT, and BI are as follow:

PEOU correlated positively with PU, AT, and BI

PU correlated positively with PEOU, AT, and BI

BI correlated positively with PEOU, AT, and PU

AT correlated positively with PEOU, PU, and BI

Table 2. Inter-correlations result

Correlations

		PEOU	PU	AT	BI
PEOU	Pearson Correlation	1	.617**	.442**	.375**
	Sig. (2-tailed)		.000	.001	.007
	N	51	51	51	51
PU	Pearson Correlation	.617**	1	.468**	.560**
	Sig. (2-tailed)	.000		.001	.000
	N	51	51	51	51
AT	Pearson Correlation	.442**	.468**	1	.566**
	Sig. (2-tailed)	.001	.001		.000
	N	51	51	51	51
BI	Pearson Correlation	.375**	.560**	.566**	1
	Sig. (2-tailed)	.007	.000	.000	
	N	51	51	51	51

**. Correlation is significant at the 0.01 level (2-tailed).

The preceding section explores the independent & dependent variables proposed hypothesis testing (see Table 3).

Table 3. Independent & dependent variables

Predictor (Independent Variables)	Dependent
H1: Perceived Ease of Use (PEOU)	Attitude(AT)
H2: Perceived Usefulness (PU)	Attitude(AT)
H3: Perceived Usefulness (PU)	Behavioral Intention (BI)
H4: Attitude (AT)	Behavioral Intention (BI)
H5: Perceived Ease of Use (PEOU)	Perceived Usefulness (PU)

As shown in Table 4, the value of R square indicates that the two predictors (PU, PEOU) explained 25.7% of the variation in AT. Therefore, this model is a rational model although it does not account for other unknown factors that may not impact the users' attitude towards using the application.

Table 4. The regression model summary analysis result

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.507[a]	.257	.226	.43884

a. Predictors: (Constant), PU, PEOU

The standardized coefficients (β) show that the Perceived Usefulness (β = .275) has a larger impact than the Perceived Ease of Use (β = .158). Also, the Sig indicates that both predictors did not have a significant and negative impact on the AT scores at the 0.001 level, as shown in Table 5.

Predictors: PU & PEOU —> Dependent Variable: AT

Table 5. The regression coefficients analysis result

		Unstandardized Coefficients		Standardized Coefficients		
Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	3.723	.706		5.272	.000
	PEOU	.158	.101	.247	1.564	.124
	PU	.275	.138	.315	1.994	.052

a. Dependent Variable: AT

Subsequently, a linear regression model was also used to test H3 and H4 which stand for/represent the impact of PU and AT on users' behavioral intention towards Augmented Reality Arabic Alphabet Application, as shown in Table 6.

Table 6. The Regression Model Summary Analysis Result

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.657[a]	.432	.408	.60534

a. Predictors: (Constant), AT, PU

The result from Table 7 has confirmed the H3 that PU has positive effect on BI, with β = - .520, Sig = .004, also AT had a positive influence on dependent variable BI, with β = .615, Sig =. 003. Predictors: PU & AT —> Dependent Variable: BI

Table 7. The regression coefficients analysis result

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	-.895	1.224		-.731	.468
	PU	.520	.169	.377	3.066	.004
	AT	.615	.194	.390	3.165	.003

a. Dependent Variable: BI

Table 8. The regression coefficients analysis result

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	3.538	.528		6.695	.000
	PEOU	.452	.082	.617	5.486	.000

a. Dependent Variable: PU

In summary, this paper brought into discussion the notion of edutainment that combines education and entertainment, and the modalities in which the use of technology in children's learning could improve the quality of the educational process. Furthermore, Augmented Reality applications have been analysed as well as the importance of using this technology in teaching Arabic Alphabet through a descriptive survey using as set of questionnaire among preschool children parents. Results have indicated the acceptance of this technology among participants and the ways in which it can enhance the learning process. As shown in Table 9, the results of linear regression analyses confirmed the five hypotheses. Perceived Ease of Use (PEOU) had the strongest impact on Perceived Usefulness (PU), followed by the influence of Attitude toward (AT) on Behavioral Intention (BI) using Augmented Reality Arabic Alphabet App. Perceived Usefulness (PU) also had a positive impact on Behavioral Intention (BI) Augmented Reality Arabic Alphabet app.

Table 9. Summary of hypothesis testing

Hypothesis	**Specification**	**Results**
H1	Perceived ease of use (PEOU) will negatively influence users' attitude towards Augmented Reality Arabic Alphabet app	Supported ((β = .158, p >0.001)
H2	Perceived Usefulness (PU) will negatively influence users' attitude towards Augmented Reality Arabic Alphabet app	Supported ((β = . .275, p >0.001)
H3	Perceived Usefulness (PU) will positively influence users' behavioral intention to use of Augmented Reality Arabic Alphabet app	Supported ((β = .520, p <0.001)

H4	Attitude towards (AT) will positively influence users' behavioral intention to use of Augmented Reality Arabic Alphabet app	Supported ((β = .615, p <0.001)
H5	Perceived Ease of Use (PEOU) will positively influence Perceived Usefulness (PU) of Augmented Reality Arabic Alphabet app	Supported ((β = .452, p <0.001)

Learning through the combination of visual and text display is one of the most important ways to access knowledge. A compressive book, which is commonly dominated by text, requires diagrams for better understanding. Learning performance on AR can be different from using a traditional desktop display, because reading performance usually depends on the device displaying text. Research has shown that 10% more time is required when AR applications containing text component is displayed compared to program on PC or book (Rau *et al.*, 2018). This is attributed to the fact that learners read slower on screen than in a book (Dillon, 1985). However, the AR has the potential to enhance learning because it involves overlaying virtual objects on the real environment, and is basically divided into wearable and non-wearable (Peddie, 2017). AR applications for education are well accepted, receiving a very positive feedback even from participants that had no previous experience with that technology. The current paper builds on the increasing number of research and studies on AR implementation in education and highlights certain user experience aspects as a crucial part of AR research. Thus, this research is a user-study to support the adoption of a prototype that had been developed for the public usage. The key unit of analysis is individual acceptance, which is determining user acceptance of the Arabic-based AR as a medium in their studies or learning. It is because learning experience can be improved with this technology, especially with the emergence of mobile computing devices.

This paper uses a quantitative experiment to investigate the impact of AR as an innovative learning medium based on the Arabic text. The findings of the research have indicated the Perceived Ease of Use of Arabic Alphabet AR Application by the users and also to the Perceived Usefulness of the App for learning. Other discussed issues were the influence of Attitude toward the usage of the App and the Behavioral Intention of using the App. Measurement reveals that these key issues under consideration have proved to be compatible for training with a special focus on practical learning scenarios. This is similar to a study performed in Garzón and Acevedo (Garzón and Acevedo, 2019), where the researcher shows the multiple benefits of the integration of AR in educational settings, but with a medium effect on the learning improvements experimented by students. Various research works (Nilsson and Johansson, 2007; Noh, Sunar and Pan, 2009; Rambli and Awang, 2010; Talebian, Mohammadi and Rezvanfar, 2014; Kolivand, Hasan Zakaria and Sunar, 2015; Sorko and Brunnhofer, 2019) also support the claims that the AR has many benefits and is very important for education because the advantages and beneficial uses of AR features are able to engage students in learning processes and help improve their visualization skills. This paper highlights the relevance of the AR as well as user acceptance towards Behavioral Intention of using AR in education.

5. Conclusion

The main objective of this study focuses on the use of AR technology in education to provide a better way of learning and gaining knowledge. This is crucial because using AR technologies can support an engagement in learning via interactive activity-based learning. The majority of the AR-based education systems were developed as a supportive/enhancing system for teaching and learning. In addition, a great part of the recent AR-related studies were based on education. Thus, the study has developed an Arabic alphabet-based AR tool for use in education. The study was conducted by using both experimental approach and subjective evaluation. During the development, the functional part of the application consists in replacing conventional learning environments with more engaging environment.

The study shows that children can improve their learning experience with the use of AR. The study has also concluded that AR-based education application is an additional means of enhancing the absorption rate as compared to the conventional materials that were used in the traditional learning method. Similarly, the AR can diversify the learning system, especially in terms of miniature games as well as autonomous and engaging learning. It can be concluded that education and AR technology can be brought together in order to gain new experience and allow students to learn better. That is why it can be viewed as a tool that will maximize the effectiveness of learning. The relationship among the proposed variables used in the study has indicated that the AR applications multimodal presentation can convey better learning experience. This shows how effective the AR multimodal input applications are in assisting vocabulary learning or pronunciation/spelling problems. As a conclusion, this study has identified that AR based on Arabic alphabet influences the teaching and learning process.

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