

# Designing a Mobile Game Based on Augmented Reality Application for Learning Media

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## ABSTRACT

Designing games for educational purposes needs to consider various aspects that help lead to the making of a good game. This study aims to describe users' responses towards the potential of the game for blended learning, the design stages and the trial which encompass pre-design input taking, design stages, trial, and evaluation. The inputs from the pre-design stage have been the basis for the media design; the trial stage inputs from the prospective users and two experts provide feedback for the validity of media both in content and construct aspects. The research subjects involved 100 Junior high school students, 5 English language teachers, and 1 game design expert. The tools of data collection are questionnaire and semi-structured interview which were developed by the researchers. The intended subject for which this game is designed is reading comprehension and the study is planned to be conducted in approximately eight months. Both types of feedback were used to evaluate the readiness of the media for the real use for blended learning model. The results showed that the validity in content and construct aspects were both very good. The trial result also suggests that the game is considered a decent product, attractive and easy to use for independent learning. Thus, the final evaluation suggests that the media is readily usable for the real context of blended learning.

**Keywords:** Augmented Reality, game design, design stages, independent learning.

## INTRODUCTION

Games as one of the language learning aids have been designed and developed specifically to enable language learners to use language in order for them to be able to interact one another and to express their ideas in the real life of social context, while also assisting ESL teachers to partially assess students' abilities to master the language. In addition to the types and the purposes of games, game activities designed for language learning may vary in the focus depending on the highlight of the language skill such as vocabulary, grammar, writing, reading, listening and speaking.

Games designed for language learning purposes may be of an integral subset of language development apparatus. They provide a means by which learning can take place which encompasses the use of language, its link to meaningful contexts, opportunities for real, spontaneous communication as well as the elements of enjoyment that cater for learners' diversity; students with different learning styles, motivation, aptitude, and interests. They altogether serve as a pivotal medium that links between language practice and the context in which the language is used, besides being usable for a tool that measures how effective learning outcomes can be achieved.

Despite being relatively new, sooner or later Augmented Reality (AR) it will revolutionize the way language learners engage in learning as it is able to facilitate learning while experiencing vivid and close to real life experience. This technology is so capable of layering virtual information to the real environment that enhances reality to a context-sensitive world. In effect, this offers language educators and trainers numerous possibilities to create better learning experience.

Previous studies have confirmed that AR is capable of provoking a lively immersive environment for learning (Lindgren, et al., 2016) and it also helps engage learners in the learning activities (Oblinger, 2004), besides also satisfies three key elements targeted by educational activities, in a way that it can increase the level of participation, understanding and learning (Nincarean, Alia, Halim, & Rahman, 2013) which will potentially serve learners regardless of the age and social class. Other research has also reported the potentials and contributions that this technology can bring to the world of education.

In the last six or so years, the number of research publications on AR in education has undergone a dramatic increase. A research review by Bacca et al. (2014) summarizes that Science and Humanities and Art are among the fields that take the most of AR.

While education alongside with health, welfare, and agriculture are among the fields least frequently explore and capitalize it, and it is only higher education institutions and certain levels of education which have been much integrating the technology into teaching, while it has not been the case with the early stage of education, such as in elementary and high school levels. This is why any attempt to develop games based on AR application is a breakthrough in facilitating language learners especially those in the early age.

## REVIEW OF THE LITERATURE

### Digital Media

Digital mediation is all about a means by which information is delivered through various digital devices traditionally capable of presenting animation, sounds, music, gesture, and speech, etc. to humans' senses. Among the most recent digital media include the Internet, mobile phones, computer games, and interactive television (Buckingham, 2007). Even further, Balkun (2011) described digital media as an instructional toolbox that includes the Internet, e-book, video games, wikis, blogs, mobile devices, augmented reality, and virtual reality. Digital media are defined as follows:

The full range of cognitive, emotional, and social competencies that includes the use of texts, tools and technologies; the skills of critical thinking and analysis; the practice of message composition and creativity; the ability to engage in reflection and ethical thinking; as well as active participation through teamwork and collaboration (Hobbs, 2011, p. 17).

With that said, Hobbs (2011) does not only want to refer to them as electronic devices, but also include complete subsets of humans' activities in response to the availability of the technological devices.

### Augmented Reality

Carmigniani et al. (2011, p. 342) define Augmented Reality as "a real-time direct or indirect view of a physical real-world environment that has been enhanced/augmented by adding virtual computer-generated information to it". Unlike Virtual Reality which involves mostly or totally virtual environment. Like Carmigniani et al. (2011), Augmented Reality "...refers to technologies that project digital materials onto real world objects. This definition suits a large spectrum of technologies that range from a pure virtual environment to the real environment" (Cuendet, Bonnard, Do-Lenh, & Dillenbourg, 2013). Both definitions emphasize the exploitation of virtual objects which are added to the real environment.

It is also defined as a technology that allows the mixing of virtual content into a real-physical world, permitting students to see virtual content that appears in the real world (Radu, Zheng, Golubski, & Guzdial, 2010). Based on the above understanding and definitions, it can be said that AR is a system that combines virtual and real environmental content which can be equipped with additional information and data, so that both content and information as if appear to be in the same environment.

AR "consists of merging live images with virtual layers of information" (Vogt & Shingles, 2013, p. 47) whose layers include three-dimensional (3-D) models of content, images, sounds, and videos. AR technology is now embedded into the Internet browsers and known to have two different types which are differing in the way the virtual layer is associated with a given environment. They are known as location-based AR and image-based AR. Such a difference is clearly described by Vogt and Shingles (2013) as follows:

Location-based AR applications rely on the spatial position and orientation of the device to select and display location-relevant information. For image-based AR, applications use image recognition algorithms to trigger the display of relevant content over a recognized physical pattern (p. 47).

There are 3 ways of using AR, i.e. marker-based tracking, markerless based tracking and GPS based tracking. Markers, also known as barcodes, are usually black and white square illustrations with thick black borders and white backgrounds (Siltanen, 2012). Unlike marker-based tracking, markerless-based tracking does not require users to use a marker to display digital elements (Comport, et al., 2006). Currently it is developed using Face Tracking, 3D Object Tracking, or Motion Tracking. Different from the two, GPS Based Tracking method is widely developed and used in smartphone applications based on IOS and Android. In this method GPS data are retrieved from GPS and compass prior to displaying them in accordance with the direction that we want in real-time.

AR technology is born in a so disruptive and revolutionary fashion that it can change radically the way the world is viewed and understood. Johnson, Levine, Smith, and Stone (2010) stated, "AR has strong potential to provide both powerful contextual, on-site learning experiences and serendipitous exploration and discovery of the connected nature of information in the real world" (p. 21). The hybridity nature that mixes virtual objects onto the real live world environment can dramatically revolutionize the way

learners interact with the surrounding world. Despite being manipulative in some sort, it opens spaces for learners to interact with the material world and the objects in the physical world in a new way like never before. Akçayir and Akçayir (2017) believe that its being innovative carries with it attraction and inspiration to learners that stimulate creativity and curiosity of learning and provide the opportunity for interaction with abstract theories and concepts, experiments which in turns arouse deeper exploration of the objects, phenomena and knowledge being learnt that is not always possible or easy to do without it.

With all the above-described potentials and capabilities, AR technological applications should generally be capable of satisfying most or all of the following mentioned learning attributes, i.e.:

- Sense properties about the real world.
- Process in real time.
- Output information to the user, including via visual, audio, and haptic means, often overlaid on the user's perception of the real world.
- Provide contextual information.
- Recognize and track real-world objects.
- Be mobile or wearable.

(Roesner, Denning, Newell, Kohno, & Calo, 2014)

In addition, the key advantages of AR over other technologies have been summarized by Kiryakova, Angelova, and Yordanova (2018) as shown on the table 1.

**Table 1.** The advantages of Augmented Reality.

<i>Learners</i>	<i>Learning Environment</i>	<i>Learning process</i>	<i>Learning content</i>
Engagement to the learning process and responsibility for own learning.	Hybrid environment that combines the virtual and real world.	Learning by games, by doing, gamification, discovery-based learning.	Integrated multimedia Elements.
Increased motivation and satisfaction from achievements	Stimulates creativity and curiosity.	Engaging, connected to the real world.	Interactive.
Positive attitude towards the learning process	Contextual awareness	Interactive learning approaches	Included activities and tasks for learners.
Easier perception of complex and abstract concepts	Collaboration between participants in the learning process.	Active two-way transfer of knowledge	Dynamic
Development of practical skills	Facilitated communication.	Two-way interaction	Contextually dependent
Usage of all senses in perception and understanding of information	Adapted to individual capabilities and needs. Multisensory.		Adapted to learners' interests.

## Previous Studies on the Use of AR

Although Sutherland already developed the first AR interface prototype in the 1960's (or to be exact in 1965), it has only been relatively recent that researchers have begun to explore its real potentials for educational purposes (Zhou, Duh, & Billinghamurst, 2008). Jadeja, Mehta, and Sharma (2016) conducted a study of the use of AR in education setting. Using a survey method of data collection, their study showed that the use of AR produces a lot of positive results as compared to the traditional educational class. With this result, in the future AR will sooner or later replace the traditional learning mode, or at the very least will be a compatible support for traditional classroom.

One of the previous studies on VR in education setting investigated the role of VR and 3D computer modeling on learning and teaching. In the study involving academic staffs, Wu, Lee, Chang, and Liang (2013) conducted a combined study of augmented reality, mixed reality, and education and the result of which suggests that AR enables learners to get involved in an authentic exploration of real world and to experience the scientific phenomenon.

## Augmented Reality in Educational Settings

Mobile AR applications are naturally interactive and fascinating tools for learning that motivate learners to learn. Lee (2012) claims that this technology is capable

of both invigorating students' motivation and enhancing their educational practices due to its ability to bring realistic learning environment. The use of AR applications into the educational settings can be fascinating and rewarding for both teacher and students (Journet, 2007). AR applications is also able to simplify and transform complex concepts or ideas into more simple and understandable ones. Anything that cannot be viewed in real life of human because of geographical or cultural barriers can be brought to life. Both virtual objects and real-life environments, combined together, facilitate learners to visualize complex spatial relationships and abstract concepts (Wu et al., 2013).

Augmented reality is an advanced instructional tool to be used in the classroom. The effectiveness of AR can be improved when it is combined with other technologies such as mobile devices. A study found that the AR use in education has a positive impact, because of its multi-modal capacity which is attractive and interactive in increasing accessibility of educational content, increasing student control of educational content, opening opportunities for collaborative learning, motivating students to be actively involved, and changing an abstract to be concrete (Radu, et al., 2010).

### Potential advantages

1. Adventurous activities for the classroom  
Adventurous learning is explorative in nature. Through its learners can explore history, science, the arts, and the natural world. Whether you are roaming with dinosaurs or looking at Renaissance sculptures, there is something amazing to explore for every subject. This way learners may be able to have optimal memory of what has been learnt because of experiencing the event as if they experience it firsthand (Dale, 1969, p. 108).
2. Rich unique experiences  
By helping students to visualize information in a new way, learning activities can positively impact their ability to retain information. Among the learning principles of constructivism is fun (Koster, 2004). The word fun means "the feedback the brain gives us when we are absorbing patterns for learning purposes" (ibid). As such, playing game is essentially undergoing a learning activity because those involved in will likely to persistently attempt to complete the whole course or scenario of the game. A good game generally involves a mystery or sometimes puzzles that demand solution. As warned by Koster (2004) in designing game, there is a tension between the aspect of fun and learning which must be dealt with. Unless otherwise the issue is properly tackled, a game design may lose a balance. Too many elements of learning may cause

boredom, fatigue, and information overload, while too much fun may well be a waste of time.

3. Nurturing creativity and imagination  
Recent technologies are compatible for the creation of fun and interesting pedagogical activities especially when mediated by augmented reality application. The mixing of virtuality and reality provides learners with a blend of an imaginative virtual objects and the real-world live experiences that may capitalize human's senses such as auditory, visual, tactual, smell, and taste.
4. Developing socio-culturalism in the classroom  
AR games may provide them with spaces for working collaboratively to achieve the common goals. A well-designed game may facilitate learners to negotiate and get involved in partnership which typifies sociocultural process of meaning making or goal setting.

### METHOD

Conceptually, this study has taken the inspiration from the constructivist paradigm from which people actively construct or create their own subjective representations of objective reality, while the research activities are conducted based on Research & Development approach also known as design-based research (see Van Den Akker, 1999). It is the purpose and the function of the research that guide the researchers to the choice of research method (Plomp, 2007). The purpose is to trace the relationship between theory, design, and implementation that embody the principles of learning media design (Barab & Squire, 2004; Cengizhan, 2007) or in "supporting design and development of prototypical products to solve complex authentic context specific problem" (Lai, Calandra, & Ma, 2009, p. 120).

Design-based research is commissioned to generate a specific set of theoretical constructs that guide, evaluate, and refine the environmental contexts of media design. Hoadley (2004), contends that design-based research has been separated from experimental research. This is in accordance with McKenney (2001) who suggested three phases for conducting design-based research which involve (1) needs and context analysis, (2) design, development, and formative evaluation, and (3) semi-summative evaluation. The results of research and data collection are used to provide inputs for product prototypes of the learning media design. The output of this second stage is the design that will be used in the next stage, namely the initial product development. The initial product will then go through testing and evaluation of stability, consistency, as well as its useability.

**Research subjects and instruments**

The research subjects involved 100 Junior high school students, 5 English language teachers, and 1 game design expert in Semarang, Central Java. The tools of data collection are questionnaire and semi-structured interview which were developed by the researchers.

**Data analysis**

The data gathered were on: (1) the expectation of the good features of game that include design aspect, content of game, functionality, and user-friendliness, as well as (2) the guiding principles in designing a good game.

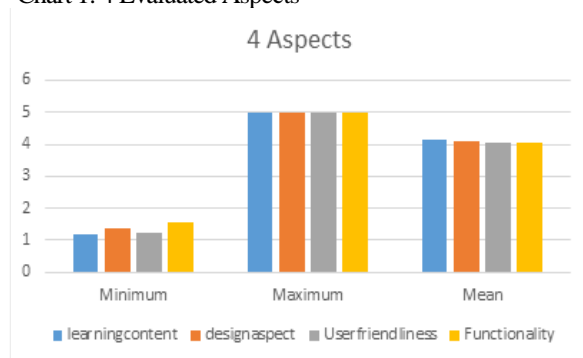
**RESULTS AND DISCUSSION**

This section presents the results of the study which included quantitative data analysis and transcript analysis of the results of structured interviews.

**1. Quantitative Analysis**

To answer the first research question, they were asked to fill in the questionnaire consisting of statements pertaining to 4 aspects of game design, i.e., design aspect, learning content, user-friendliness, and functionality. The statements were designed based on a Likert scale (1 = strongly disagree; 2 = disagree), representing the negative perception of the respondent; 3 = agree; 4 = strongly agree), representing the positive perception of the respondent. Based on their answers, it was discovered that the results of the questionnaire showed a high perception seen from the Mean (average) value as illustrated by Valid Percent and Cumulative Percent in the following table:

Chart 1: 4 Evaluated Aspects



The data gathered from the questionnaire are primarily intended to obtain relevant feedback about what they think about a good game and what need to be considered as the game designer make a game. From the four aspects evaluated, i.e. learning content, design aspects, user-friendliness, and functionality, the respondents consider that all four have an equal importance. All four aspects are valued equally high with overall mean average of above four (4) suggesting that in designing a game, game designers need to

consider each detailed aspect under each of the four categories.

Below is a table of complete figures from the SPSS statistical descriptive analysis output elaborating the overall mean value of the four aspects:

Descriptive Statistics					
	N	Mini- mum	Maxi- mum	Mean	Std. Deviation
Learning content	100	1,20	5,00	4,1460	,71059
Design aspect	100	1,38	5,00	4,0738	,67516
User-friendliness	100	1,25	5,00	4,0700	,72132
Functionality	100	1,56	5,00	4,0422	,68871
Valid N (listwise)	100				

The following are the details of elements as detailed and illustrated per item in the table below:

**1. Design aspect**

Descriptive Statistics					
	N	Mini- mum	Maxi- mum	Mean	Std. Deviation
A good game is well animated	100	1,00	5,00	4,5400	,77094
A good game is a speedy access	100	2,00	5,00	4,3300	,85345
A good game has quality pictures	100	1,00	5,00	4,3100	,80019
A good game has quality video	100	1,00	5,00	4,2300	,95193
A good game has quality sound	100	1,00	5,00	4,1800	,96797
A good game is easy to play	100	1,00	5,00	3,7000	1,08711
A good game has no access issues	100	1,00	5,00	3,6500	1,23399
A good game has no inconsistency	100	1,00	5,00	3,6500	1,35121
Valid N (listwise)	100				

The table shows that for a game to be called good or to meet good game design criteria, such aspects as image quality, sound, graphic and video animations, ease of play and access and ensuring consistency of the game are important to consider. Even though the last three relatively get lower valuation compared to the first three, the assessment and respondent's expectation of design aspects asked are high. The overall score of the responses is above here (3) which means that they are all important to consider.

**2. Learning Content**

Descriptive Statistics					
	N	Mini- mum	Maxi- mum	Mean	Std. Deviation
Game must have clear achievable goals	100	1,00	5,00	4,2800	,88854
Game must be fun and challenging to learn	100	1,00	5,00	4,2300	1,02351
Game elements should facilitate learning	100	1,00	5,00	4,2100	,95658
Game should help memorize things	100	1,00	5,00	4,0700	,97706
Game should be beneficial for learning	100	1,00	5,00	3,9400	1,04272
Valid N (listwise)	100				

The table above shows that a game must have goals to be achieved, must challenge, and facilitate gamers to learn. In addition, a game can be said to be good if the game helps gamers to remember important things from the contents of the game, and no less important is that a game must provide benefits for its users to learn, meaning that this aspect must be an important consideration in designing a game.

### 3. User-friendliness

	Descriptive Statistics				
	N	Mini- mum	Maxi- mum	Mean	Std. Deviation
It is important that a game is easy to play and present good content	100	2,00	5,00	4,4100	,73985
AR is great in that it combines virtual objects onto real objects that helps clarify concepts	100	1,00	5,00	4,2500	,91425
I find it important for a game to be playable on mobile gadgets	100	1,00	5,00	3,8900	1,08148
I find it important for a game to be played anywhere and at any time	100	1,00	5,00	3,7300	1,23791
Valid N (listwise)	100				

The table above contains matters relating to the ease of a game to be played so that every game designed will not be a waste due to its complicatedness and its being difficult to play. The overall response of the respondent reinforces the importance of not only the ease of a game to be played, but also the practicality. A game is said to be friendly to users if it can be played anywhere and at any time so that place and time are not supposed to be a barrier.

### 4. Functionality

	Descriptive Statistics				
	N	Mini- mum	Maxi- mum	Mean	Std. Deviation
A game requires strategies to play	100	1,00	5,00	4,4200	,78083
A game demands thought	100	1,00	5,00	4,3900	,76403
A game functions as trigger for problem solving	100	1,00	5,00	4,2900	,97747
A game demands memory	100	1,00	5,00	4,2300	,86287
A game provides tokens or rewards	100	1,00	5,00	4,1700	,99549
A game functions well and easy to play	100	1,00	5,00	3,8100	1,30031
A game contains luck elements	100	1,00	5,00	3,7700	1,22972
A game does not have to need much time to play	100	1,00	5,00	3,5300	1,34431
Valid N (listwise)	100				

A game must have elements such as luck to be able to entertain through the element of surprise that arises from playing it. Losing or winning is normal in playing but players will feel comforted and encouraged to continue playing because they get a prize if they win or succeed in overcoming a barrier or an obstacle. With a right strategy a game should encourage players to think and overcome problems to win the game. Functionality is also related to the ease of players playing the game.

## 2. Qualitative Analysis

Interview results show that although the world of education is currently trying to keep up with technological advances, most schools currently still lack of technological-based learning media besides the limited access to good learning media. AR-based games have the potential for students to learn a variety of language skills, although they can obviously be used for other language skills such as listening and writing or grammar. Cellular gadgets are unfortunately prohibited in almost all schools in times when lessons take place but for the purpose of learning and activities that support teaching and learning activities, then there are opportunities to be used in schools. Learning material that is packaged in a game will be very suitable and that the game has to have clear goals, be easy to play, and be challenging.

## CONCLUSION

Feedback from the research subjects and input from the game expert helps provide input at the stage of prototype game design which encompasses design aspect, content of game, functionality, and user-friendliness. To the four important aspects of designing a good game above, the respondents expressed almost equally high expectation. This suggests that the game designers must consider all the aspects in all stages of the game design. This AR game model is considered a prospective media for learning because of placing virtual objects into actual learning objects. Although currently access to mobile gadgets is generally constrained by institutional rules and regulations, AR mobile games can remain be integrated through blended learning by integrating the game as the home supporting learning media. Good AR game design must consider relevant instructional objectives and quality aspects such as sound, graphics, and animation, etc.

To ultimately produce a viable learning media, the four aspects of game design studied must be considered in the stage of game development.

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