GRAPHICAL INSTRUCTION FOR COLORING MOBILE-BASED AUGMENTED REALITY APPLICATIONS

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ABSTRACT
This paper describes an empirical study of effectiveness and satisfaction utility in augmented reality coloring application. Five children aged 6, 7 and 8 from several Primary School participated in usability test. This study involved applications that were used to study and observe the children interaction with augmented reality coloring application. These pre-tests were to measure the effectiveness and satisfaction on wizard Oz by conducting usability test, observation survey methods in order to assess children experience with augmented reality application. By following children computer interaction methodology the usability test appears to be helpful by providing input to design user interface and improve user experience. The result offers graphical instruction on interaction design framework for children augmented reality application. This research employed a qualitative experimental research with purpose to investigate the effects of user interface and user experience. This study had resulted animated graphical instruction in the production of coloring augmented reality application. It is a critical and comprehensive review of a range of recently published literature sources addressing various issues related to children computer interaction.

Key Words
Interaction Design; Human Computer Interaction; Children Computer Interaction, Cognitive Development and Technology, Augmented Reality, Graphical Instruction

INTRODUCTION

Over the past decade new generation of children is more experienced in the use of smartphones; the number of children time spent on smartphones has tripled. Unfortunately, most interactions are adult based consequently it is not suitable and ease to use for children. (Janet Read, 2015), (Alborzi, 2000). Thus, it needs more improvement not only in terms of interaction but also in the case of basic elements such as navigation and productivity. In this study, an attempt to design interaction design that feels friendly and in accordance with the Child Computer Interaction (CCI) for education based mobile augmented reality (AR) applications. Child Computer Interaction is part of the Human-Computer Interaction, which the user is a child. It is characterized as a control with respect to the evaluation and implementation framework that is intuitive registration for the use of children and to the investigation covers their real phenomenon. Application should be child friendly and age-appropriate by connecting signs to be effective (Ronald Azuma, 1997). Through observing children interact with the system, explore their diligent attitude will make them do things that might not be estimated. User interface designers often make assumptions that will occur their knowledge and experience. This assumption requires a mature understanding of the context of the user, usability,

and usage. Most children involve in the process of designing interactions shows honesty facial expressions and gestures affect motivation, performance, or fun. (Janet Read, 2015) There are many CCI study involving children directly in the process of testing the usability and user experience. However, the involvement of children in usability studies and research assessment is not without some difficulty. In practice many gulideline should admit to ensure that children able to contribute in a meaningful way, and there are ethical concerns around understanding the participation of children. (Juan Markopoulos, 2015) The innovation behind AR increase the actuality by bringing real-world perspective, children that use this technology have concentrated on the task and appeared more attentive to the lesson. As interactivity is a strong influence in learning, they are able to witness realistic representation of the object moving in real life. For example children are able to see what a water molecule looks like in 3D and gather knowledge about how H2O is formed. (Mark Billinghurst, 2005) Furthermore sights and sounds add new experience for children by watching animals sound like in real-life, enhance the background ambiance while reading, and more. A book about spaceship could make the reader participate and feel how it feels like to at the outer space. AR brings new meaning to textbook by showing examples of the content to the reader for greater clarity. AR technology has proven endless possibilities, as students are capable to touch a seemingly real-world change through the use of computer-generated imagery. (Mark Billinghurst, 2005), (Ronald Azuma, 1997). This research examines children use of AR application focus on user interface, by observing, understanding and gain new experience by enhancing graphical instruction in order to facilitate the ease of use and improve the user experience in order for them to explore their creativity and probelm shoving skill.

PROBLEM STATEMENTS

Interaction for education based augmented reality applications require natural and intuitive features, easy to learn and user-friendly that reflects on children. AR gestures interaction should serve the purpose of the application, multi-touch technology-based interaction, multi-touch technology declared the coming of a new era of more natural, more direct human-machine interaction. Multi-touch technology presents us a brand new multi-user interaction experience with its direct touching and flexible gestures (Marco de Sá, 2008). Most interaction are adult based and not age-appropriate thus not suitable for children, nor it is not easy for children. Since the user (children) are not familiar with the interface. This showed that the children could not identify the gestural input affordances when they had to focus on maintaining the marker-based AR-view with the same hand and modality as with they were expected to create gestural input, natural and easy-to-learn paradigms for any human (Xiaohua Yu, 2010). Due to lack of design guidelines for AR application the user interface designs based on assumption, an adult trying to put in children shoe and come up with a design that what they would want if they were children. Designing interfaces for children's application require a thorough understanding of the subject and follows appropriate design guidelines. Studies have shown that most of the application developed for a child has been adopting a general design guideline that is based on adult's preferences. This has led to many situations such as confusion and lack of interaction. This is mainly because the design guidelines for adult-based application design strives for simplicity while children need more assistance that can guide them to use the interface. This situation calls for a less complicated and self-explained interfaces. (Janet Read, 2015), (Chiasson, S , 2005),(Hanna, L, 1999).

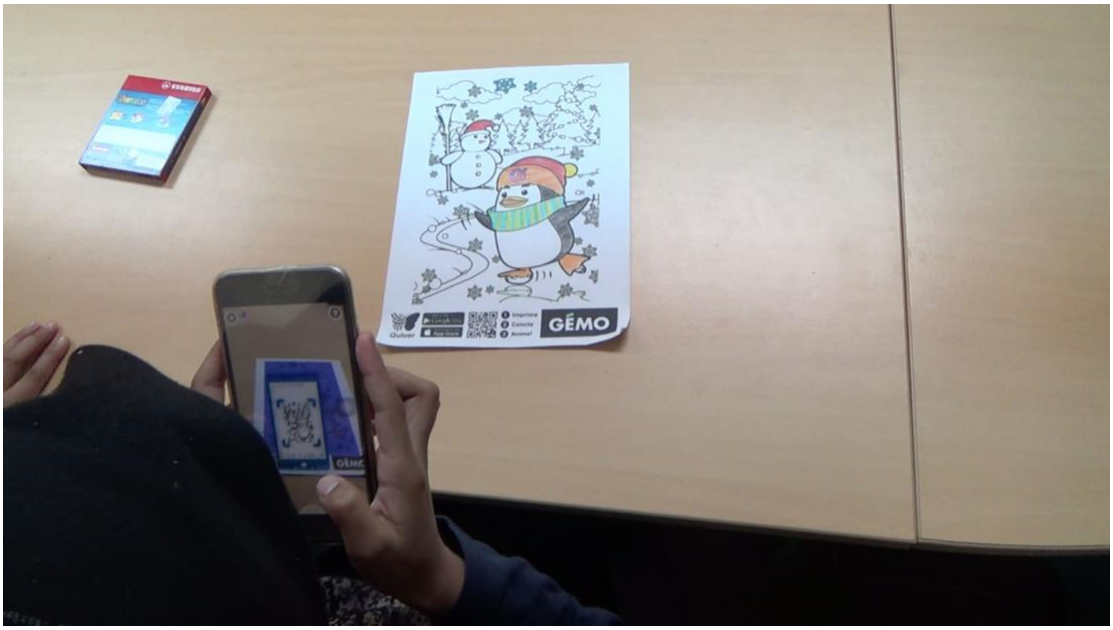

Figure 1, Children using wizard oz graphical instruction to scan the marker.

Children computer interaction is a branch in human-computer interfaces, which focuses on designing interfaces for children's application development. The concern of this field is to get closer to the factors, which enable a great engagement between children and the application to be developed. Our study aims at gathering as much information as possible on the children's need in terms of user interface design. To understand the need for the subject (children), observation is a good approach to see how children's respond to certain user interfaces. From the observation, a clear guideline should be obtained to guide designers in developing a more comprehensive and effective applications for children. (Janet Read, 2015), (Chiasson, S, 2005),(Hanna, L, 1999).

METHODOLOGY

Usability tests are conducted to ensure the user interface design is suitable for children and able to complete tasks with clearly, transparent, agile and useful. This study employs wizard oz, namely the provision of low-fidelity ai prototype pasted on the screen smartphones with running quiver coloring application. In order to make sure assess usability in terms of interface design is age-appriorate. The main objective of this assessment is to prove that the initial hypothesis of the user interface design is too focused on adult and inappropriate to the child. (Janet Read, 2015), (Chiasson, S , 2005),(Hanna, L, 1999).

Wizard OZ

David Gouldin first used this method back in the 1983, although it was only named Wizard of Oz when Johanna Höysniemi described it. There are instances where Wizard of Oz studies have been effectively carried out with children; study has proven children played a game which was driven by a wizard sitting in the room where they could see him, in this instance, the game was sufficiently engaging that the children were unaware that the wizard was controlling the interface. (Janet Read, 2015) These low-fidelity prototypes are typically used with the Wizard of Oz technique [58]. As sketches gain form and UIs are drawn on paper cards, these are used, following specific sequences and navigation arrangements in order to simulate the actual application, as it should function. This simulation is usually achieved through techniques such as the Wizard of Oz technique where a designer acts as the computer, changing sketches and screens according to the user's actions, whereas, if possible, another designer annotates and analyzes the user's behavior and errors that

might be detected [58]. Virzi et al. conducted a thorough study focusing specifically on the efficiency with which low-fidelity prototypes can be used during evaluation stages and how they allow designers to detect design errors, in several stages of the design process. Two types of data are classified as 1) Input on user interface and 2) experience and behavior of the children featured in the study, during the study session audio and video recordings as evidence conducted and also the exposure to reference shall consist datang. Input on user interface are rated by few task such as;selecting the main icon, understand the main menu, able to scan marker, looking for instruction, interact with 3D. In order to assure the user interface is age appropriate two interface are tested, the first one is quiver graphical instruction and second is the wizard oz version of graphical instruction with a interface orinted on a transparent paper and place it on top on the mobile screen. Children response are observe throught their response and time rate of scaaning the marker. Next quiver did not have any interface for inteacting with the 3D model as the wizard oz version implement an arrow pointing at a button, again children response are observe throught identify the interface and interact with the 3D model. A total of 6 children randomly selected from various schools of the city to participate in the trial. Children aged 7-9 years consists of male and female students. The students come from a family background of parents exposed to and familiar with the use of digital technology and smartphones in their daily activities. At the beginning of the study, children were given a form to fill out their name, age and school name to see their ability to read and write. Then children were asked several questions about Peguin, in case children seen Peguin in real life or in video. Children were asked Peguin true colors and a coloring sheets of peguin were given for them to color. Children do not know that the paper is a marker that will be scanned later. Once the coloring are completed the quiver application are shown to them for the first time, and their reaction of excited and happy, trigger them to try it themself. First its with quiver graphical instruction,during this time the rate of time scanning the marker and error rate are recorded. Second a piece of transparent paper that content graphical instruction (see figure 2) affixed on to the top surface of the smartphones screen, again the rate of time scanning the marker and error rate are recorded. Next the children are test if they are able to interact with the 3D Peguin with quiver interface.The second transparent paper pasted with the arrow pointing at button to press to see children reaction in case they are able to inteact with the 3D Peguin. Children are ask regardless the texture on top of the Peguin is the color that they colored. For the data on user experience children are given a smileyometer ranked 1 to 5; 1 (Awful), 2 (Not very good), 3 (Good), 4 (Really good), 5 (Brilliant). The scale like and was it easy to play. Few questionnaires will be asked as the children pointing at the smileyometer. In order to evaluate how children interact or prefer to interact with the application, naturally as new applications for them. It is based on the hypothesis that the interaction with augmented reality applications based education requires the characteristics of natural and intuitive.

RESULT

Measuring Usability Testing

This research main objective is to study and measure the rate of effectiveness and satisfaction of an AR coloring application. ISO 9241-11 (ISO 9241, 1998) defined usability as “The level to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use”.

The two important factors definition are:
1) Effectiveness: The accuracy and totality with which user complete specified goals.
2) Satisfaction: Subjection from distress and positive outlooks toward the use of the system.

Usability emphases on the effectiveness factors and objective characteristic, while satisfaction focus on subjective characteristic measured.

Hence the effectiveness metrics measured by using a usability measurement, which introduced by Nielsen (Jacob Nielsen, 2001) by evaluating user's success rate, the simplest usability metric. Nielsen (Jacob Nielsen, 2001) described success rate as the section of tasks, which users complete accurately. This uneven metric will not be able to suggest the reason behind the users failure or how well user able to complete the tasks. Thus, success rates measure the users failure due to user unable to accomplish the task. This research emphasis on user success rate from the observation, which may be utilized toward the analyst time performing that usability test from post questionnaire with the children.

Effectiveness

Effectiveness measures the ability of the user to complete a task with the graphical instruction (Jacob Nielsen, 2003). For this study, effectiveness is measured from the beginning until the end of the application. The task lists are shows in Table I. Effectively completed task will be count as 'Yes'. A success sign is given the full credit of 100%. For tasks, which are not completed effectively, will be given a 'No' sign with zero (0%) credit. The table shows the list of tasks that were evaluated for its effectiveness. The data are later brief for easy analysis and were analyzed for its effectiveness using success rate evaluation:

TABLE I. LIST OF TASKS FOR EFFECTIVENESS EVALUATION

Task	Child 1	Child 2	Child 3	Child 4	Child 5	Child 6
Manage to press the apps Icon	Yes	Yes	Yes	Yes	Yes	No
Main menu graphic appealing to children	No	No	No	No	No	No
Searching for UI guidelines	Yes	Yes	Yes	Yes	Yes	Yes
Interacting with 3D object	Yes	Yes	Yes	Yes	Yes	Yes
Showed positive response	Yes	Yes	Yes	Yes	Yes	Yes
Focus on the game	Yes	Yes	Yes	Yes	Yes	Yes
Past experience with AR related games	Yes	No	No	No	No	Yes
Tendency to text instruction preference	No	No	No	No	No	No
Tendency to graphical instruction preference	Yes	Yes	Yes	Yes	Yes	Yes
Requires music during interaction with game	No	Yes	Yes	Yes	Yes	Yes

The brief data is shown in Table II.

Answer	Child 1	Child 2	Child 3	Child 4	Child 5	Child 6	Subtotal
Yes	7	7	7	7	7	7	42
No	3	3	3	3	3	3	18
						Total:	60

Table I shows 10 tasks with 3 attempts per task, totaling 60 task attempts. 42 attempts were successful and 18 were not successful. Therefore, the following equation were use in order to attain at the overall effectiveness rating for this set of task:

Effectiveness (%) = (Yes) / Total x 100%

= 42/60 x 100

= 70.00%

This equation proves the usability testing with children has showed that the effectiveness rating for graphical instruction user interface is approximately 70%.

Time Rate

Task	Time 1	Time 2	Time 3	Average	% Difference
Child 1					
Scan the Marker (Quiver)	11	12	8	10.33	55%
Scan the Marker (New UI)	6	5	3	4.7	
Child 2					
Scan the Marker (Quiver)	42	50	44	45.3	89%
Scan the Marker (New UI)	7.3	4.6	3.4	5.1	
Child 3					
Scan the Marker (Quiver)	4.95	4.72	5.48	5.1	26%
Scan the Marker (New UI)	3.32	4.33	3.55	3.7	
Child 4					
Scan the Marker (Quiver)	5.48	5.8	6.22	5.8	37%
Scan the Marker (New UI)	4.26	3.55	3.15	3.7	
Child 5					
Scan the Marker (Quiver)	3.18	5.13	3.4	3.9	80%
Scan the Marker (New UI)	0.68	0.88	0.75	0.8	
Child 6					
Scan the Marker (Quiver)	3.69	5.28	3.16	4.0	7%
Scan the Marker (New UI)	4.2	2.6	4.52	3.8	

Error Rate

Task	Time 1	Time 2	Time 3	Average
Child 1				
Scan the Marker (Quiver)	1	1	2	1.3
Scan the Marker (New UI)	1	1	1	1.0
Child 2				
Scan the Marker (Quiver)	2	1	1	1.3
Scan the Marker (New UI)	2	2	1	1.7
Child 3				
Scan the Marker (Quiver)	2	2	1	1.7
Scan the Marker (New UI)	1	2	1	1.3
Child 4				
Scan the Marker (Quiver)	2	2	1	1.7
Scan the Marker (New UI)	2	2	1	1.7
Child 5				
Scan the Marker (Quiver)	1	0	0	0.3

Scan the Marker (New UI)	0	0	0	0.0
Child 6				
Scan the Marker (Quiver)	2	2	2	2.0
Scan the Marker (New UI)	0	0	0	0.0

Satisfaction

Measures of satisfaction were acquired using post questionnaires with children. In addition, children were required to answer few questions after accomplishing all tasks. (Jacob Nielsen, 2003). The questions and answers are arranged using a 5 point smileyometer scale rate. The scale ranged from 1 to 5 as per below (Table III):

TABLE III. SMILEYOMETER SCALE RATE USED IN POST QUESTIONNAIRE

All questions were aimed to get inputs from the child on how their experience with the user interfaces, do they like it and was it easy to play. Table III shows the post questionnaire asked to children by indicating out their answer in the smileyometer scale rate.

Post Test Questionnaire	Child 1	Child 2	Child 3	Child 4	Child 5	Child 6	Subtotal
I like coloring	5	3	5	5	4	4	26
The game was fun	4	5	5	5	3	3	25
The game was easy to play	5	3	4	4	5	5	26
I like interacting with 3D objects	5	5	5	5	5	5	30
I know how to play the game	4	3	3	3	4	3	20
I need graphical instruction	5	5	5	5	5	4	29
I can understand the graphical instruction	5	3	4	4	5	4	25
I know how to use the graphical instruction	4	5	5	5	4	4	27
I like graphical instruction	5	5	5	5	5	3	28
I like animated graphical instruction	4	5	5	5	4	4	27
I want to play this game again	2	5	5	5	3	2	22
						Total:	**285**

Expending a 5 point smileyometer scale with a negative growth to 1 and a positive growth to 5, each question answered by 6 children offers shows possible positive response factor of 30 points and for 11 questions there are total of 330 points or 100% satisfaction. The following equation were use in order to achieve the total effectiveness rating for this set of task:

Satisfaction (%) = Answer Point / Total Point x 100%
= 285/330 x100
= 86.36%

Solitary Metric for Usability

To measure the total usability (effectiveness and satisfaction) of the user interface, each usability factors were conveyed in a percentage. By averaging these three scores, the usability of a product can be defined with a number between 1 and 100. Therefore, the solitary metric for usability of this research can be consequential based on the following equation:

Usability (%) = (Effectiveness + Satisfaction)/2 x 100%
= (70.00+86.36)%/2
= 78.18%

From the above equation, the usability testing with children has proved that the usability level for graphical instruction is approximately 78%.

CONCLUSION

This study gathers input on children acceptance of a product and how children would evaluate a user interface and user experience is practical, fun and user friendly. This research has emphasized age-appropriate user interface in order to help children to perform certain action such and finishing a task. The graphical instruction manages to minimal the time of scan and error rate. The result prove the effectiveness of the user interface to the time taken for children to complete a specific task, for example, time taken to scan the marker, while Children exhibit effectiveness when they could complete a task within a short period. Almost all participant manage to complete the task with less error rate and significantly faster time on scanning the marker, thus they stay focus and interact with the 3d Penguin. Due to not English literate one student were unable to read the instruction thou he manage to complete the task with the help of the graphical instruction. This may be due to the different background knowledge of the students. Effectiveness is measured based on the time the children spend on getting the accurate action the complete the whole task. Most children were looking for instruction, from the observation, we observe the children eye movement and they were looking for graphical instruction. For this purpose an animated graphical instruction action layer may help the children to get to the right action faster. After the test with the application, it is reported that Quiver User Interface main page is too confusing it require age-appropriate user interface. AR application require age-appropriate user interface to fit the user in order to complete the task. We also discovered that this coloring application provides more excitement and engagement in terms of user experience. The first instruction in the application should be fun to attract the children to continue the game, more interaction for children to engage. The score is the solitary metric that would be used to answer some important questions about coloring application such as:

- How ease to use is the application for children?
- How do we know if the graphical metaphor is suitable for children?
- How much more ergonomic must the application be?
- How will we know if augmented reality is a fun experience for children?

This metric is great to reading durable improvement on a project and could contribute a way to measure the progress to improve, more age-appropriate designs in the future.

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