Development of Edutainment Content for Elementary School Using Mobile Augmented Reality

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Abstract. Recently, the movement to bring digital technology inside school environment as learning media has been increased. In this paper, we complement one of the digital technologies with conventional edutainment tool. Together with our research partner, we developed digital edutainment content that combines Augmented Reality (AR) technology with tangram toy. This AR technology was built on the latest mobile device, iPad2. Through this paper, we report one of the promising digital edutainment content that able to increase the excitement of this new learning environment. The usage of mobile device in this AR project offer two benefits, namely mobility beneficial and easiness-to-use beneficial. Beside that, the colorful markers in this project able to attract children attentions without losing tracking robustness ability

Keywords: Edutainment Content, Augmented Reality, Mobile Device

1 Introduction

Nowadays, Korean Government has a plan to immigrate all paper textbooks into digital version. Through their Education Ministry, they want to increase an online class too, so that student will be able to continue their study even outside the school. Digital gadgets were planned to be the media to deliver school lesson combined with cloud-based computer system.

Related with the digitalization in education by Korean Government, recently more experts give some suggestions to add digital technology with its content to education field. It is because the recent generation has experienced drastic change in surrounded environment, compared to previous generation. Mostly present generation is accompanied by digital technology such as computer, video games, smart phone until computer tablet completed with its digital content.

As a starting step to realize the government purpose that already been stated above, our research lab – Institute of Ambient Intelligence (IAI) – collaborate together with Sungsan Elementary School (SES) decided to develop a Digital Edutainment Content. In this project, we are going to add some digital approaches in existed edutainment media.

From several conventional edutainment media that already commonly used in SES, we decided to combine the Tangram Toy and its manual book with an AR technology. The combination of the Tangram toy, Physical Book and the AR was expected to reach better learning environment and create more interesting learning experience for the user.

2 Edutainment Content Using Mobile AR

2.1 Edutainment

The recent educator started to realize that they need to combine education with digital entertainment. There are a lot of changes related to the surround environment of present student compared to previous era.

Many of today's young people spend more time playing in digital worlds than watching television, reading, or watching films [3].

Significantly, recent students are mostly surrounded with various digital gadgets such as computer, smart phone and computer tablet. Based on this fact, Kurt Squire, a professor from University of Wisconsin named them as an interactive age. This phenomenon creates the emergence of new technologies around interactive age. And it pushes educators to understand, leverage and even implement these technologies to classroom use [1]

Without the implementation of these new technologies, the learning process still can be held, but there will be a wide gap between their 'inside the school' time and their 'outside the school' time. Thus, this combination is really expected to bridge up the gap between their school time and social time outside the school [1].

From the concept to melt down entertainment side with education field, rose up the definition of Edutainment. Edutainment is engaging entertainment and media-based materials to promote learning process [9]. Considering the advantages of games which are fun and engaging, combined with educational field, is really expected to make students participate actively, feel interested and engaged to the education content [4].

In this project, Tangram toy was chosen as an existed edutainment media that will be improved by adding an AR technology. More specifically, it will be produced on mobile device based. We found that an AR that built on mobile device offers mobility beneficial and also easiness-to-use for the user.

2.2 Mobile Augmented Reality

In 1960, Sutherland introduced the AR for the first time. Then it became one of emerging research topic when Paul Milgram and Fumio Kishino introduced the concept of 'Virtuality Continuum' in their paper [10]. From that moment, the knowledge of AR grew significantly until today.

Reaching more than 10 years of development age, some people convince that AR knowledge has entered mature period. There are a lot of AR's research areas and topics have appeared these several years come along with the emerge of latest technology such as Mobile AR and the others [2].

To successfully melt the digital technology into school environment, our research partner-SES- has already been supported by at least 30 iPads in their special class namely U-class (Ubiquitous Class). Our lab research-IAI- has responsibility to create some digital edutainment that are portable with the existed physical device, iPad2. And finally, we decided to combine an AR technology that built on mobile device with Tangram toy, one of the favorite edutainment media at SES.

2.3 Design and Development Process

The tangram toy edutainment content (figure 1) was used to improve the spatial cognitive ability of the user. Cognitive systems include sensation and perception, thinking, imagery, memory, learning, language, reasoning and problem solving. That is the reason why this media commonly used in early education phase such as elementary school. When playing the tangram toy, usually users do it together with the manual book. The manual book provides the shape problem that need to be solved by player. The manual book also completed with problem solution to help the user when they meet some obstacles during play time. This edutainment media has both interesting side and challenging side. It is the reason why it becomes one of the most favorable edutainment content at SES.

Figure 1. Tangram Toy

Figure 2. The Using Scenario

Figure 3. Back and Front Cover Design

In order to develop an AR project, we built an AR environment based on Unity3D software. Actually there are several options of software that can be chosen and one of them is Unity3D. Originally, Unity3D is a game engine. This software is used by many game developers in the whole part of the world. There are many

advantages that offered by unity3D game engine. One of them is the possibility to publish project on the mobile device platform, both Android and iOS.

Then, Qualcomm Corporation released the AR extension for Unity3D. This extension is able to compile with the advantages of Unity3D. That is why the AR project that built using Qualcomm AR extension can be published for Android and iOS. Based on these several advantages, researcher decided to use this software to develop an AR edutainment project.

In the process of developing the content, we decided to apply a complementary approach. It means that we are going to add this new digital technology, AR, into existed edutainment content, the tangram toy. We are not going to sacrifice any previous edutainment tools and replace it with the new technology. The main reason behind this decision is because it is still a transition phase, at least until this moment. During this transition phase, there are several preparations need to be done by the parties who closely related with it. The student will need some moment to get used with this new device and learning environment, the teachers as a class facilitators need to adapt as well.

During the development process, we have deep discussion with our research partner. And finally, the new learning experience was designed. The tangram toy physically remains the same, but some modifications were adjusted in the manual book. In general, the using scenario of this new edutainment content is shown in figure 2.

2.4 The New Physical Book Design

Before, the manual book contains shape problems and its solutions. But in the new learning environment, we excluded the solution and put it in the iPad's application (App). Also, we renew the overall outer-look book design with cheerful color (Figure 3.). Since we combined it with an AR technology, we added colorful markers on the manual book. The marker is the most important thing in the AR technology. Through this marker, it can calculate and visualize the registered virtual content. Traditionally, the marker was in Black/White but in our project we use colorful marker to make it more interesting for children. The figure below will show the example of new book design and colorful marker that used in this project.

To make it more meaningful, beside constructing the tangram's shape, we add Korean-English vocabulary for each shape as an additional learning objective. So that, during playing time, student will not only learn about how to construct the shape but also they learn about some English vocabularies in the same time. The figure below will show the new book's content design.

Figure 4. The Colorful Marker

Figure 5. Book Content Design

2.5 Mobile AR Application (iPad Version)

AR technology is the chosen digital technology to be combined with conventional edutainment media. Previously, this technology was developed using PC based and web camera to capture the marker. Some developer also uses Head-Mounted Display (HMD) to visualize the virtual content (figure 6). In our project, we developed an AR project using Mobile devices as seen in Figure 2. The modern mobile devices mostly have built-in camera. This feature was used to capture the marker, track it then visualize the registered virtual content on the screen.

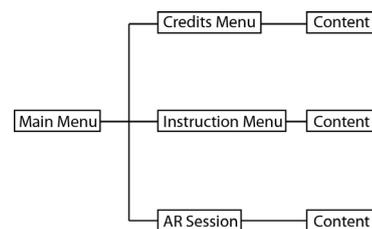Figure 6. Web Camera Based and HMD Based of AR Project

Figure 7. App Work Flow

The design process of the iPad's app was started with the workflow architecture as shown in the Figure 7. Starting with Main Menu, then it divided into 3 branches namely Credits Menu, Instruction Menu and AR Session. We consciously simplify the design of this application workflow so that it will be easy and friendly to be used both for student and teacher.

In general, we use similar visual approach on the book's design. The similar design approach was applied starting from the App' Icon design that will appear in the iPad main screen and also on the whole menu's design. Using similar design will create an integrated and holistic ambience of this new learning environment. Figure 9 is the Main Menu design. As seen on the workflow, the main menu contains 3 buttons to reach its own part namely Credits Menu, Instruction Menu and AR Session. So, the "C" button is the representative of Credits Menu, the "?" button is the representative of Instruction Menu and the "Start" button is the representative of AR Session.

Figure 8. App' Icon Design

Figure 9. Main Menu Design

Figure 10. Credits and Instruction Menu

Credits Menu contained the project member and other acknowledgement, also some attributes related to this project. Instruction Menu contained how to operate this app and other function that possible to be used by user during the playing time. Both in this menu, researcher used button-less approach. It means that user only need to swipe their hand to change page-to-page in these both menus. Figure below will show the Credits and Instruction Menu design.

The main part of this App is the AR Session. When user chooses an AR session, the device camera will be activated automatically. Next, user needs to point it to the colorful marker on the book. Then, the software will track the marker and visualize the registered virtual content 3D model of each marker. Come along with the 8 marker on the book, there are 8 different 3D models as seen in figure 11.

The AR session will start their part with the visualization of 3D model as a shape problem that needs to be solved by user (Figure 12).

Figure 11. Virtual Content 3D Model

Figure 12. AR Session

In this session, there are 3 solution options to help user when they find some obstacles, namely 1 Solution, 2 Solution and All Solution. When "1" button chosen, it directly shows the 3D model with 1 color solution of shape problem. When "2" button chosen, it directly show the 3D model with 2 color solution of shape problem. Both in 1 and 2 color solution, user can touch the screen to enable the other colors appear on the screen. And lastly, the "all" button enable user to go to the full color solutions.
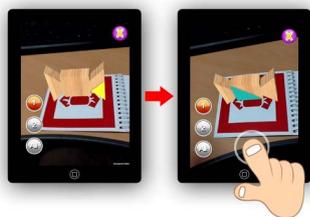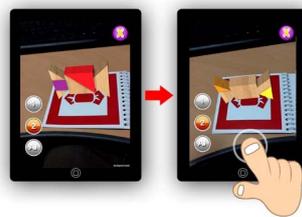

Figure 13. 1 Solution AR Session

Figure 14. 2 Solution AR Session

Figure 15. Full Color AR Session

2.6 User Experience (UX)

In this project, we expected AR technology can increase the excitement of this new learning environment more than before. So that, we spent more time to discuss about this matter. Principally, we stick on the idea that the UX should be able to create better learning experience and provide better solution compared to previous learning environment. Also, it should allow the user to interact directly with the virtual content. Finally, we put these functions into our AR app, namely Rotation, Pinch Zoom In/Out, Double-Tap Reset and Call-back 3D Function.

First function is rotation both X and Y axis. To do this function, user just only needs to slide their finger horizontally to rotate in X axis and slide their finger vertically to rotate in Y axis. Figure below will show the using procedure of rotation function.
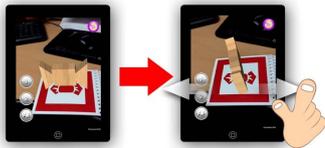

Figure 16. Rotation X Axis Procedure

Figure 17. Rotation Y Axis Procedure

Second function is Pinch Zoom In/Out. Sometime user wants to see the virtual content in detail. Rather than move their device closer to the marker, user can directly zoom in and out the virtual content from their device screen. To use this function, user needs to pinch their 2 fingers in device screen. Figure below show the procedure to use this function.
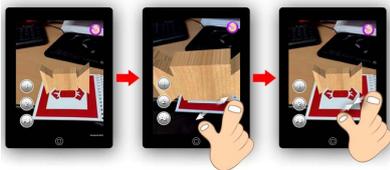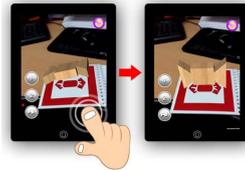

Figure 18. Pinch Zoom In/Out Procedure

Figure 19. Double-Tap Reset Procedure

Figure 20. Call-Back 3D Procedure

Third function is Double-Tap Reset function. When user realized that their virtual content already messed up during the previous function, user can implement this function to reset its position to the early position. User just need to tap the screen twice then the 3D model will back to the early position automatically. Figure below show this function procedure.

Researcher realized that it is hard for student if they need to hold and point the device to marker all the time during the learning process. Based on this fact, researcher added other function namely Call-back 3D function. Using this function, user able to call back the virtual content even though they do not point their device's camera on the marker.

This function make user can put the device in the table then they can concentrate to construct the tangram toy without losing their virtual content as a construction guide. After the virtual content appeared in the device screen, the user can use the basic functions such as rotation, pinch zoom in/out and others. Figure 20 show the Call-back 3D procedure.

3 Discussion

In this paper, researcher has explored the possibilities to combine the AR technology with conventional edutainment media.

Combining an AR technology with the conventional edutainment media, Tangram toy and its manual book, has been proven as a great decision. AR technology offers new and interesting learning experience. The virtual content that appeared in the screen and able to interact with user makes this new learning environment become more interesting than before. Because of that, the user becomes more engaged and interested with it than just using conventional method.

In the same time, the usage of mobile device in this AR project offers at least two benefits, namely mobility beneficial and easiness-to-use beneficial. Since it is built based on the mobile device, this project can be played where ever and whenever the user want, as long as the user have that mobile device around them. This is what we called mobility beneficial.

The other benefit is easiness-to-use beneficial. This AR project was finalized as an application that install inside the device; it means that the user just only needs to play it as a general application like the other. There is no complex usage procedure, such as early installment and else. The easiness-to-use becomes an important issue, since this AR project will be operated by general people with various knowledge backgrounds. We need to ensure that everybody able to operate this application since the beginning until the end and it requires the easiness-to-use beneficial.

The other advantages that rose up from this project are the using of Colorful marker. The colorful markers are able to attract children attentions better than just black/white markers, without losing its tracking robustness ability.

Some challenges appeared in this project. This project was tailor-made specifically to our research partner, SES. This App was created based on the student's and teachers' characteristic behavior at SES. How to create AR edutainment app that can be used in general, would be a further interesting research topic in the future.

4 Acknowledgment

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