How Designer Think About Designing an Augmented Reality App for the Study of Central Nervous System

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Abstract: The purpose of this qualitative case study is to explore the process of designing an augmented reality application for the study of the Central Nervous System. The researcher wants to gain an understanding of the process that take place during the entire of development process in developing the augmented reality application. Semi-structured interviews were conducted to seek the detailed process of developing the application and the designer's interaction with the medical faculty members. The participant of the study is a designer who have relatively high experience in designing various software and developing games. Five themes emerged from the data analysis namely; (1) Planning, (2) Analysis, (3) Design, (4) Implementation, and (5) Maintenance.

Keywords: Augmented Reality, SDLC, Waterfall Model, Educational Software, Designer, Central Nervous System

1. Introduction

Mobile applications or commonly referred as apps are considered as one of the fastest growing trends in Information System Industry (Eddy, 2011). The number of effort to apply mobile technology in the learning process has rapidly increased over the years. The education system is also increasingly being supplemented by augmented reality technology to make learning more attractive and useful for learners. Using an augmented reality technology can offer an exclusive opportunity for educators to embed learning and supply three dimensional in a natural learning environment (El Sayed, Zayed, & Sharawy, 2011). The combination of these three concepts: augmented reality, education, and mobility will open great possibilities that can be utilized in numerous ways.

The rapid growth of mobile computing technologies alongside mobile software applications has made ubiquitous learning possible (Johnson, Adams, & Cummins, 2012). The major affordances of mobile computing technologies for learning include user mobility resulting from device portability, relatively stable computing power in small devices, and always on connectivity (Hsu & Ching, 2013). These affordances lead to the various potential for innovative uses of mobile technologies in education. The development of mobile apps has also raised interests among educators because it facilitates teaching and improves student's motivation to learn (Johnson et al., 2012). Nowadays, Augmented Reality (AR) and Virtual Reality (VR) applications have an enormous popularity and significance with offered opportunities in concern with providing information to the sensory channels of individuals.

It is imperative to know what is in the mind of the designers while they are designing the application. As in many processes of building and developing computer software and information system, the waterfall model of SLDC has been used widely in industrial and engineering fields (Thayer & Yourdon, 1997). In relations, knowing whether the designer feels that they are following the steps in tandem with the waterfall model can illuminate some of the issues or a gray area that might be overlooked when creating the AR application. This is particularly the case for AR as this approach is still novel in the field of education. Besides that, there is a lack of research being done on interpersonal understanding between designers and the process of developing the application. This research is conducted in the hope of exploring this issue. The experience during the process of developing AR application can shed light on what is in the minds of the developer. Most development processes follow a very specific approach, and the Waterfall model is one of them. Knowing this will help understand

the development process of AR better and in return contribute to improving the application of AR in education.

2. Study Background

Recent developments in the field of technological advances have led to a renewed interest in transforming the educational processes from traditional methods to contemporary styles. Such advanced educational technology has improved the process of teaching and learning through the existence of hypermedia, mobile technology and the most recent is e-learning (Sriram, 2011). To satisfy the needs of educational technology, different adaptive methods are developed and practiced in the teaching and learning process. In addition, several types of research are conducted to analyze different educational software requirements and techniques used in the development software (Costa, Loureiro, & Reis, 2009; Riley, 2007). The use of educational technology is believed to have a profound effect in providing a student-centered learning environment. Similarly, Flemmer (2007) found that there are numerous areas in which the use of educational technology may benefit the students in the way of improving and satisfy the needs of students. Although there were various researcher studies conducted on the widespread use of educational technology, very few of them are focused on the full potentials of how educational software can contribute to the teaching and learning process. Against this background, it is necessary to examine in depth the relationship between the educational requirements and the software dynamics.

The rapidly emerging technological advancement influences the teachers' or educators' perspective in educational approach. The use of AR to revolutionize the teaching pedagogy in schools has become a worldwide trend (Chai, Wang, & Chiang, 2014). AR can be understood as an environment in which virtual and real elements appear to coexist. Similarly, in a widespread survey of Augmented Reality, AR is summarized as a field that lets the real world to be seen by the user, where it is superimposed or composited with virtual objects (Azuma, 1997). AR allows for a seamless combination of virtual content with the real world (Azuma, Billinghurst, & Klinker, 2011). The possibilities of integrating AR into education are endless as it can be applied to different types of learners and in a variety of fields ranging from language study to complex biological experiment such as medical simulation and high-risk experiment. An analysis by Hamilton and Olenewa (2011) explores several AR applications considered for teaching, including those developed for various industries such as media and entertainment, gaming, tourism and travel, social networking, marketing, and enhancement of daily life.

In the context of this study, the research is focused on the development of AR application for the Central Nervous System. At Universiti Putra Malaysia, medical students are usually required to attend both classes and laboratory sessions where they will be introduced to the 3D model of the human anatomy. The problem arises as the medical students have difficulty in visualizing 3D anatomy from the textbook. Most of the time in visualizing human anatomy, the students heavily rely on the lecturer's creativity as well as how the lecturer delivers the learning process. In the previous research done by Shirazi and Behdazan (2013), the level of engagement between students in STEM education is gradually decreasing as they cannot understand the abstract concepts. Realizing this situation, an AR applications is developed to overcome such challenges and enhance the teaching and learning process. Through this application, it is hoped that the medical students will be able to understand the human anatomy in detail as they will be able to interact with the visual 3D human anatomy model. Thus, this study was conducted to understand the designer's perspectives on how the process of developing an AR application takes place.

3. Research Questions

The purpose of this study is to explore the process of developing an AR application for the study of the Central Nervous System. Specifically, this project paper aims to answer the following research question, "How does the process of developing an augmented reality application for Central Nervous System take place?"

4. Methodology

Data Collection

Qualitative research design was employed for this study where data were collected through semi-structured interviews and document analysis. This method has been provided as it is believed to provide a better understanding of the process of designing an AR application and garner information on the designer's expertise in the process of developing the application. This is supported by Merriam and Tisdell's (2016) views which claimed qualitative research design is the most appropriate to use when the study involved to understanding the process from an individual's perspectives. Using a qualitative methodology, the researcher played the role as human instruments which are immediately responsive and adaptive are ideal means of collecting and analyzing data (Yin, 2014). Besides that, the researcher has also refer the participant as Ahmad; a pseudonym given to protect his identity (Patton, 2015).

In this study, the researcher has used semi-structured questions to draw out the responses from the participant. The participant was interviewed on the basis of an interview guide questions in which he was asked to describe the process of developing AR application. The interviews were conducted in three separate sessions over the cause of five weeks and each session lasted for about 40 to 60 minutes. Each interviews was audio recorded then transcribed to preserve the responses of the participants.

Besides interviewing, documents analysis was also employed. The researcher specifically used Ahmad's personal documents to be part of documents that need to be analyzed. Besides that, the researcher has also analyzed the photography and media in the documents gathered as they are also considered as visual documents. This is in line with Pink (2013) which stated digital images are considered as part of contemporary reality due to its increasing presence in the world nowadays. The researcher has analyzed the designer's photo album where most of the photos show the process of developing the AR application from beginning to the end. Through this technique, the researcher can observe the important of cultural values and story conveyed from that particular photo (Pink, 2013).

Selecting Research Participant

A purposive sampling technique is employed as it is as one of the effective ways in exploring the case specifically in the social domain context (Tongco, 2007). The researcher used this technique to ensure the selected participant has prior knowledge and expertise in the subject matter, which focuses on the development of AR application. In a similar context, Chein (1981) explains the purpose of purposive sampling is not to have an average opinion but rather the participants are carefully selected because of their unique experience and competence. The researcher knew the participant, Ahmad, through his supervisor. Ahmad was contacted and briefed about the purpose of the study. He then agreed to participate in the study. Only a single participant is used for this study as Ahmad is the sole designer involved in designing and developing the AR application for the Central Nervous System. From the initial plan of the project, the designer is responsible for the development phase until the software is delivered to the stakeholder, which is the Faculty of Medical and Health Sciences, Universiti Putra Malaysia. Ahmad can be described as a fully dedicated, inspiring person and has a vast knowledge in the development of software.

5. Data Analysis

In this study, the systematic grounded theory analysis has been adopted to analyze the data collected. The data have been analyzed by using the open coding method to enable the researcher look for patterns and trends (Yin, 2014). This technique was also adopted to ensure that the data are not left behind and important information are not overlooked. Before starting data analysis, the researcher has carefully listened to the interviews and then transcribed them by using the verbatim technique. Then, the transcribed interviews were read several times to enable the researcher to familiarize with the data. The researcher has also marked the meaning units he considered appropriate for the purpose of reading, discussing, and reaching consensus. Other than that, the researcher has adopted several different techniques in analyzing data including writing memos on what the researcher learns, try out ideas and themes on participants, and by exploring new literature while in the interview session (Anderson, 2010).

The researcher started conducting the intensive data analysis to ensure that it is sufficient to answer the outlined research questions earlier.

Adhered to Yin's (2014) suggestion that a qualitative research requires a careful data management of data collection, the researcher has used colorings notes to set out thoughts, hunches, and speculations to data collection. Besides that, the researcher also provides a log book to act as personal inventory which has records of field notes, interview data, documents, and memos. The inventory then is organized and labeled accordingly to enable easy access to the researcher. To interpret data collected from the interviews, the researcher has categorized the findings into several themes. The formation of themes are based on different process based on the waterfall model. This is in line with Creswell (2013) who suggested development of themes are required and recommended in the data analysis procedure. By using member checking technique, the researcher is able to construct reliable and valid themes to be used in this study (Merriam & Tisdell, 2016). Through this technique, the researcher has asked the participants to read and view the transcripts and documents. The researcher has asked the participants to verify that all transcripts did not have any additions other than what he had stated in the interviews. This is similar with Patton (2014) who stated that member checking involves the process of taking data and interpretations back to the people from whom the data were derived to confirm the credibility of the information.

6. Findings

This section will discuss the findings related to the compelling research question, "How does the process of developing an augmented reality for the study of Central Nervous System take place?" Five main themes have emerged from the data analysis, namely (i) planning, (ii) analysis, (iii) design, (iv) implementation, and (v) maintenance.

6.1 Planning Phase

In the planning phase, the medical faculties together with the designer needed to identify the requirements to determine the objectives of this project. A simple application has been developed as a preliminary experiment based on the requirement given by the medical faculty. To gain a better understanding of this requirement, this preliminary output has been demonstrated to medical lecturers from the Faculty of Medical and Health, UPM along with the Computer Scientist lecturer from Faculty of Computer Science and Information Technology, UPM. The goal of this phase is to develop an initial understanding of the new system or software. The designer stated that in the planning phase, the medical faculty would explain the problem. From the discussion, it was decided that the application should display a human brain in a 3D model. Alongside the 3D model are some information and a set of questionnaires. This is evident in the following excerpt:

> "At this phase, the stated problem was the medical students need a model of the human brain when they want to study about the Central Nervous System. Because of the limited availability of this model, they only can use the model in the laboratory only. They cannot learn outside the laboratory as the model is not there. The purpose of this apps is to provide them access and the model of the brain when they want to learn anytime."
>
> [Interview 1]

During the planning phase, the designer highlights two important things. First, the importance of user requirements and second, the dynamic of user requirements to the learner's perspective as well as educator's perspective. This is where the designer works together with the medical faculty in addressing any discrepancies between the educational needs and software that need to be developed. In the second interview, the designer mentioned this issue:

> "In the planning phase, for me, user requirements are very important. Because the requirements show what the problem is, what learner's needs to be addressed and what the educators want. This is why I have several meetings with the medical faculty and science computer faculty to clarify the requirements. They also need my expertise to

explain the available technology and how to integrate it with the proposed solution."

<div align="right">[Interview 1]</div>

According to Boehm (1970), the first phase of Waterfall Model is called "System Feasibility" where the planning phase focus on the development proposal that consists of the formation of the project timeline, initial project estimation plan, and communication plan. In this case, the designer stated that the importance of project timeline and the communication plan that involve the medical faculty as well:

"In the beginning, I create the Gantt chart where there is a specific period for every phase. For example, week 1 and week 2, I will only focus on the planning phase. Week 3 until week 13 I will focus on implementation phase."

<div align="right">[Interview 1]</div>

"To avoid any misunderstanding during the planning phase, I create a Whatsapp group where I can communicate directly with the medical faculty. If there is greater problem occur, I will personally meet-up with them."

<div align="right">[Interview 2]</div>

To proceed to the next phase, the designer explains the importance of clear understanding about the proposed solution. The designer felt that it is vital to not waste time by solving the wrong problem. Throughout the several meetings, in the beginning, the designer must have a clear understanding of the given project and work with the medical faculty in creating the new system.

6.2 Analysis Phase

The goal of this phase is requirements determination where the designer required to understand the requirements of the proposed apps and to develop the proposed apps as required by the medical faculty. The designer also mentioned the need of drafting the level of detail for the system to be functioning.

"Medical faculty provides me the user requirement, where it has the objective of the apps, why it the apps need to be developed and the required function of the apps. They also provide a draft interface on how the apps should be functioning"

<div align="right">[Interview 1]</div>

In this phase, the designer also mentions the importance of analyzing the current applications on the market to get a statement of what the application must do and the characteristics of the proposed apps must have. Figure 1 exhibits some of the existing AR application in the market. The designer commented as:

"In this phase, I was required to explore the various type of article and journal, and I also do some applications review on the current market. This is to give me more information on how the apps should be, the design interface and the content."

<div align="right">[Interview 1]</div>

In addition to the analysis requirements, the designer highlighted the process of defining the project scope such as user scope, content scope, and system scope:

"Based on my previous experience, when I need to design a new system, I normally divided it into three scopes; First user scope, then contents scope and system scope. For user scope, I need to analyze the user requirement given by the medical faculty. Then in content scope, I will look on the storyboard provided, and the system scope is where I will prepare a design for the system and later present to the stakeholder."
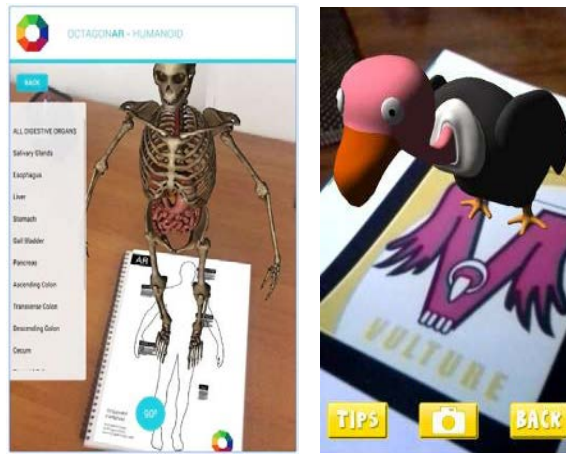
<div align="right">[Interview 2]</div>

Figure 1. Some existing AR application in the market.

6.3 Design Phase

The design phase looks at how the architecture of the system will be built and how the system will function in particular emphasis on software, hardware, user requirement, and application interface. The designer explains the purpose of this phase which required the development of a blueprint that will satisfy the requirement as given by the stakeholders.

> "In the design phase, I will create a storyboard which is the same as a blueprint. The storyboard I produce is based on the requirement given by the medical faculty. From the complex requirement, I make it simple through the storyboard. I also make a draft interface for the design application, around 20 pics of interface and then I present it to the stakeholders."
>
> [Interview 1]

He also added that the blueprint would identify the input and output needed and the overall process of how the application should behave. The designer mentioned in the following comment:

> "The storyboard will have a draft interface on how the application will look like, the specific button and how it will interact with the content. If the stakeholders satisfied with the blueprint, then I don't have to add anything."
>
> [Interview 3]

6.4 Implementation Phase

This phase is focused on the physical development of the system as set out in the blueprint during the design phase. Normally in the implementation phase, the project required a development team that consists of programmers, testers, interface designers, and other experts. However, in this case, the designer will solely act as a programmer, interface designer, and tester specialist. The designer also highlights six key activities in this stage which are slightly different to normal activities as the implementation stage should be. this is explained in the following excerpt:

> "In my previous experience where I have design games, there are only 3 to 4 activities during the implementation stage. I thought there is no different when designing an AR app. However, through the development process, I notice that there are different activities that I need to complete in order to finish this phase."
>
> [Interview 3]

The implementation phase starts with digitization process of the real model is turned into a 3D model. Figure 2 shows the process of digitization and the result of the model. The designer explained the process of digitization as follow:

"First step is modeling which I called as digitization process. Using the real model of the brain that supplied by the medical faculty, I turn it into a 3D model. At first, I used a software called Kinect; later I found it not compatible with others software. That is when I used software called Autodesk Remake. The digitization process is where I need to take a picture of the brain model from every angle, from top to bottom."

[Interview 3]

Figure 2. The process of digitization.

Coding is where the physical design and development of specifications are turned into working computer code. The designer also described the process of video recording as shown in figure 3. The designer explains the development process of coding and video recording activities:

"In the coding phase, I will create an interaction by using the draft interface such as picture, buttons, symbol and the digitized model to link to an action. For example, if I click this button then it will bring to the next interface or users can interact with the 3D model. I use Unity software which allows me to create a programming environment to develop the AR apps."

[Interview 3]

"Based on the requirements given by the medical faculty, I was given a task to develop a video specifically for this app. I need to set up a schedule with the medical lecturers and do a video recording of lecturer given a lecture on Central Nervous System."

[Interview 3]

Figure 3. The video used in CNS app was recorded at the Museum of Anatomy in Universiti Putra Malaysia

Next step in the implementation phase is testing where the designer needs to confirm whether the system meets the requirements as set out by the stakeholders. In this phase of testing, the designer will perform a validation process with the medical experts. All of them have the experience of teaching Anatomy of Central Nervous System subject for more than five years. The designer said overall suggestions and comments had assisted him greatly in the process of making this application a success. The designer also described the medical expert as the first level user during the testing process:

"In the testing phase, I need to do a validation process to confirm the function of the apps to tell with the requirements of the stakeholders. The first step in the testing phase is when I did validation with the medical experts. They will try the apps and then give

feedback on the function and content used."

<div align="right">[Interview 3]</div>

Also, the designer also mentioned the need for re-testing process which includes the medical students as a second level user.

> "After the testing process with the medical experts, I need to make some improvements. Later after one week of improvements, I do re-testing with 12 students from medical faculty in order to get feedback from their perspective."

<div align="right">[Interview 3]</div>

After the re-testing process, the next key activity is documentation that consists of feedback from users and medical experts. In this phase, the designer will compile the feedback and improvements given by the end-user to finalize the apps. The designer also highlighted the implementation phase as the longest compared to other phases:

> "For me, this phase is the longest and most difficult compared to other phases. Because I took a longer time to find the right technique for digitization process. I should have completed it in week ten however due to the difficulty in digitization process; I completed it in week 13 as I only discover the right technique. "

<div align="right">[Interview 1]</div>

> "When I stuck at implementation phase, I feel not very confident enough whether I can deliver this project or not. This is where I got the problem in digitizing the model and turn it into a 3D model. Looking back at my timeline, after week ten then I only got a solution to my problem, and I got so happy. I can say that this was the most difficult process."

<div align="right">[Interview 2]</div>

6.5 Maintenance Phase

The final phase of the Waterfall model is maintenance. As the new system is implemented, it will often need ongoing maintenance and support. The designer stated that the maintenance phase in vital to ensure the designed apps is operating at optimum levels of performance.

> "The main activities in this phase includes getting feedback from the end users and analyze the feedback in order to make changes. From the previous phase, where I have conducted a pilot test with the medical students, the result of the test is being analyzed to ensure the application is operating within the requirements as specified."

<div align="right">[Interview 2]</div>

However, the designer mentions that there is no maintenance phase for this project. This is due to the requirements stated by the stakeholders. The designer commented as follow:

> "There is no maintenance phase for this project. I was given a project where I only need to develop only a prototype. The maintenance phase is where you have the official product and later need ongoing maintenance.
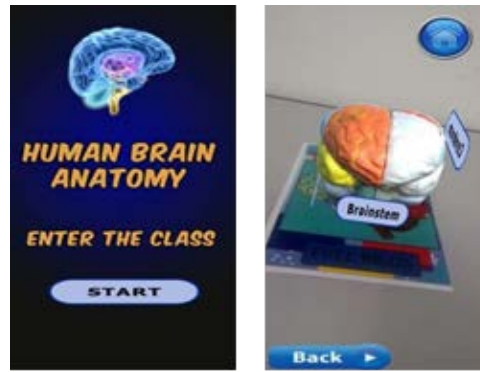
<div align="right">[Interview 1]</div>

Figure 4. The prototype of the Central Nervous System anatomy on the AR application

7. Conclusion

In understanding designer's thinking when designing an AR application for the study of the Central Nervous System, this study had found that the design process went through different phases of the Waterfall model. This study revealed that software methodology play significant roles to serve as a development framework to the designer. This is consistent with McMurtrey (2013) as he found the use of methodology can give a great impact on the success of a software development. Through this study, the researchers also found the Waterfall model adopted by the designer shows that different phases and approaches affect the process and quality of the AR application. It is clearly proven that tach software methodology has significantly different characteristic that makes them suitable for different type of projects.

Other than that, the designer in the interview also emphasizes that designer's understanding towards the project's requirements facilitate the selection of appropriate SDLC for a particular project. Similarly, Mahanti, Neogi, and Bhattacherjee (2012) also stated the aspect of understanding user requirements, project complexity and project team are associate with the SDLC's selection. The finding is consistent with past studies conducted by Chakraborty, Arefin, Baowaly, & Bahar, 2012; Mahanti et al., 2012; Sriram, 2011) which highlights user requirements as the most important factor in selecting an SDLC model. In this study, the researchers found that the Waterfall model chosen by designer was chosen based on several factors. Apart from its clear framework, the designers claimed that the use of this model is more effective in the time factor when compared to other model. In conclusion, this study found that the result of clear requirements in planning phase provided by the medical faculty give a huge impact on the development process and its successful product delivery.

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