Augmented Reality in Nursing Education: Addressing the Limitations of Developing a Learning Material for Nurses in the Philippines and Thailand

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Abstract

The application of Augmented Reality (AR) in nursing education is relatively new. When used as a learning tool, AR provides new digital media that result in teaching and learning enhancement. However, there seems to be a gap in the development and use of AR tools between the learners in the developed world and those who are in the developing world. Most, if not all, of the existing AR initiatives in nursing originated from economically and financially advanced countries. There is a limited number of researches and case studies done in the Association of Southeast Asian Nations (ASEAN) where a majority of the countries are developing. For this reason, this exploratory study aims to provide a proof of concept for budget constrained and technologically challenged implementers from developing countries such as the Philippines and Thailand. An appropriate AR tool was chosen among the reviewed authoring tools. Utilizing the selected tool, a learning material prototype on English nursing communication was developed to aid nurses in potentially improving their English competency. The prototype, a talking comic strip that consists of a clinical scenario, was well-received. A majority of the respondents agreed that the AR-enhanced material was better than the printed material alone and that it enhanced their learning experience. It was also found to be usable, receiving a system usability score of 68.5937, which is higher than the mean global score of 68.

Keywords: Augmented Reality, Nursing Education, English Communication, Open Educational Resources, System Usability Survey

Introduction

ASEAN Integration

The Association of Southeast Asian Nations (ASEAN) is composed of 10 countries, namely, Brunei Darussalam, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Vietnam. By the end of 2015, member-countries sought economic integration by establishing a common market through the ASEAN Economic Community. Key areas include human resources development, recognition of professional qualifications, and industry integration across the region (Long, 2014). This integration promotes free movement of goods, services and people of various backgrounds and professions. One profession, for which there is an arrangement, is on nursing services. The ASEAN Mutual Recognition Arrangement (MRA) on Nursing Services has been formed with the following objectives:

- To facilitate mobility of nursing professionals within ASEAN;
- To exchange information and expertise on standards and qualifications;
- To promote adoption of best practices on professional nursing services; and
- To provide opportunities for capacity building and training of nurses.

The MRA allows nurses who meet certain qualifications to register and to apply for a license in any ASEAN country, subject to law and regulations of the host country. Thus, to strengthen the ASEAN MRA on Nursing Services, it is necessary for nurses to communicate in English, the official working language of ASEAN, and acquire competency (Aungsuroch & Gunawan, 2015).

Augmented Reality and Nursing Education

There have been several advances in technology at present, such as Augmented Reality (AR). AR is a technology that supplements the real world with virtual objects that appear to co-exist in the same space as the real world (Azuma et al., 2001). Virtual objects are computer-generated inputs that include audios, videos, graphics and GPS data. AR started way back in the 1960s, but it was only during the 1990s when AR's remarkable progress started. AR, considered a novelty in the literature (Zhu et al., 2014), can be applied to a wide range of application domains.

One domain for which AR can be used is nursing, specifically in nursing services and education. AR as a learning tool provides new digital media that can enhance teaching and learning (Bower et al., 2014), as it improves how a learner perceives of and interacts with the real world. Moreover, the information imparted by virtual objects helps him perform real world tasks (Azuma, 1997). It makes learning more interactive, engaging and convenient for everyone. When applied to nursing education, it results to a useful learning technique that may enhance the knowledge and clinical skills of nursing staff and students through realistic situations with computer-aided technology.

AR has been used in the nursing educational system of developed countries. However, applying and adopting AR in nursing practice seems to be challenging, especially for Filipino and Thai nurses. This may be attributed to the limited number of research and case studies done in the ASEAN where a majority of the countries are developing. Most of the existing AR initiatives were done in economically and financially advanced countries. Consequently, there exists a gap in the development and use of AR tools between the learners in the developed world and those who are in the developing world.

Objectives of the Study

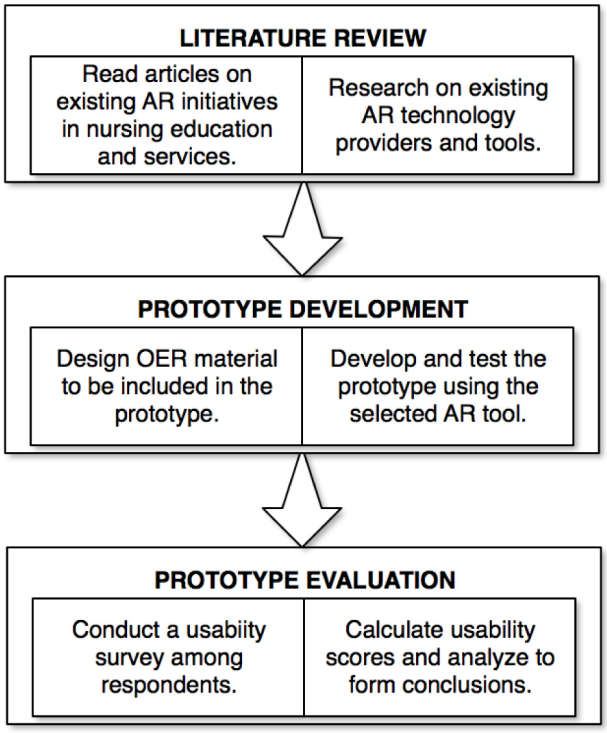
AR in nursing education is a relatively new research area. It can be utilized to improve the English communication skills of nursing professionals in the ASEAN. This initial study or exploration aims to address the gap and to provide a proof of concept for future implementers in the region by accomplishing the following objectives:

1. To determine existing AR initiatives in nursing education and services.
2. To identify relevant AR development tools that could be considered by implementers with limited finances.
3. To develop an AR prototype that contains an open educational resource (OER) for English nursing communication.
4. To learn the perceptions of Filipino and Thai nursing students concerning the prototype by conducting a usability survey.

Methodology

Figure 1 shows the flowchart of methods and procedures followed in this study. The flowchart below was patterned after Teplechuk's diagram (2013).

Figure 1. Flowchart of Methods



Literature Review

A general literature review was utilized to explore existing AR initiatives on nursing services and education, and AR technology providers. According to Grant & Booth (2009), a general literature review is a review of published materials that provide an examination of the recent or current literature. It is typically narrative and can cover a broad range of subjects at various levels of completeness and comprehensiveness. It may or may not include comprehensive searching and quality assessment.

Prototype Development

A prototype called the talking comic strip was developed. It contains an OER content for nursing communication in English. Using the prototype, whenever the user points his mobile device to the comic strip, its accompanying audio is automatically played. He can read the comic strip and hear its sound at the same time, and this enables him to learn the proper pronunciation of words and the intonation of statements. AR facilitates the integration of the physical entity (comic strip) and the digital entity (audio conversation). Listed below are the phases involved in developing the prototype.

1. A nursing professional wrote the script (Figure 2), a conversation between the nurse and

the patient. The theme of the script is about providing basic care to patients.

Figure 2. Script Snippet

SITUATION 1: *The nurse in the morning shift is assigned to a female patient in the Medical Ward. Reading the medical charts, the nurse found out that the patient was diagnosed with Congestive Heart Failure and Unstable Angina. The nurse approaches the patient to assess her Functional Health Patterns on Activity and Exercise, and Role and Relationships.*

Nurse: *Good morning, Ms. Ellen. I'm Luisa, your nurse for this morning shift. How are you feeling today?*

Patient*: Good morning, Nurse Luisa! I am actually feeling dizzy from a whole day of coughing. (coughs hardly)*

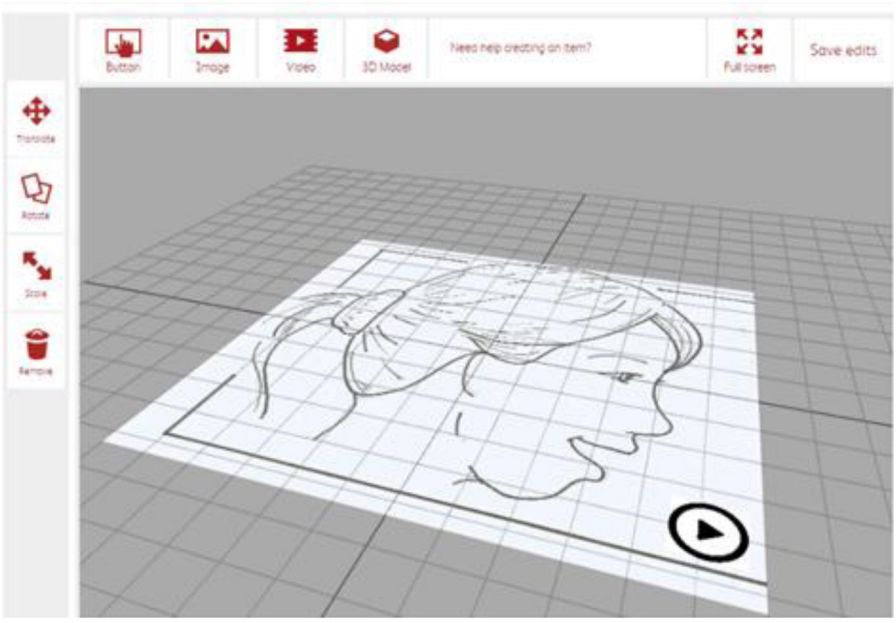
2. An artist designed and drew the comic strip based on the script, as shown in Figure 3.

Figure 3. Sample Comic Strip

3. Voice actors recorded the audio track to produce the audible form of the script conversation.

4. The selected AR tool integrated the audio and the comic strip, to make the latter talk back to the user. Figure 4 displays how the audio track was attached to its respective image using CraftAR.

Figure 4. AR Content Creation in CraftAR



5. Once the prototype was configured and installed in the mobile device, the user may use it by pointing his device's camera to an image in the strip as illustrated in Figure 5.

Figure 5. The user pointing her mobile device to the comic strip

Prototype Evaluation

It is important to measure the perceptions of the users of a particular system, application or software, through the quality aspect of usability. ISO 9241-11 defines usability as the degree to which a system can be used by target users in a particular context of use to achieve specified goals. According to Brooke (1996), measures of usability include the following:

- Effectiveness - The ability of users to complete tasks using the system, and the quality of the output of those tasks.
- Efficiency - The level of resource or the number of steps consumed in performing tasks.
- Satisfaction - The subjective reactions of the users in using the system.

Users are said to have a good sense of which systems are usable or unusable. If a system is considered to be highly usable, users can achieve their tasks easily and efficiently. On the contrary, if a system is hard to use, people will not use it (Spencer, 2004). In this study, 17 respondents were asked to assess the prototype's usability by accomplishing a survey based on the System Usability Scale (SUS). Brooke's SUS, cited in over 1,300 articles and publications, provides a quick and reliable tool for measuring usability. It is effective in differentiating usable and unusable apps and systems. It is a 10-item questionnaire that the respondents can rate from 1 (strongly disagree) to 5 (strongly agree). Listed below are the items of the test.

Figure 6. System Usability Scale Questionnaire

	The System Usability Scale Standard Version		Strongly disagree				Strongly agree
			1	2	3	4	5
1	I think that I would like to use this system.		O	O	O	O	O
2	I found the system unnecessarily complex.		O	O	O	O	O
3	I thought the system was easy to use.		O	O	O	O	O
4	I think that I would need the support of a technical person to be able to use this system.		O	O	O	O	O
5	I found the various functions in the system were well integrated.		O	O	O	O	O
6	I thought there was too much inconsistency in this system.		O	O	O	O	O
7	I would imagine that most people would learn to use this system very quickly.		O	O	O	O	O
8	I found the system very cumbersome to use.		O	O	O	O	O
9	I felt very confident using the system.		O	O	O	O	O
10	I needed to learn a lot of things before I could get going with this system.		O	O	O	O	O

To compute the usability score from each respondent, the following steps are applied.

1. For odd-numbered items: Subtract 1 from the respondent response.
2. For even-numbered items: Subtract the respondent response from 5.
3. Get the sum of the converted responses and multiply that total by 2.5.

Once the usability scores from each respondent are computed, their average is obtained. If the usability score is higher than the mean global score of 68, this means that the system or app being evaluated is relatively usable. Furthermore, another survey with the following items was also given. The respondents were asked to rate each item, from 1 (strongly agree) to 5 (strongly disagree).

1. "The AR-enhanced material is better than the printed material alone."
2. "AR enhances my learning experience."
3. "I will recommend it to training institutions."

Results and Discussions

Existing AR Initiatives

Computers have been adopted in some healthcare services. They are embedded in several nursing bedside instruments such as ventilators, electrocardiogram monitors, etc. Similar to AR, the

integration of digital information with live video was first introduced in healthcare service in an operating room to assist surgeons (Fuchs et al., 1998). Afterward, AR has been adopted in several healthcare activities. For example, AR provides crucial information on patients' status directly to their glasses (Hasvold, 2002), giving surgeons virtual x-ray vision which used relayed images from an endoscopic surgical camera through keyhole incisions, and revealing hidden vessels inside organs during operation via AR iPad app (Vaterlaus-Staby, 2015). Furthermore, AR has been applied and increasingly used in healthcare education since 2002. For some instances, AR was adopted in several subjects such as endotracheal intubation, clinical breast examination, laparoscopic surgery, and life support training (Zhu et al., 2014).

In nursing, AR has been used in nursing education activities earlier than in nursing services. An example is Evena's glasses, which is computer-powered with high-tech 3D light imaging system. It was used by nurses to visualize the blood flowing through the veins of patients and capture images of the veins on the skin layer (Hirschberg et al., 2014). Another is a tablet-based AR system used for training nursing staff in interacting with patients, to build up empathy and to promote caring approaches, while delivering technical skills (Bichlmele, 2014). In 2010, the School of Nursing and Midwifery and the Health Information Technology Lab at the University of Tasmania, Australia applied AR in patient health assessment to visualize organs and its functions underneath the skin (University of Tasmania, 2010). In 2013, Sheffield Hallam University also introduced AR in the nurse training and midwifery curriculum. They adopted this technology through iPads to learn real-life situation regarding patients' reactions and emotions (Pultarova, 2013). In Denmark, AR was also undertaken as a project aiming to create a realistic visualization of parts of the human body to enhance their learning outcomes (Rahn and Kjaergaard, 2014).

Selection of Relevant Technologies

In choosing the most appropriate tool/s used in this exploration, several cloud-based AR tools were first examined and compared. The selection was based on the following factors:

1. A free license is available. This is the primary consideration due to the limited budget of the researchers.
2. AR scenarios and content can be easily created and tested. Programmers and non-programmers alike should able to create any AR scene easily.
3. The AR tool is widely used. A tool that is widely used speaks of its credibility and reliability.

Based on the considerations as mentioned above, Wikitude, Vuforia and CraftAR were shortlisted. These tools are described below:

Wikitude, the first publicly available application that uses a location-based approach, was initially released in 2008 (Arth et al., 2015). Its features include image recognition and tracking, and geolocation technologies (Figueiredo et al., 2014). Touted as the world's leading augmented reality tool, it has received numerous awards including the Best AR Tool in 2012 (Marden, 2011). Wikitude offers free/trial and commercial licenses. The trial license, however, limits 1,000 calls to the cloud recognition service per month and the AR content created bears a watermark ("Wikitude Cloud Recognition", n.d.). Moreover, Wikitude provides a software development toolkit (SDK) for programmers and a drag-and-drop interface for non-programmers. Wikitude has more than 100,000 registered developers and is used for over 10,000 published AR-based apps ("Wikitude - The World's leading Augmented Reality SDK", n.d.).

Vuforia uses computer vision to recognize and track planar images and simple 3D objects (Park & Park, 2014). It was formerly known as QCAR when Qualcomm released it in 2011 (Arth et al., 2015). In 2015, Qualcomm sold its business unit responsible for Vuforia to PTC. At present, Vuforia still provides a free, starter license that limits recognition of images to 1,000 scans per month (Baldwin, 2014). Creating a simple app in Vuforia requires a series of steps that include programming using the provided SDK. There are over 25,000 AR apps powered by Vuforia (Takahashi, 2016).

CraftAR has an SDK and a Web-based drag-and-drop interface as well. Released in 2014, CraftAR was intended to provide an easy and convenient way of creating AR content, especially for businesses and brands (Woods, 2014). It allows user interaction tracking and analysis. CraftAR offers free and commercial licenses. An AR content created using the free license can only be scanned 1,000 times per month ("CraftAR Service", n.d.). Since CraftAR is relatively recent, figures on the community of developers and the number of published apps are not yet available.

Table 1 summarizes the comparison of the three shortlisted tools. Among them, CraftAR was eventually selected for the implementation of the prototype. Firstly, the shortlisted AR tools all provide free licenses, though there are certain limitations. An example is that an image to be used for AR purposes can only be scanned 1,000 times per month. Another limitation that makes Wikitude the least preferred is that a watermark is automatically appended to the AR content, which can be distracting to the users.

Table 1. Comparison of Wikitude, Vuforia, and CraftAR

AR Tool	License Available	Creation of AR Content	Range of Use
Wikitude	Free/trial and commercial licenses	Through a drag-and-drop interface and an SDK	100,000+ developers, 10,000 published apps
Vuforia	Free and commercial licenses	Through an SDK	25,000+ published apps
CraftAR	Free and commercial licenses	Through a drag-and-drop interface and an SDK	No figures available yet

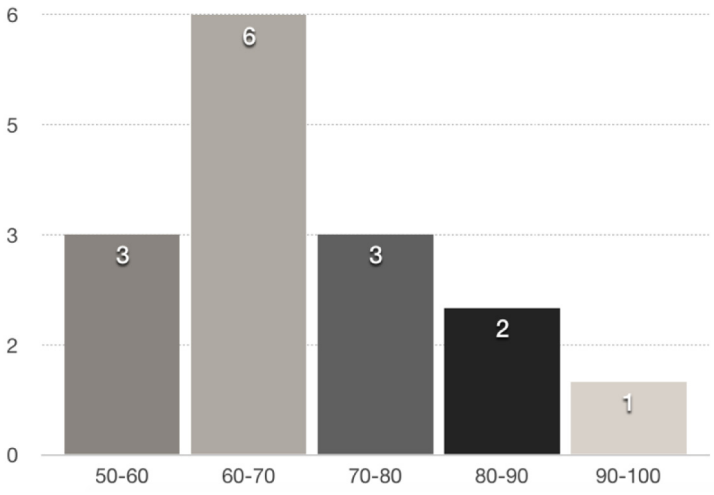
Secondly, an SDK is used by programmers to write a highly-customized AR content by coding. On the other hand, a drag-and-drop interface is beneficial to technologically challenged persons who do not possess any prior programming experience, and this allows them to create an AR content conveniently. Buttons, videos, and 3D models can easily be placed to create an AR environment. Wikitude and CraftAR provide both, while Vuforia only offers an SDK.

Thirdly, based on the recent number of published apps, Vuforia is the most widely used AR tool among the three. Though figures are not available for CraftAR, the company behind the said tool is trusted by several globally recognized brands, including Intel and Bosch.

Results of the System Usability Survey

Based on the SUS survey given to 17 respondents, the prototype obtained an SUS score of 68.5937, which is slightly higher than the mean global score of 68. This implies that the AR app, to a small degree notwithstanding, is relatively usable. The histogram of SUS scores among the respondents is shown in Figure 7.

Figure 7. Histogram of SUS scores given by the respondent



Results of the Additional Survey Items

The answers to the additional survey items were also collated. The first item obtained an average rating of 4.5294 and 14 out of 17 respondents agreed (those who chose a rating of 4 or 5) that the material enhanced by AR is better than the printed material as shown in Figure 8.

Figure 8. Summary of responses for the item on whether the AR-enhanced material is better than the printed material

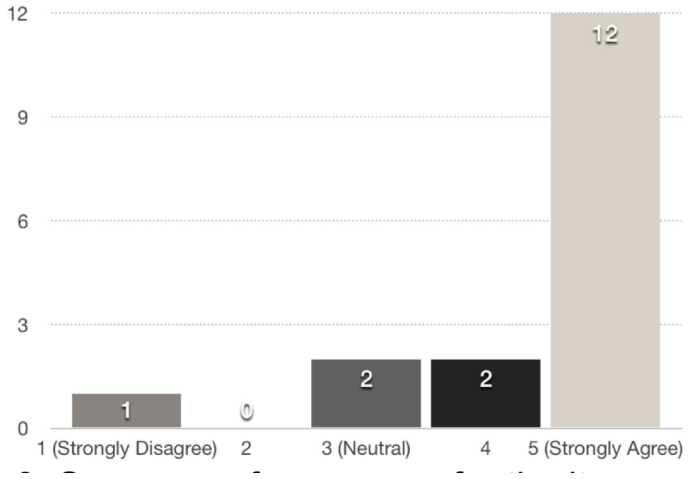
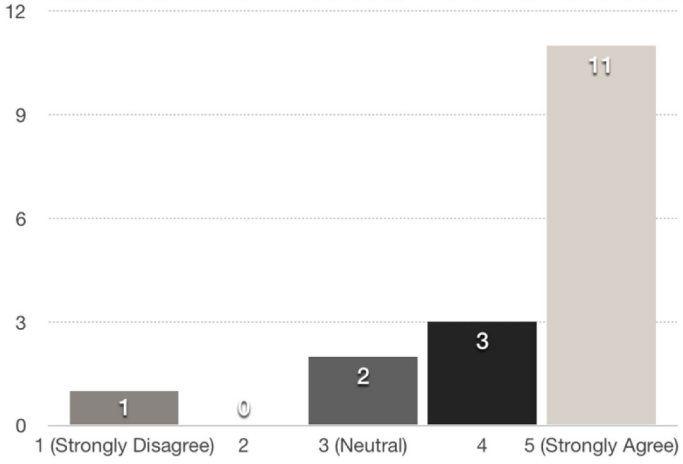
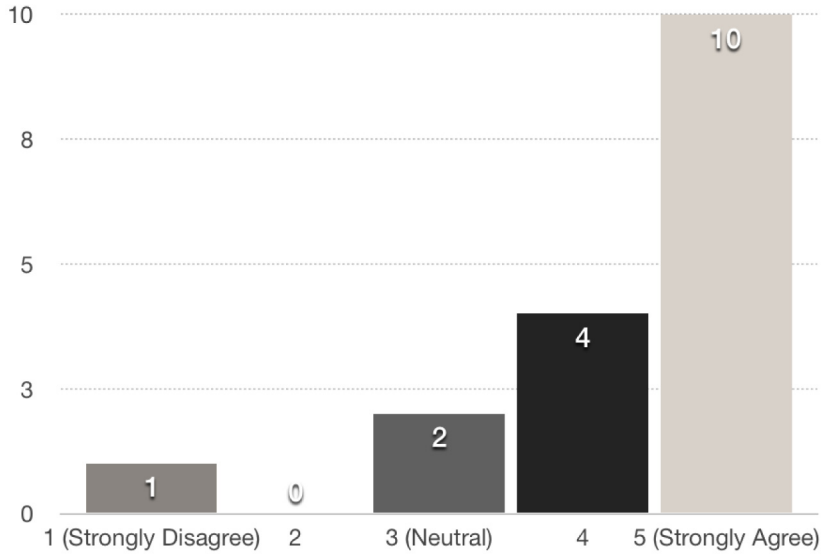


Figure 9. Summary of responses for the item on whether AR enhances learning experience



The second item acquired an average rating of 4.3529, with 14 out of 17 respondents agreeing that AR has enhanced their learning experience as shown in Figure 9.

Figure 10. Summary of responses for the item on recommending AR-enhanced materials to educational and training institutions



Finally, for the third item that has an average rating of 4.3529, 14 out of 17 respondents said that they would recommend the AR-enhanced materials to training institutions. This is illustrated by the graph in Figure 10.

Conclusion and Recommendation

This exploration has determined existing AR initiatives in nursing and these initiatives originated from developed countries. Albeit a relatively new and seemingly expensive technology, AR can be used by budget constrained and technologically challenged implementers from developing countries in the ASEAN such as the Philippines and Thailand. This is evidenced in the selection of an appropriate AR tool that is free and easy to use, and in the utilization of that tool in developing a learning material prototype on English nursing communication. Moreover, the prototype, a talking comic strip, has been well-received and proven to be usable for learning.

AR is a recent technology that is still evolving as of this moment. In this regard, future studies shall include a fresh round of survey of newly released and updated AR tools that might better address the limitations faced by the implementers. Enhancement of the talking comic strip shall also be made to improve the prototype's usability further. Factors such as sustainability and accessibility shall be considered as well.

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