ARSci: A 3D Augmented Reality-Based Learning Tool in Earth Science

Crissel Lyka Arce[1], John Jeric Cabuyaban[2], Sandra Kate Gaces[3], Wilben Christie Pagtaconan[4]

Mariano Marcos State University, Department of Computer Science, City of Batac, Ilocos Norte, Philippines

ARTICLE INFORMATION

Corresponding author: Wilben Christie Pagtaconan (wrpagtaconan@mmsu.edu.ph)

ABSTRACT

This paper discusses the development of a 3D augmented reality-based application named ARSci, which includes three aspects: 1) determining the level of technology integration among the Science teachers; 2) designed and developed the ARSci application; and 3) conducting users' acceptance testing. The ARSci application covers selected topics in Earth Science for Junior High School. The study determined the level of technology integration of a science teacher. Scrum Methodology was used for the software development. This study provides a different way of learning and gives an outlook on the potentials of AR in teaching and learning. The ARSci application can be used not only inside the classroom but anywhere and anytime. The study does not cover the assessment on the effectiveness of the application to the learners. However, it is recommended that an assessment would be done to understand the effectiveness of the application.

Introduction

E-learning provides limitless access to learning outside the traditional classroom and is continuously on the rise. Fundamentally, e-learning incorporates all educational activities, which are done by individuals or groups working online or offline, and synchronously or asynchronously via networked or standalone computers or via other electronic devices like smartphones (Naidu, 2006). People can acquire knowledge anytime and anywhere. Some forms of e-learning online course or learning, web-based learning, and web-based training, learning objects or learning tools include.

Augmented Reality (AR) is a new technology that is currently developing and expanding its flexibility. This technology has also a great potential as a learning tool for students. AR's power is on its ability to enable students to see the world around them in new ways and engage them in realistic issues in a context in which the students are already connected. This technology provides a new dimension of learning not just for students

but for everyone by merging real and virtual environments (Klopfer & Sheldon, 2010).

The Substitution Augmentation Modification Redefinition (SAMR) Model for integrating technology into teaching, has gained a good deal of exposure in recent years. The model provides a technique for moving through degrees of technology adoption to find more meaningful uses of technology in teaching and move away from simply using "tech for tech's sake" (Walsh, 2015). Hence, Augmented Reality is appropriate in achieving the level of technology integration of teachers from enhancement to transformation level.

Nowadays, technology can be found anywhere and it provides countless ways of improving life. The Center for Applied Research in Educational Technology (CARET) found out that when technology integration is used in collaborative learning methods and leadership that is aimed at improving the school, technology impacts achievement in content area learning and promotes higher-order thinking and problem solving skills (Why Do We Need Technology Integration?, 2007).

Apparently, the concept of the Science curriculum is to integrate Science and Technology in the civic, personal, social, economic, and the values and ethical aspects of life. Furthermore, science as a subject or course promote a strong link between Science and Technology, including indigenous technology, keeping our country's cultural uniqueness and peculiarities intact. The goal of the Science curriculum is to provide learners with a repertoire of competencies important in the world of work and in a knowledge-based society (Department of Education, 2013).

However, the current state of educational system in the country especially in the public schools is the lack of textbooks. In fact, as of 2015, the Department of Education (DepEd) received higher budget than 2014 to fulfill the limitations of textbooks yet millions of books remain undelivered and hundreds of them are riddled with typographical and grammatical errors. There were digital versions of the textbooks offered but most available materials are just lesson guides (Ortilla, 2015). Additionally, based from the non-formal interview conducted by the researchers with teachers and other stakeholders, there is a lack of learning material. Furthermore, the use of audio-visual aids stirs the imagination, thinking process and reasoning power of the students since these are more effective than verbal. Absence or lack of these can be a reason to not understand the lesson well (Samutha, 2013).

Hence, this research was conceptualized to provide a supplementary learning material to the learners.

Purposes of the Research

The study aimed to design and develop an augmented reality-based learning tool for students that introduces a new technology in learning. Moreover, the researchers intended to 1) determine the level of technology integration of Science teachers in teaching; 2) design and develop the augmented reality application; and 3) conduct a user acceptance testing.

Methodology

Descriptive and developmental types of research were utilized during the conduct of this study. Descriptive research was used to describe the level of technology integration of science teachers. This was used in identifying the subject matter, contents of the application, and in determining the users' acceptability of the ARSci.

Table 1

Levels of technology integration matrix.

| Level	Description
Entry	The teacher begins to use technology tools to deliver curriculum content to students.
Adoption	The teacher directs students in the conventional and procedural use of technology tools.
Adaptation	The teacher facilitates students in exploring and independently using technology tools.
Infusion	The teacher provides the learning context and the technology tools to achieve the outcome.
Transformation	The teacher encourages the innovative use of technology tools. Technology tools are used to facilitate higher order of learning activities that may have not possible without the use of technology.
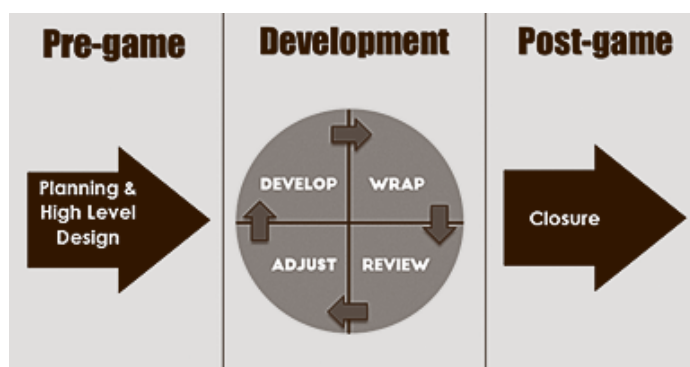
Figure 1. Scrum Methodology.

To determine the level of technology integration of science teachers in teaching, ten (10) science teachers of the Mariano Marcos State University – Science and Laboratory High Schools were considered as respondents. Thirty (30) randomly selected Junior High School students and ten Science teachers served as respondents in the sampled university.

Research Instrument

Table 1 shows the technology integration matrix used in understanding the level of technology integration of science teachers in teaching. While appendix A shows the 5-point Likert scale used in analyzing the results of the users acceptance test (UAT) as shown Appendix C.

Data Collection and Analysis

To determine the level of technology integration of science teachers in teaching, a survey questionnaire (*Appendix A*) was provided to the respondents. Also, interviews with the science teachers were conducted.

Design and Development of the Augmented Reality Application

The researchers made use of the Scrum Methodology. This methodology is an agile method and is commonly used in software development (Clifton & Dunlap, 2003). The phases of the Scrum Methodology are presented in Figure 1.

Pre-game. Pre-game is the preliminary phase that includes planning and high level design. Contents of the application were based from the K to 12 Science Curriculum
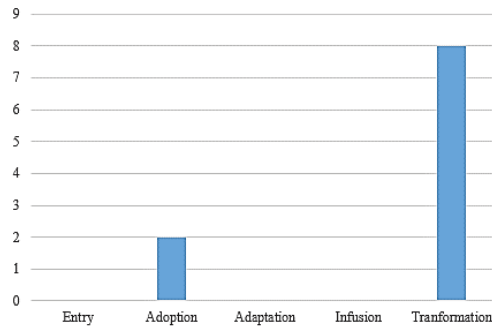
Figure 2. Result of the level of technology integration survey.

and learning materials such as books and teaching guides obtained from the Science teachers.

To create a good design of the application, review of related concepts and applications was undertaken through online research. Logical designs such as logical framework, use case diagram, and screen prototypes were prepared.

Development. The researchers carried out the arranged activities based on the logical designs produced in the Pre-game phase. The researchers made use of the following development software and tools in creating the application: Qualcomm® Vuforia – an augmented reality SDK; Unity Game Engine; Android Studio; Cinema 4D; Blender; and Photoshop.

The researchers checked the application by testing the Unity Module, 3D models and trackers to prepare for validation. Also, to ensure the correctness of the content of the application, a content validation by the Science teachers was conducted. Any errors identified during the content validation were fixed to improve the application.

Post-game. The researchers finalized the application and prepared the implementation plan.

User Acceptance Testing

The user acceptance test (UAT) determined the acceptability of the application based on the following criteria: design and layout; usability; learnability; efficiency; errors; and satisfaction. The respondents were given the chance to use the application and evaluated the application using the UAT questionnaire (*Appendix B*). the UAT were tabulated and the researchers computed the overall mean. The overall mean was used to interpret the result based from the Likert scale in Appendix C.

Results and Discussion

This section presents the results of the study that includes results from the conducted survey on the level of technology integration to teachers, design and development of the application, and the user acceptance testing.

Level of Technology Integration

Based from the survey conducted, Science teacher respondents are using teaching tools such as books; handouts, chalk and board, PowerPoint presentation and visual aids.

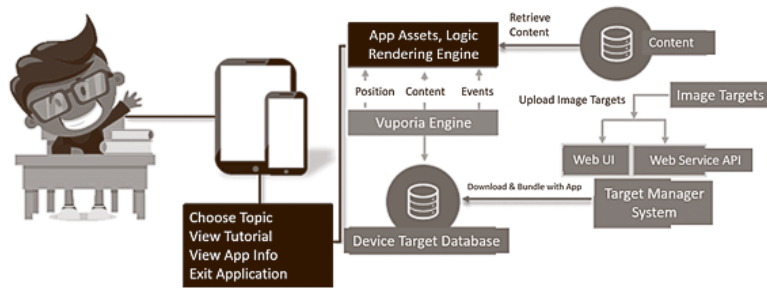In terms of the level of technology integration the survey conducted among the Science teachers shows (Figure 2)

Figure 3. *Logical Framework*

Figure 4. User interface of the ARSci Application

that 20% (2 out of 10) of the respondents assessed themselves within the adaption stage. This means that said teachers guide students in procedural use of technology tools. Furthermore, 80% (8 out of 10) of the respondents are under transformation level wherein the teachers use technology to facilitate higher order learning activities that may not have been possible without the use of technology. Transformation level, on the other hand, promotes teachers cultivate a rich learning environment, where blending variety of technology tools with student-initiated projects, and activities, across any content area (Arizona Technology Integration Matrix, n.d.).

System Design and Development

The overall view of the developed ARSci application and its relationship to the user is shown in Figure 3 – Logical framework. A user simply uses smartphone to use the ARSci application and the application executes the processes. The ARSci application is powered by Unity and runs only in smartphones and tablets running Android 4.4 operating system.

The ARSci application consists of following selected topics in Earth Science for Junior High School:

- The Philippine environment
- Seasons in the Philippines
- Eclipses
- Earthquakes and faults
- Other members of the Solar System
- Volcanoes
- Climate
- Constellations
- Plate tectonics

Figure 4 shows the user interface also known as the physical design of the ARSci application. The main menu consists of 4 buttons namely *Choose Topic*, *View Tutorial*, *About*, and *Quit*.
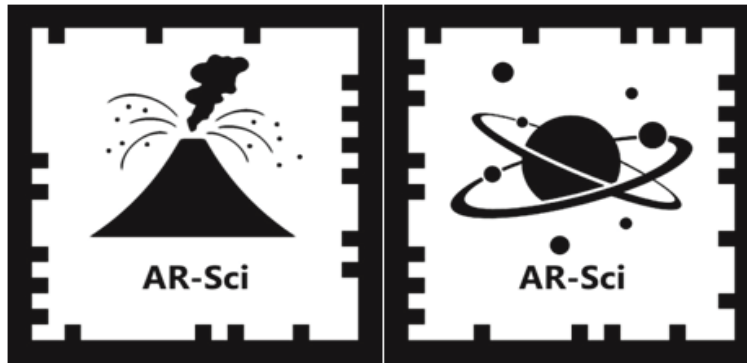
Figure 5. Sample Trackers.

Table 3.
User acceptance test summary of results.

Criteria	Mean	Descriptive Equivalent
1. Design and layout	4.96	Strongly Agree
2. Usability	4.89	Strongly Agree
3. Learnability	4.99	Strongly Agree
4. Efficiency	4.96	Strongly Agree
5. Errors	4.73	Strongly Agree
6. Satisfaction	4.96	Strongly Agree
Overall mean	4.92	Strongly Agree

The sample tracker used in simulating 3D models is presented in Figure 5, the tacker serves as trigger of the ARSci application to be able to display the images of the selected topics.

Through the developed ARSci application, the use of applications in mobile devices is a potential tool to support teaching and learning. Also, its mobility makes it stand apart from other types of learning and the new learning environment that makes the most of the opportunities it could offer. Although some say that physical books count as mobile devices too, mobile devices have distinct features and functionality for supporting learners (Tuliao, Duldulao, Pagtaconan, & Galang, 2015).

User Acceptance Test Result

After the development process, a UAT was conducted. As a result, respondents showed a positive response on the acceptability of the ARSci application. The computed overall mean is 4.92 which means that the students and teachers *strongly agreed* with all the requirements and expectations of the users of the ARSci application as reflected in Table 3.

Based from the results, all the six (6) criteria marked *strongly agree* from the respondents' responses. This implies that the ARSci application passed the software evaluation process handled by the target users. The UAT conducted is the last phase of the software testing process (Eriksson, 2016). Hence, the application is ready for production or implementation.

Conclusion and Recommendations

Conclusion

This study aimed to design and develop an augmented reality based learning application names ARSci. The developed ARSci application provides a new tool and a supplementary tool in teaching and learning Earth Science. Also, it offers a user-friendly environment for learners.

Augmented Reality (AR) is one of the products of technology that brings a new dimension of learning. Since most Science teachers are under transformation level in terms of technology integration, the potential of introducing the ARSci application in their teaching is high. With this, students can access their lessons anytime and anywhere which offers possible opportunities to support teaching and learning.

In addition, it is also noted that based from the UAT conducted, the ARSci application is acceptable to users. With this, learning materials can be transformed from prints to interactive applications (computer or mobile-based).

Recommendations

Through careful analysis and design of the system, the researchers recommend that the ARSci application should have more lessons to be incorporated. Since the application was developed using Android platform, only Android-based devices are capable in running the application. Hence, it is suggested that same application be developed to cater the other mobile operating systems.

On the other hand, the effectiveness of the ARSci application to the learning and teaching process should also be evaluated to understand the strength and weaknesses of the developed application towards teaching and learning process. Also, other researchers may deem to develop an application for other subject areas using the same technology and methodology.

• • •

References

Arizona Technology Integration Matrix. (n.d.). Retrieved from Arizona K12 Center: http://www.azk12.org/tim/.

Clifton, M., & Dunlap, J. (2003, August). *What is SCRUM?* Retrieved from Code Project: http://www.codeproject.com/Articles/4798/What-is-SCRUM.

Department of Education. (2013, December). *K to 12 Curriculum Guide - Science for Grade 3 to Grade 10.* Retrieved from http://www.deped.gov.ph.

Eriksson, U. (2016, September 29). *The Ultimate Guide to User Acceptance Testing Template Design*. Retrieved from ReQtest: https://reqtest.com/testing-blog/ultimate-guide-to-user-acceptance-testing/.

Klopfer, E., & Sheldon, F. (2010). Augmenting your own reality: Student authoring of science-based augmented reality games. *New Directions for Youth Development*, 85-94.

Naidu, S. (2006). *E-Learning A Guidebook of Principles, Procedures and Practices.* New Delhi: Commonwealth Educational Media Center of Asia (CEMCA).

Ortilla, M. (2015, June 25). *Problems hounding K-to-12 program (Part 2): Errors in textbooks*. Retrieved from CNN Philippines: http://cnnphilippines.com/incoming/2015/06/25/Problems-hounding-K-to-12-program-Part-2-Errors-in-textbooks.html

Samutha, G. (2013, November 15). *Teaching Aids (Audio Visual Aids)*. Retrieved from Teaching of Physical Science: http://gsamutha.blogspot.com/2013/11/teaching-aids-audio-visual-aids-meaning.html.

Tuliao, D. P., Duldulao, T., Pagtaconan, W. C., & Galang, A. A. (2015). Development of a Mobile Learning Application for Kindergarten: Process, Issues, and Challenges. *International Journal on Open and Distance e-Learning (IJODeL)*, 15-25.

Walsh, K. (2015, April 20). *8 Examples of Transforming Lessons Through the SAMR Cycle*. Retrieved from EmergingEdTech: https://www.emergingedtech.com/2015/04/examples-of-transforming-lessons-through-samr/.

Why Do We Need Technology Integration? (2007, November). Retrieved from Edutopia: https://www.edutopia.org/technology-integration-guide-importance.

Appendices

Appendix A

SURVEY QUESTIONNAIRE

Name (optional):_____ Date: _____

Instructions: Please answer the following questions honestly. Check the box(es) of your choice. Also, feel free to write your answer in the space provided if your answer is not included in the choice given.

1. What ICT-based tools do you use? (Please check all that apply.)
   - ☐ Word Processors
   - ☐ Presentation Software
   - ☐ Spreadsheets
   - ☐ PDF
   - ☐ Others, please specify: _____

2. Do you use software-based tools as a medium in giving activities, assignments and learning modules?
   - ☐ Yes
   - ☐ No

   2.1 If yes, what software-based tools do you use? (Please check all that apply.)
   - ☐ Schoology
   - ☐ Edmodo
   - ☐ Facebook
   - ☐ Others, please specify: _____

3. Do you allow your students use their smartphones, laptops or gadgets in class?
   - ☐ Yes
   - ☐ No

   3.1 To what extent do you allow them?
   - ☐ For Activities
   - ☐ For Exam
   - ☐ Others, please specify: _____

4. What is your level of technology integration? (Please choose one)
   - ☐ Uses technology to deliver the lessons to students.
   - ☐ Directs the students in the conventional and procedural use of technology tools.
   - ☐ Facilitates students in exploring and independently using technology tools.
   - ☐ Provides the learning context and students choose the technology tools to achieve the outcome.
   - ☐ Uses technology tools to facilitate higher order learning activities that may not have been possible without the use of technology.

Appendix B

USER ACCEPTANCE TEST

Name: _____

Age: _____   **Gender**: _____

Instruction: Please fill out the evaluation form completely and place a check mark corresponding to your evaluation. Thank you very much.

Rating: 5 Strongly Agree, 4-Agree, 3-Fair, 2-Disagree, 1-Strongly Disagree

CRITERIA	Rating				
	5	4	3	2	1
1. Design and Layout					
- The fonts, color, and buttons are consistent all throughout the application					
- The buttons perform their designated operations or actions.					
- ARSci is compatible to any screen size.					
2. Usability					
- The application is easy to learn, easy to use and enjoyable.					
- The words/descriptions can be read easily.					
3. Learnability					
- ARSci contains informative lessons.					
- It provides visuals for the Earth Science topics.					
4. Efficiency					
- All modules are working well and properly.					
- The 3D models are clear and interactive.					
5. Errors					
- The application displays the correct models.					
- ARSci is error-free.					
6. Satisfaction					
- The interactions offered by the application are satisfying.					

Appendix C

Appendix C. Scale to determine the acceptability of the application.

Quantitative Scale	Statistical Limit	Descriptive Equivalent
1	1.00 – 1.80	Strongly Disagree
2	1.81 – 2.60	Disagree
3	2.61 – 3.40	Fair
4	3.41 – 4.20	Agree
5	4.21 – 5.00	Strongly Agree