RESEARCH ARTICLE OPEN ACCESS

Planet Saga: A Gamified Learning Application Using Augmented Reality

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Abstract –

This study provides a brief overview of existing augmented reality applications for learning and the development of a gamified learning application using a game card marker and a smartphone. The study also would want to find out the significant effect on the student's learning while using this application.The main goal of this research project is to solve the non-existence and lack of utilizing augmented reality on a gamified learning application provided the benefits found on this technology, it is then concluded that the development and used of a gamified learning application using augmented reality that creates a playful, engaging and a social learning environment has a significant effect in the student's learning based on the statistical evidence gathered from the test. Where the researchers found out that those students who played the app has a higher average score compared to those students who read the booklet.

Keywords – **Augmented, Gamified, Learning application, Technology, Student learning.**

INTRODUCTION

A. Background and Rationale

Emergent technologies such as IoT, augmented reality and virtual reality are playing a more important role than ever with nearly 90% of respondents already using some form of virtual or augmented reality in their business, and 42% using demos or interactive tools to help improve employee and customer interactions with products and services(Maddox, 2016). Not only this but emergent technologies are also applied in enhancing learning through technology.

In the recent years, researches in technology-enhanced learning has increasingly focused on emergent technologies such as augmented reality, ubiquitous learning(u-learning), mobile learning(m-learning), serious games and learning analytics for improving the satisfaction and experiences of the user in enrich multimodal learning environment(Bacca et al, 2014). These researches takes advantage of technological innovations in hardware and software for mobile devices, as well as the popularity among the people. In particular, augmented reality(AR) can now be used in various fields of learning such as in biology, chemistry and astronomy. It has also proven its usefulness in handing-out abstract information that are critical for students to learn.

Augmented reality creates a bridge between the real world and virtual world in a seamless way(Lee, 2012), supplementing real world objects with virtual objects. As a result augmented reality is closer to the real world. However augmented reality is not only limited to seeing virtual objects but AR adds graphics, sounds, haptic feedback and smell to the real world with virtual objects. Virtual reality on the other hand expects people to immerse in a computer-generated virtual environment(Lee, 2012). In short, AR supplements reality rather than replacing it(Bacca et al, 2014).

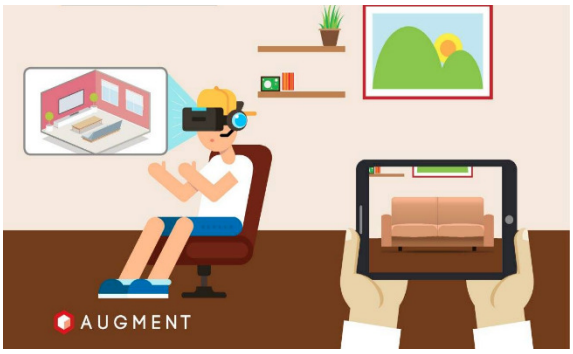


Figure 1 Virtual and Augmented Reality

In regards to researches and studies in augmented reality in the field of education science category emerge to have the most data having a percentage of 40%. This only shows that the most researches done in AR in education has been concentrated on identifying the benefits of AR in science education. A study also showed that purpose of using AR in education is effective in explaining the topic(43.75%) and delivering augmented information(40.63%). Also by using AR as an educational game having a percentage of 18.75%. Although showing good percentage on the study of the purpose of AR in education, there were no studies with the focus on using AR for evaluating a topic. In regards to the advantages of AR in education there are numerous advantages as such learning gains, motivation, collaboration, facility interaction and collaboration. Lastly in regards to how effective using AR in education there are a few as such better learning performance, learning motivation, student engagement and improved perceived enjoyment(Bacca et al, 2014).
Moreover, AR in education is not only limited to studies and researches, but their are already existing applications. AR Applications in education includes Anatomy(6.9%), Astronomy(10.3%), General Science(3.4%), Architecture(13.8%), Chemistry(3.4%), History(3.4%) and Math(3.4%).

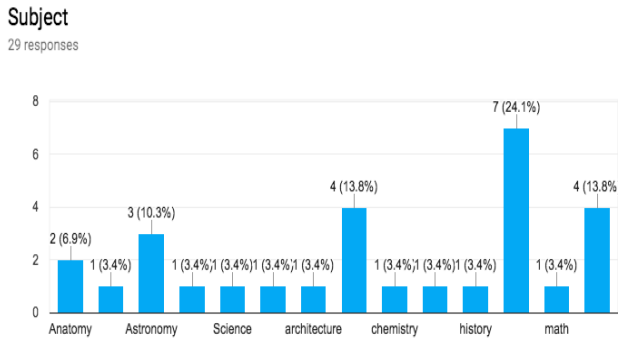


Figure 2 Survey on augmented reality application in education per subject

In the field of AR in science education especially in Astronomy most of the application prototypes that design to teach astronomy is 66.7% visual aids and 44.4% reference. As to AR specific application there is only 55.6%. In regards to game-based learning there is only 11.1%. This would also mean that there is a lack of a gamified tool in this category.

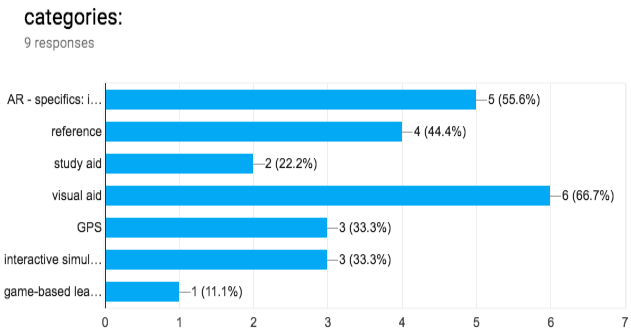


Figure 3 Survey on augmented reality application per category

Games can change the way people think and behave and with games students become more engaged in their learning and taught content is reinforced and class positivity is increased. Playing games in the classroom benefits the students by motivation, controlled competitiveness, strategy simulator, smaller stress, mighty memory, class cooperation, alert attention, new knowledge and friendly fun(V., 2017). Games are also described for STEM(science, technology, engineering, math) education positioned as a way to foster scientific explorations and that online games provide a

safe space for trial and error especially for low-performing students(Larkin, 2015).

Moreover, integrating augmented reality in games especially in the field of education creates an eye-catching presentations that captures that attention of audience, interactive lessons can gain a better understanding of the concepts they are studying, portable and less expensive learning materials, higher retention and foster intellectual curiosity as they will be excited by new ideas and think critically about the world around them.(Augment, 2015)

In assessing students learning through a game it must not be solely on the gameplay experience and it is not best to compare learning games with commercial games because effective learning games are designed with specific learnings outcomes and they are made to serve a distinct purpose. Assessing comprehensive learning is done by incorporating the game with the traditional classroom teaching methods but the game won't be a stand-alone activity. Also games are a teaching tool that will be used to teach difficult concepts as such spatial and abstract concepts.(Shanahan, 2017)

Moreover pure assessment by giving test to the students would not conclude that the application is capable of handling effective learning through the means of games. Statistics play a vital role in determining the effectivity of the assessment. A good type of statistical test to use is the t-test. Student t-test analyzes two populations means through the use of statistical examination(Investopedia, LLC.,n.d.). This is commonly used with small sample sizes and testing the relationship among the given sets of data.

With these indications the researchers have come up with a study to develop a gamified learning application using augmented reality and an assessment of students' learning. Although there are numerous study in augmented reality in the field of science, there are only a few interactive applications and most of these applications are visual aids and references. Also, provided the benefits of using the game in learning and integrating the benefits of augmented reality in education.

The general problem of this study is the non-existence and lack of utilizing Augmented Reality on a gamified learning application as a tool for learning.

Research Objectives

The study aims to develop a gamified learning application using augmented reality to have an interactive and fun way of learning while finding out if the application has a significant effect on the student's learning.

Design a gamified augmented reality mobile application with easy-to-use interface that could usually run on smartphones and work together with a game card.

Develop a gamified learning platform using augmented reality that creates a playful, engaging and a self-learning tool.

Test the usability and the significance of the Interactive Augmented Reality Learning Application to the Grade 4 students.

Extended tracking allows the tracking a degree of persistence once a target has been detected. As the target goes out of view, Vuforia uses other information from the environment to infer the target position by visually tracking the environment. Vuforia builds a map around the target specifically for this purpose and assumes that both the environment and target are largely static.

B. *Review of Related Literature*

According to Firmin and Genesi (2013), technology is rapidly changing the way we live and work. The field of education is not an exception for this, in fact during the late 1990s, new technologies were being designed and invented almost monthly. At that time education was the primary target for those eager researchers who wanted to see if their product could transform education.

Over the years, different countries were continuing and successfully integrating information and communication technologies(ICTs) into the education of their students. Educators are encouraged to make the best use of available technology in order to benefit nation's, schools, surrounding

communities, and most importantly, the students. In other words students must be equipped with skills that will help them thrive in the future.

1) Overview of ICT in Education

Most educational technologies today fall under the category of Information Communication Technologies (ICTs). ICT covers any product that can store, retrieve, manipulate or transmit information electronically in a digital form. Some examples of ICT include Microsoft Word, Excel, PowerPoint, Adobe Indesign, Photoshop and Illustrator, email, video conferences, digital cameras, CD-ROMs, fax machines, and of course, the World Wide Web (Firmin and Genesi, 2013).

As mentioned ICT is simply a tool for educators to implement and integrate into their daily instruction. It is the teacher's responsibility to take the time to learn how to use it effectively (Firmin and Genesi, 2013).

ICT integration in classrooms is becoming more and more prevalent in schools today. Every classroom,however, has its own unique culture which ultimately affects how ICT is integrated and implemented into daily instruction (Firmin and Genesi, 2013).The classroom culture is influenced by a vast variety of people and circumstances. There are national and global influences, not to mention the influences of the school culture and subject culture.

According Firmin and Genesi (2013), they found a significant correlation between levels of ICT use and teachers' attitudes. Their study showed that those teachers who were more inclined to see the benefits of ICT use for themselves and their students tended to use ICT more often. Those teachers who were prone to experience problems and worries tended to use ICT less because the difficulties and mishaps seemed to outweigh the possible benefits. Interestingly, study showed that those who taught mathematics or science had a more negative attitude toward ICT, while those teachers who taught business and management classes had a more positive attitude towards ICT. ICT use does depend on many factors, as mentioned above. But still in the end, study found that teachers are ultimately the most important agents of change in the classroom.

2)Implementing ICT in Today's Classrooms – The Benefits

Implementing ICT into classroom instruction also has its barriers and limitations. According to Firmin and Genesi (2013), the main reason given by primary teachers for not using ICT was the lack of availability of ICT resources. Therefore, the difficulty of access to technology tended to override all other factors in determining the amount of ICT implementation.

Other factors that prevent the usage of ICT in classroom are the inadequacy felt of the instructors about their computer competence. Moreover, many teachers lack confidence in regards to using computers and other forms of ICT, it naturally shows that there would be some hesitancy on behalf of teachers who are required to implement ICT into their daily instruction. Other similar barriers given by primary educators are a lack of familiarity with ICT resources and a lack of skills in order to implement them effectively (Firmin and Genesi, 2013). As a consequence, the lack of confidence will bring burden to the education administrators to exert extra effort in providing training sessions and professional development in regards to usage of ICT beforehand. These training sessions, however, add an extra financial burden to many school districts. It would seem that cost or lack of technical support would be strong inhibiting factors to ICT use in the classroom (Firmin and Genesi, 2013).

3) Types of Game Learning

3.1 Computer Games in Education

In educational contexts, not only learners need to be able to enter the world of the game, but also be critical about the process, so as to be able to reflect upon their relationship with the game when viewed from outside. This suggests that creative learning through gaming requires substantial efforts from teachers, in order to achieve positive results (Al-Azawi et. al, 2016).

In today's information society, digital learning has the features of not being constrained by time and space. Being more attractive to learning attention of students compared to traditional instruction, can increase learning motivation;

promote problem-solving ability, which results in achieving better learning effects (Al-Azawi et. al, 2016). In other words video games have great positive potential in addition to their entertainment value and there has been considerable success when games are designed to address a specific problem or to teach a certain skill.
Despite the use of educational computer games in teaching many subjects, still there is a need for more games to teach several other subjects.

3.2 Gamification in Education

According to Al-Azawiet. al (2016), Gamification is the practice of using game design elements, game mechanics and game thinking in non-game activities to motivate participants. We could define gamification in a simple way as it is the use of all the factors of a game to enhance non-game contexts. This is the main function that gamification could provide to enhance a situation through the use of gaming mechanics.
Educational gamification proposes the use of game-like rule systems, player experiences and cultural roles to shape learners behavior. The benefits of gamification include: a) increased engagement; b) higher motivation levels; c) increased interaction with the user (customer or employee); and d) greater loyalty. For this reason, gamifying a course would be a great help to primary students by taking advantage of the motivational power of games and applying it to the motivational problems in education so that successful learning can take place.

3.3 Game-Based Learning

Game-Based Learning (GBL) is being used to encourage students to participate in learning while playing, and make the learning process more interesting by adding fun to the learning process (Al-Azawi et. al, 2016). The idea of combining the game and courses was formulated because traditional learning process is boring and game-based learning can improve learning motivation of students.
Al-Azawi et, believe that game-based learning can considerably help middle school science, technology, and mathematics education. Children also believe that digital game-based learning helps them to learn faster, and have greater interest in focusing on learning topics. Game-based learning just makes people feel as if they are playing computer games.

C. Methodology

The researchers of this study will develop an alternative and interactive learning environment using augmented reality technologies.
The augmented reality content includes exploratory of the topics from NASA Space Place: Explore Earth and Space and a battle boss feature after exploring those included topics.
The research study is going to be conducted based on the methodology. This methodology plays an important role in implementing this research study accordingly. The details of the methodology are explained in details in this chapter.

1) Planning Methodology

In this study, the researchers have conducted a survey and an interview at Oro Christian Grace School Science teachers to gather information about the learning methods they use to teach their students. The researchers has also reached Alubijid Elementary School for usability testing this January in one of the grade 4 classroom.
The design and development of an interactive learning environment that could usably run on smartphones. The researchers will use Unity + vuforia SDK, MySQLi, Sqlite and codeigniter in the development and blender3D, adobe illustrator and sketch app for the design tool.

2) System Architecture

The researchers will develop an augmented reality game through mobile application. The students will use the mobile application to test their knowledge in astronomy in accordance to the NASA Space Place: Explore Earth and Space. In the augmented reality system, a card will be given to the students which serves as the marker.

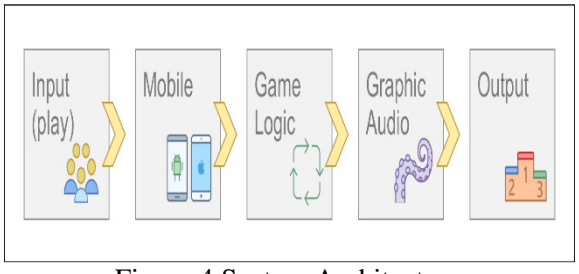


Figure 4 System Architecture

3) Augmented Reality System Usage Flow

In the usage of the augmented reality feature, users are expected to have a smartphone and the mobile application.

The flow consists of 3 steps. The first step is to open the app in the smartphone. The second step is to project their smartphones onto the game card and the third step is to play and enjoy.

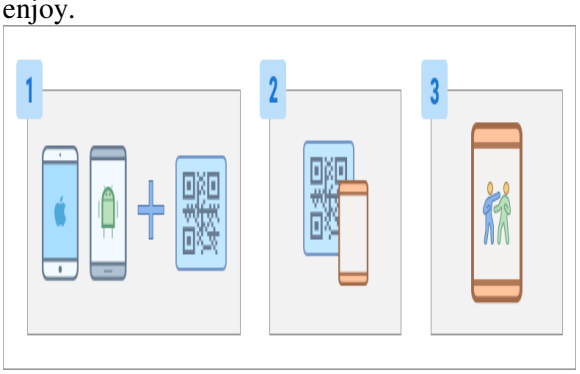


Figure 5
Represents the flow of user usage of the AR system

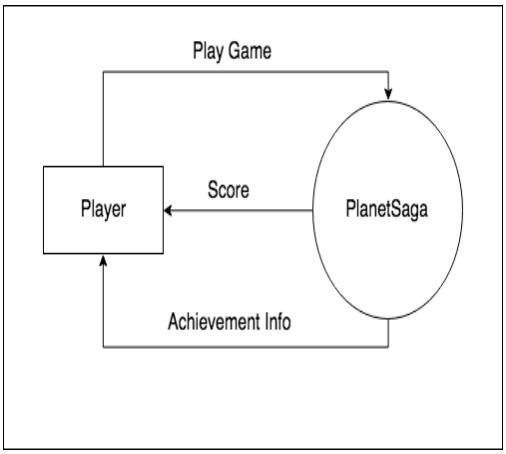


Figure 6 Context Diagram of the application

Figure 6 shows the context diagram of the application, the application contains 1 user which is the player who will be playing and using the application.

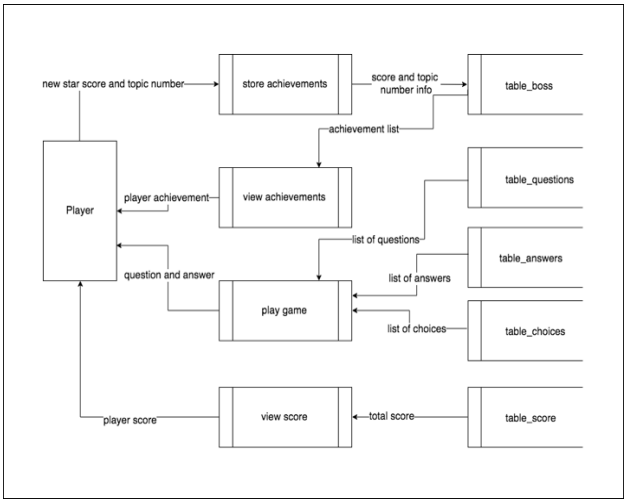


Figure 7 Dataflow Diagram for the player

Figure 7 shows the Dataflow Diagram for the player of the application. The player can view achievements, view score, and play the game.

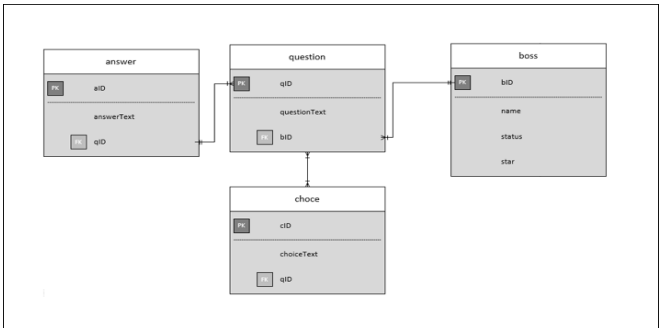


Figure 8 Database Design of the application

After formulating the process of the application, the researchers have come up to this database design. Figure 3.7 shows the database design of the application.

4) System Development

In the choice of development tools, we will use open source or free software and platforms as much as possible to minimize the cost and boost the future development productivity.

D. Results and Discussion

1) Planet Saga Augmented Reality Application

This chapter present the results and discussions of the methods outlined in the previous chapters. This study came up of developing a gamified learning application using augmented reality.

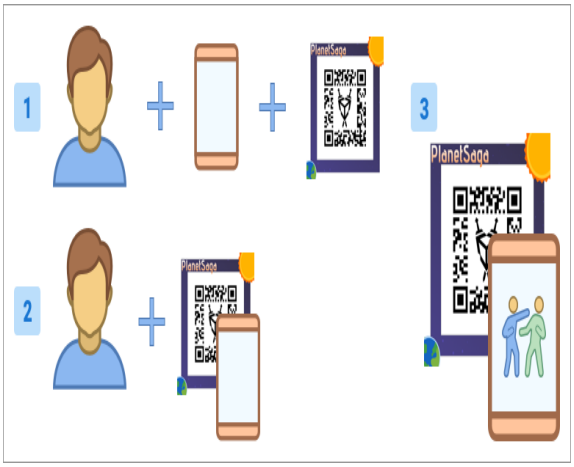


Figure 9 Planet Saga Interaction with Smartphone graphics view

2) Evaluation Result

The following graphs show the result of the evaluation from the students of Alubijid Elementary School. The researchers test the significance of the app by getting the result scores of the game then analyze it using T-test and the feedback from the students through a usability survey. Overall, there are 62 respondents in this research study consisting of 29 females and 33 males from two different sections.

In hypothesis testing using T-test, the researchers needed 24 respondents only, wherein each group has 12 members. The first group of this testing are the controlled group who read the booklet and answered a long test while the second group of this testing are the experimental group who played. Moreover, the scores between two groups were assess by using the Independent Samples T-test to provide enough evidence to conclude that the application has a significant effect on the student's learning. the application and got their scores by fighting the bad creature of the game. Furthermore, in the usability testing the experimental group along with the remaining respondents rated the game wherein (five) 5 signifies strongly agree, (four) 4 signifies agree, (three) 3 signifies fair, (two) 2 signifies disagree and (one) 1 strongly disagree.

Table 1 Evaluation Response Sheet of PlanetSaga Usability Scale

Usability Statements	Strongly Disagree	Disagree	Fair	Agree	Strongly Agree
1. I think I would like to use this application all the time.	1	0	2	4	43
2. I found the application to be simple.	22	9	10	1	8
3. I thought the application was easy to use.	1	0	7	8	34
4. I think that I could not use the application without the support of a technical person.	18	13	11	1	7
5. I found the different functions in the application were working smoothly.	2	0	7	10	31
6. I thought there was too much inconsistency in this application.	19	15	15	0	5

7. I believe that most people would learn to use the application very quickly.	1	2	4	5	38
8. I think the application was so awkward to use.	19	11	14	0	6
9. I felt very confident using the application.	4	4	8	3	31
10. I needed to learn a lot of things before I could get going with the application.	10	14	21	0	5

The Table 1 shows the raw evaluation response sheet. Statements on these sheet are phrased in a way that allows it to be administered on any type of application a user interacts with. The odd items are all written in a positive sentiment while the even items are about negative perceptions that the user felt after interacting with the application. The scores of each participants were derived by subtracting the value of odd items to (one) 1 and the value for even items are subtracted from (five) 5. This scales the value from 0 to 4.After that the partial scores were add up for each participants and multiply that total by 2.5. This converts the range of possible values from 0 to 100 instead of from 0 to 40

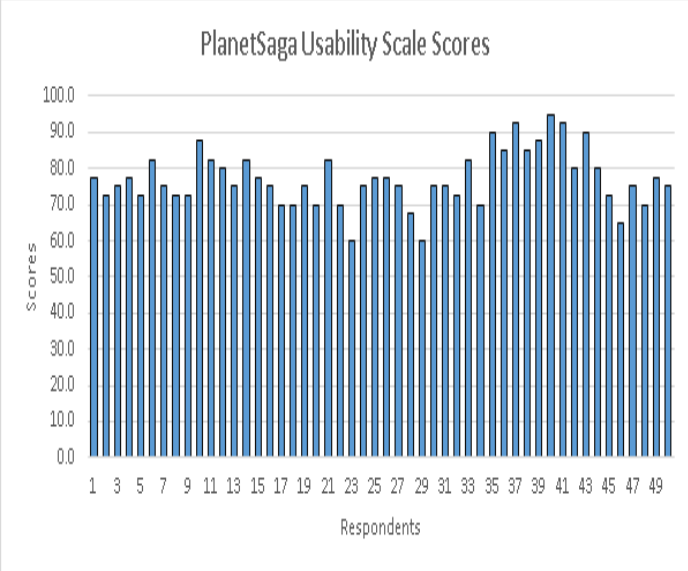
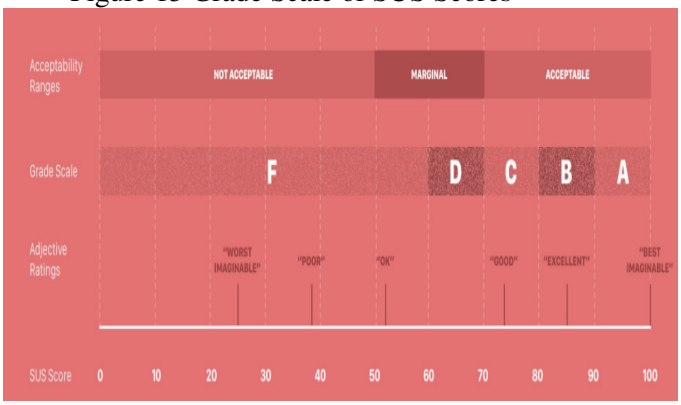


Figure 14 Scores of PlanetSaga Usability Scale

Figure 15 Grade Scale of SUS Scores



In the Figure 15 it shows the graph result of each respondents where the scores range from 0 to 100, these scaled scores are not percentage. According to Jeff Sauro (2013), a score of a 68 is 68% of the maximum score, but it falls right at the 50th percentile after looking scores from 500 products. It's best to express the raw number as a score and, when wanting to express it as a percentage, convert the raw score to a percentile. As seen from the first figure the lowest score the application get is 60.0 coming from two respondents while the highest score is 95.0. Furthermore, the average score of all the respondents was computed and come up with an system usability score of 77.1, wherein Figure 15 shows that the result of the testing is above average and it belongs to the acceptability range where we can interpret the score as a grade of C which is equivalent to good.

BOOKLET	SCORES	GAME	SCORES
Student-1	18	Student-1	23
Student-2	21	Student-2	24
Student-3	22	Student-3	25
Student-4	23	Student-4	27
Student-5	24	Student-5	27
Student-6	25	Student-6	28
Student-7	26	Student-7	29
Student-8	26	Student-8	29
Student-9	27	Student-9	29
Student-10	28	Student-10	30
Student-11	28	Student-11	30
Student-12	31	Student-12	31

Table2 Score Sheet of the participants

GROUP STATISTICS				
	Groups	N	Mean	Std. Deviation	Std. Error Mean
Scores	Game	12	27.67	2.535	0.732
	Booklet	12	24.92	3.554	1.026

Table 3 Scores Descriptive Statistics

Table 2 shows the score sheet of the students from the two groups that was conducted to the 24 participants, while Table 3 shows the descriptive statistics drawn out from the score sheet that will provide statistical information about the participants output.

The Group Statistics table provides basic information about the group comparisons, including the sample size (N), mean, standard deviation, and standard error for the scores by group. In the table, there are 12 students who read the booklet and 12 students who played the application. The mean score for those students who read the booklet is 24.92, and the mean score for those students who played is 27.67. It clearly shows that the mean score of the Game is higher than the Booklet. These two sample means serve as a basis for the test statistics. We can also see from the table on how dispersed are the set of data from the mean through the standard deviation where Booklet has a value of 3.554 and the Game has a value of 2.535, it shows there is a difference on how the scores between the groups are distributed. And lastly, the standard error mean of each group, the Booklet has a value of 1.026 while the Game has a value of 0.732, this measures on how precisely the mean of the sample students estimates the population mean of all the Grade 4 students of Alubijid Elementary School. Even though we have an equal number of students in each groups it shows that the Game has a lower value that also indicate a more precise estimation than the Booklet.

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Differences	Std. Error Differences	Lower	Upper
Scores	Equal variances assumed	0.985	0.332	2.182	22	0.040	2.750	1.260	0.137	5.363
	Equal variances not assumed			2.182	19.891	0.041	2.750	1.260	0.121	5.379

Table 4 Independent Samples t-test of the two groups

We interpret results from a statistical test that will help us to conclude whether there is enough evidence that the application has a significant effect in the student's learning. It is important to have a null and alternative hypotheses using statistical notation before proceeding in analyzing the results. In this case the hypotheses of this study can be expressed as:

$H0$: $\mu booklet = \mu game$

$H1$: $\mu booklet \neq \mu game$

where μbooklet and μgame are the population means for booklet and game, respectively.

In the table above there are two parts that provide different pieces of information: (A) Levene's Test for Equality of Variances and (B) t-test for Equality of Means. The results for Levene's Test is the result of testing the homogeneity of variance that will be required in making an independent samples t-test, This test also requires a null and alternative hypotheses to help as indicate whether the variance of the two groups are equal or not. In this case the hypotheses for Levene's Test are:

$H0$: $\sigma booklet = \sigma game$

$H1$: $\sigma booklet \neq \sigma game$

whereσbooklet and σμgame are the population variance for booklet and game, respectively.

From the table it shows that the *F* is the test statistic of Levene's Test that has a value of 0.985 and the *Sig.* is the p-value corresponding to this test statistic that also has a value of 0.332. Based on the result it implies that there is no evidence to suggest that the variance are not equal because the p-value (0.332) is greater than 0.05, the significance level that serve as a threshold to decide whether a test result is significant. Therefore we do not reject the null hypothesis of Levene's Test and we will use the Pooled t-test results found in the first row of the table that has a column of *Equal variances assumed*.

The other section of the table, the t-test for Equality of Means provides the results for the actual Independent Samples t-Test. So we use the *Equal variance assumed* row since we already test the homogeneity of variance. From the table shown, column *t* has a value of 2.182 which is the computed test statistics, *df* has a value of 22 which stands for the degree of freedom, *Sig (2-tailed)* has a value of 0.040 which is the p-value corresponding to the given test statistic (2.182) and degree of freedom (22), *Mean Difference* has a value of 2.750 which is the difference between the sample means where we can see it from the Table 4.3 (Scores Descriptive Statistic), *Std. Error Difference* has a value of 1.260 as a standard error, and lastly the *Confidence Interval of the difference*, this part of the t-test output complements the significance test results. Typically, if the CI for the mean difference contains 0, the results are not significant at the chosen significance level. In this study, the 95% CI is [0.137, 5.363], which does not contain zero; this agrees with the p-value of the significance test.

Based on the output there is enough evidence that the application has a significant effect in the student's learning. It can be express as:

$t22 = 2.182; p\text{-}value = 0.040 < 0.05$

Which means the test statistic with a degree of freedom of 22 has a t-value of 2.182. Since the p-value is lesser than the chosen significance level 0.05, we reject the null hypothesis and conclude that the means score between the Booklet and Game is significantly different where the average score of Game is 2.750 higher than the average score of Booklet.

E. Summary

Table 5 Summary of evaluations

Test Type	Results	Recommendation
Usability	The overall response was agreeable that the application is usable and is efficient in terms of utilizing an augmented reality in mobile platform for education and learning after getting a grade of C which is equivalent to good.	To increase usability, add more levels on the game and improve graphical and musical effects to have a greater player experience. Also for better interaction that will engage more with the player, a drag and drop feature to interact with the 3D models to enhance learnability.

Hypothesis	The statistical results provide enough evidence that the application has a significant effect in the student's learning after getting a higher average score compared to the traditional method of learning. This is when an activity that is not inherently game-based involves the use of game design elements and mechanics can make the student an active participant in their own learning process.	To achieve much higher results, add new methods to present the content and new types of test that will be more challenging to the students as they go on, but at the same time they will learn while having fun playing the game.

F. Conclusion

The main goal of this research project is to solve the non-existence and lack of utilizing augmented reality on a gamified learning application provided the benefits found on this technology, it is then concluded that the development and used of a gamified learning application using augmented reality that creates a playful, engaging and a social learning environment has a significant effect in the student's learning based on the statistical evidence gathered from the test. Where the researchers found out that those students who played the app has a higher average score compared to those students who read the booklet.

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