Development of Augmented Reality Mobile Apps for STEM Education

Siti Hasnah Tanalol[1], Aslina Baharum[1#], Mohamad Maruf Ahmed[2], Asni Tahir[2], Azali Saudi[2], Shaliza Hayati A. Wahab[2], Nordin Saad[2], Jurry Foo[3]

1 UXRL, Faculty of Computing and Informatics, Universiti Malaysia Sabah, Jalan UMS, 88400 Kota Kinabalu, Sabah, MALAYSIA.
2 Faculty of Computing and Informatics, Universiti Malaysia Sabah, Jalan UMS, 88400 Kota Kinabalu, Sabah, MALAYSIA.
3 Faculty of Humanities, Art and Heritage, Universiti Malaysia Sabah, Jalan UMS, 88400 Kota Kinabalu, Sabah, MALAYSIA.
#Corresponding author. E-Mail: aslina@ums.edu.my; Tel: +6088-320000; Fax: +6088-435324.

ABSTRACT This paper presents the design and development of mobile apps with the integration of augmented reality technology to support science, technology, engineering and mathematics (STEM) learning in the experiential learning context. A preliminary study on user experience testing was conducted towards 16 respondents of age between 6 - 9 years old. Based on a quantitative methodology and interpretative approach, it is found that the learning is more interesting and efficient in capturing student's attention and promotes STEM learning with the use of the Augmented Reality (AR) technology. Prototyping methodology was used to develop the Fun with STEM mobile apps. This AR-TESG (AR Technology for Eco-Science Garden) project is a community-based project which aims to bridge the digital divide as well as to provide exposure in the usage and building AR-based content to SK Kundasang students in particular. They will be imparted with ICT skills which will improve their ICT literacy and STEM knowledge through AR applications.

KEYWORDS: STEM; experiential learning, augmented reality, mobile apps development, user experience
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INTRODUCTION

Several reports reveal a growing lack of interest in science, technology, engineering and mathematics (STEM) subjects among Malaysia's younger generation, especially in rural schools. According to The Star, every year, the number of students interested in STEM (Science, Technology, Engineering and Mathematics) is decreasing in Malaysia. In 2018, the number of Malaysian students in the STEM stream decreased from 48% to 44% compared to 2012, the former Education Minister Dr. Maszlee Malik said when delivering the keynote address at the Bett Asia Leadership Summit and Expo 2019 in Kuala Lumpur. This represents an average reduction of around 6,000 students each year, according to him.

A study found that a total of 69 percent of teachers and 56 percent of students agree that the Stem curriculum is too difficult and requires too much time to study. (O'Brien, 2019). According to Benjamin Cuff (2017), students nowadays are not interested in science-based subjects as the percentage of students who are in science stream keeps declining each year, not just in Malaysia but everywhere in the globe (Cuff, 2017). Based on the Malaysian Examination Council STPM analysis report, a drop of 16.6% of STPM's science candidate from 5,475 in 2017 to 4,566 in 2018 (Chin, 2019).

Science education plays a significant role in fostering future generation imagination, critical thinking, and innovation. The nation's target is to have a ratio of 60:40 students in comparison with Art stream curriculum. Unfortunately, the present ratio of the subjects is still 20:80. (Balakrishnan & Azman, 2017). The number of students taking the Malaysian Certificate of Examination of Education in Science in 2016 was only 90,000, much less than the annual number of 270,000 expected. To achieve the country's dream, Malaysian students need to engage with STEM education as early as possible.

Exposure to STEM hands-on experiments positively impacts students and promotes their interest in these subject matters (Dhanapa, 2014). Lack of knowledge about how the STEM skills are applied also adds to misperceptions of the importance of STEM. Science, engineering, technology, and mathematics (STEM) education is a lifelong learning activity that includes integrated STEM-based learning on an informal curriculum through co-academic and co-curriculum activities and informally through indirect learning for each group age, starting from early childhood education, primary school, secondary school, tertiary and industrial or community level education (Azman, 2016). The Government will achieve so by offering a supportive education system that prioritizes STEM education to maximize the desired number and quality of potential science and technology human capital. As recently as December 2011, the Durban Forum for Enhanced Action has dedicated action on global climate change with significant consequences to creating or implementing technical solutions to pollution for countries like India and China. STEM education is an integral component of the global response to climate change or some of the other technical problems facing society today.

Today's young people are growing up with electronic games and mobile devices in their possession. They quickly thumb through apps, play sports, and watch videos before knowing how to write or read. Their daily exposure to visual products at such a young age has made today's children uniquely critical product design assessors, creating a high standard for firms looking to cater to this age demographic. This refers not only to businesses that produce general technology for children but also to those based on instructional technology used in the classroom by pupils. The design of an application or platform relates to its aesthetics and how practical and friendly it is to use. Design determines the feeling that an application or platform provides its users, and kids are particularly unwilling to use technology that does not sound or looks nice. Educational applications and networks are shifting towards a student-centered paradigm to help accomplish this, in which the emphasis is moved from the teacher to the student. This suggests that applications are designed with a greater understanding of the user's desires, habits, and ambitions in the sense of an application and/or network than before. Developers of the companies rely more on incorporating main user audiences, such as educators, instructors, and parents of young people, to include their viewpoints during the creation process and ensure that user expectations and goals are fulfilled. To ensure that apps can accurately satisfy the demands of their customers, this movement encourages users to have a more influential say in how devices are developed. The student attention must also be applied to UX and UI design to optimize the productivity of educational apps and platforms. It must meet the following five requirements for the UI of an application or website to be effective: it must be easy for students to use, it must have constant input to keep students motivated and engaged, it must elicit joyful and playful feelings, it must have special, appealing, and eye-catching graphics, and it must be tailored accordingly to the intended age demographic.

PROJECT BACKGROUND AND MOTIVATION

SK Kundasang is one of the rural schools situated 92 KM from Kota Kinabalu, the capital city of Sabah. In 2019, an Eco-Science Park was built in the school with the initiative of the Ranau District Education Office together with the National Science Center. This project was built as one of the various strengthening strategies for STEM subjects to produce more experts in the field.

In addition, in socio-economic planning and development based on strategic technology and knowledge culture, to develop a culture of science and technology to ensure the economic development process of the modern industry will be successful.

SK Kundasang headmaster, Mdm Asnah Arifin said the elements of high order thinking skills (HOT) are introduced to the students from basic science problem-solving skills through exhibition materials and STEM activities in an interactive, innovative and creative manner. It is expected that the Eco Science Park will have a big impact on the students' STEM learning experience. It is also hoped that the park will be an attractive spot for tourists, not only as a recreation center but also as a platform to support experimental academic activities, especially in STEM. Figure 1 shows some of the experiential learning sections available in the Eco-Science Park.

Figure 1. Eco-Science Park, SK Kundasang.

FUN WITH STEM AR MOBILE APPS

There are four topics included in the AR mobile apps development: bio composite, aquaponic, insect eyes and metallophone. The said topics were chosen because there are sections related to the topics in the Eco-Science Park. The students can do hands-on activities at the park and the developed mobile apps can be used to retrieve more interesting information with some interactivities through AR modules and gamified quizzes.

At the main menu, Fun with STEM apps offers two modules; Learn and Quiz. AR module is included in every topic in the Learn module (Figure 2). Students can open AR camera's and scan the target images (Figure 3) to watch the explanation videos on the topic or an interactive 3D model will be shown as in Figure 4.

The quiz is based on the information given in each chapter, and students can take the quiz to check their knowledge. At the end of the quiz, the students will be able to see their score as in Figure 5.

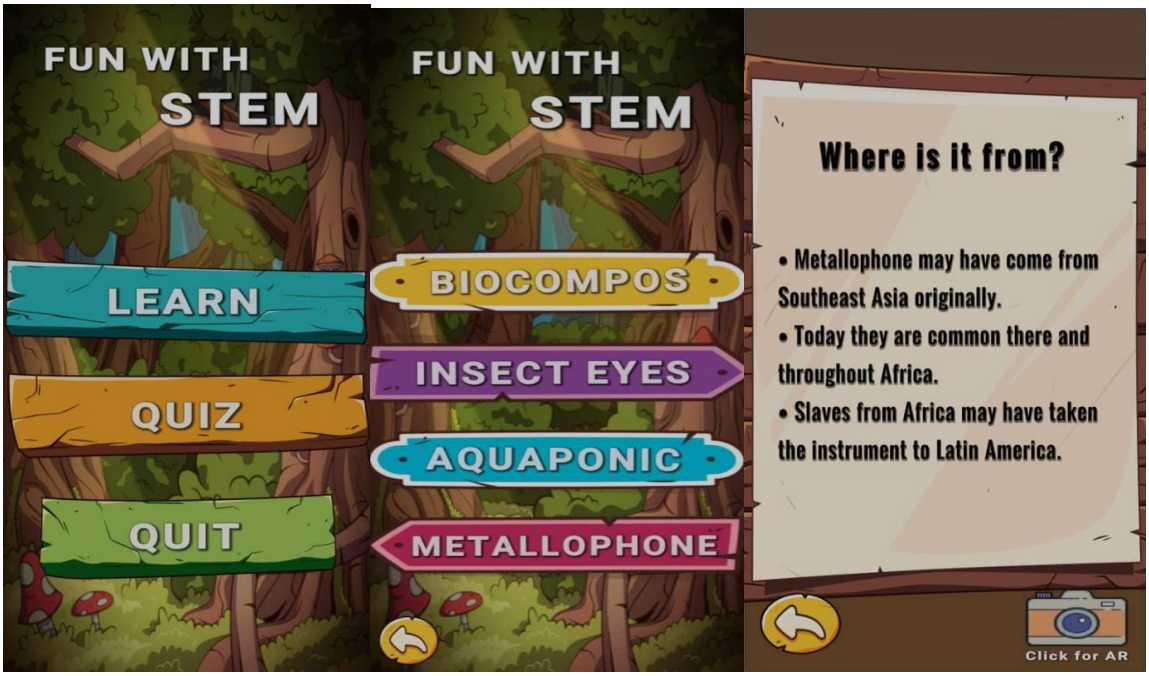

Figure 2. Main Menu, Chapters and Inside Chapter interfaces.

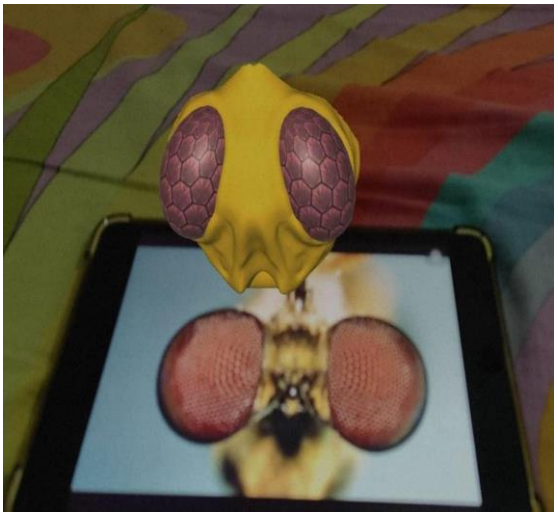

Figure 3. 3D models from AR module

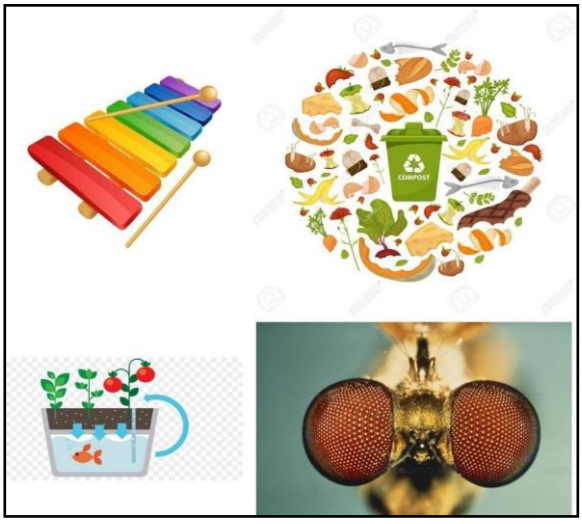

Figure 4. Image targets for AR modules

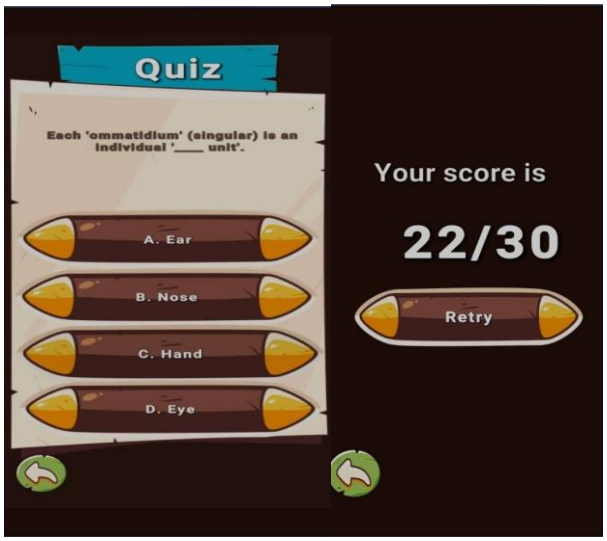

Figure 5. Quiz, Score and AR Camera interfaces

By using this mobile application, the students' learning process will be enjoyable from the new Eco Science Garden. They will feel the urge to learn STEM by using the app. When the students use the application, the effectiveness of the application will be evaluated. How the app is being affected by the students is the most important thing and evaluation of that part is important. To understand the application effectiveness, a survey will be done.

METHODOLOGY

Prototyping Methodology

Prototype methodology is characterized as a Software Development model in which a prototype is built, tested, and then reworked as appropriate until an acceptable prototype is reached. It also creates a base for the final system to be created. Software prototyping models work well in situations where the condition for the project is not understood. It is an iterative, trial, and method of error that exists between developer and client. The prototyping model has six steps of the SDLC as follows (Figure 6):

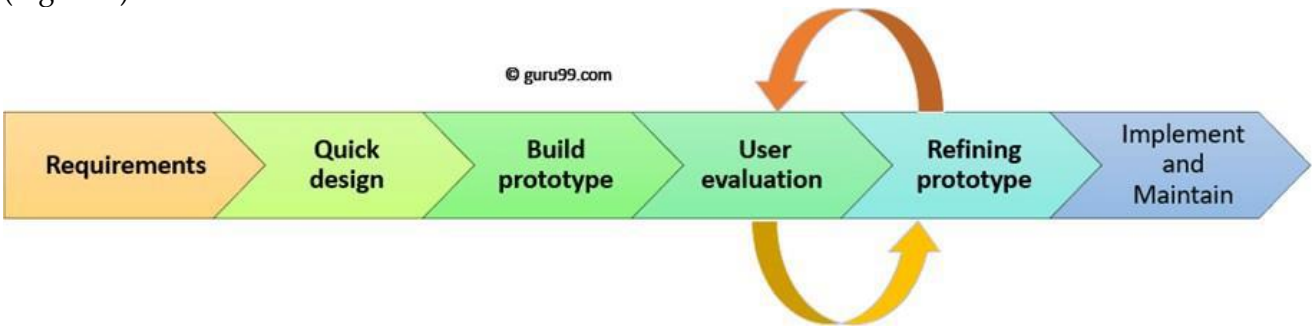

Figure 6. Steps of Prototyping (Source: guru99.com)

Step 1: Requirements Selection and Analysis A Prototyping Model Starts With Requirement Analysis

During this step, the device specifications are described in detail. Throughout the process, program users are consulted to learn from the client what their goals are. The requirements to make this app are Unity 3D, Vuforia SDK, laptop, Visual Studio and Canva.

Step 2: Quick Design

This phase is to select a design. A user-centered design is chosen to design the mobile app. A simple design of the system is generated at this level. It is not a complete build though. It is giving the user a quick idea of the program. The quick design helps with prototype creation. This design is chosen because how effective the app is on the students will be checked by doing surveys.

Step 3: Build a Prototype

An actual prototype is designed in this process based on the information gathered from the quick design. It is a tiny working model of the device required. A prototype was created with Just in Mind to make a basic design of the app. Then Unity 3D and Vuforia to create the prototype.

Step 4: Initial User Evaluation

The proposed program is presented to the users for an initial evaluation at this point. It helps the project model to find its strength and weakness. Comments and feedback are gathered from the users.

Step 5: Refining Prototype

When the user is not pleased with the current prototype, he/she has to modify the prototype according to feedback and suggestions from the user. This process will not be finished until all the user-specified criteria are met. If the user is pleased with the prototype developed, a final system is developed based on the end prototype accepted.

Step 6: Implement Product and Maintain

Once the final system, based on the final prototype, is produced, it is thoroughly tested and deployed for production. The system is maintained daily to reduce downtime and to avoid large-scale failures. For the app development part Unity 3d and Vuforia SDK will be used. Beside this for the coding part visual studio will be used. For the 3d objects google poly library will be used. The research element is how effective the application will be on the students. This experiment will be conducted to check the effectiveness of the AR application on the students. After the augmented reality mobile application is made, the app will be given to the students of grade 1-5. Then a survey would be done to check how the mobile application affects the students like will it evoke happy and playful emotions, is it eye catching for the kids, can the students use the application without any effort, is the app creative etc. Then the survey results will be discussed in the testing part of this project.

RESULT AND DISCUSSION

Usability testing is an alternative to test the ease on how to use the application with the users. The users were asked to complete several tasks and were observed by the developer. The observation will focus on problems faced by the users while completing the tasks. Hence, recommendations will be needed to overcome the usability issues.

A student response form was used to gather data from all participating students to test the usability and interactivity of the apps. There were 16 respondents for the survey. The questions for this survey were made to check how effective the mobile applications are for the students. The questionnaire is completed individually immediately after they finished interacting with the aps. The following descriptive questions were asked:

1. The effort required to deal with the interaction and access any information with it
2. The visual quality in terms of adherence to the dimensions of the screen, showing the important information in style and also use of proper colours
3. Information displayed by the interaction are complete and cover all the concepts and ideas that the interaction is built for
4. The interaction provides learning assessments.
5. Is it easy to get familiar with the product and to learn how to use it?
6. Is the app informative?

For Q1 (Figure 7), “the effort required to deal with the interaction and access any information with it”, most of the students did not require a lot of effort to use the interaction in the apps (93%). This means that the interactions provided in the apps are straightforward and easy to understand.

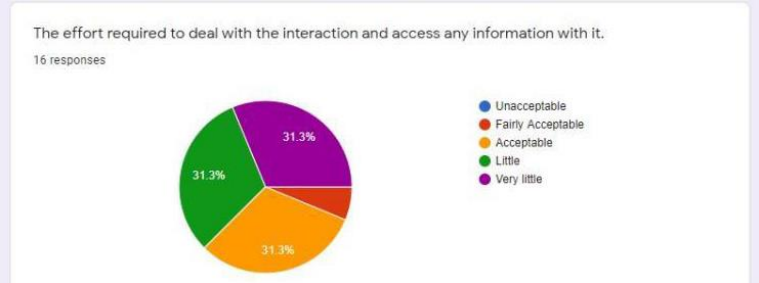

Figure 7. Result for Q1 "the effort required to deal with the interaction and access any information with it".

Most of the students (43%) agree that "The visual quality in terms of adherence to the dimensions of the screen, showing the important information in style and also use of proper colours". The choose of color, the position of information in text, video and graphics put on the screen are acceptable (Figure 8).

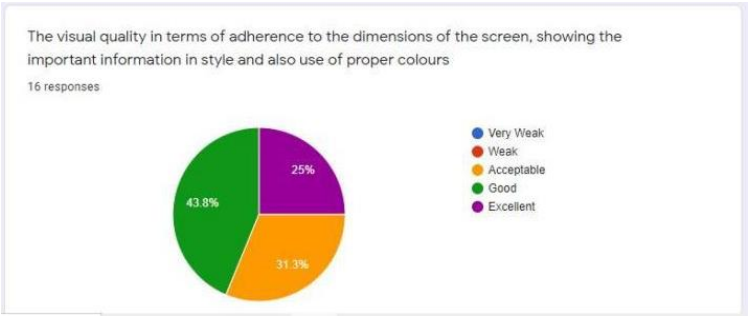

Figure 8. Q2 "The visual quality in terms of adherence to the dimensions of the screen, showing the important information in style and also use of proper colours".

As in Figure 9, 56.3% of students said the information covers most of the topic chosen (Figure 9). Though the information is quite limited and there is room for improvements for the next development.

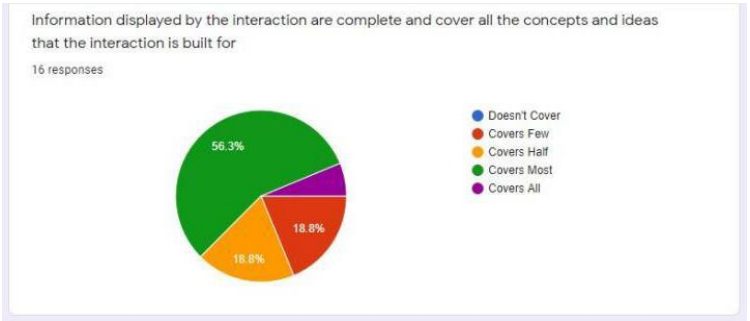

Figure 9. The first question is "Information displayed by the interaction are complete and cover all the concepts and ideas that the interaction is built for"

61% of the respondents agree (Figure 10) that the interaction provided in the apps covered in the learning assessment. There are a set of 10 questions asked in the quiz which is randomly selected every time the student takes the quiz. At the moment only one set quiz developed but in the next phase, several quizzes will be added based on the topics.

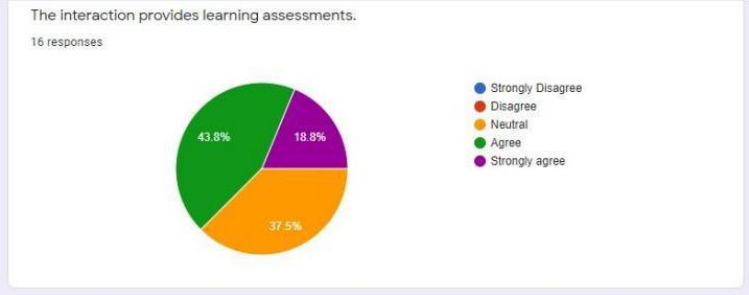

Figure 10. The first question is "The interaction provides learning assessments."

The first question answer is 43.8% with agree while 31.3% strongly agreed (Figure 11). The second question answer is mostly agreed with 43.8% votes while 31.3% strongly agree and 5% neutral.

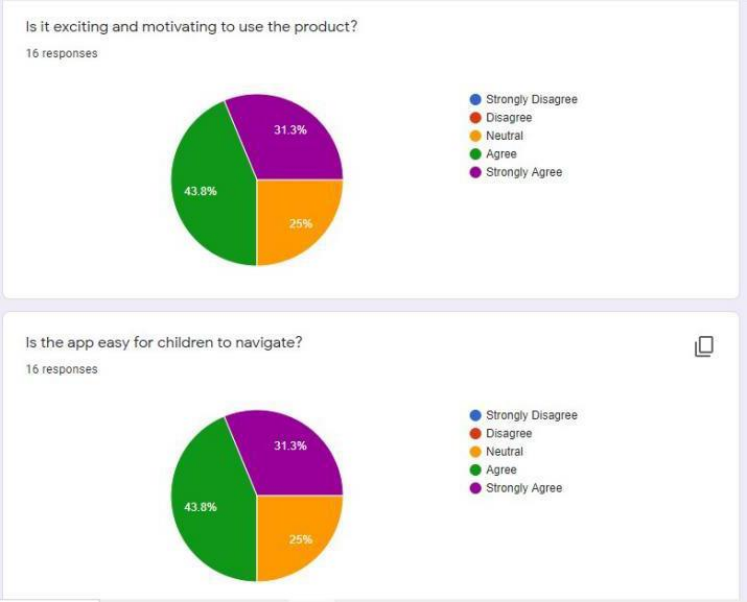

Figure 11. "Is it exciting and motivating to use the product?." and the other one is "Is the app easy for children to navigate?".

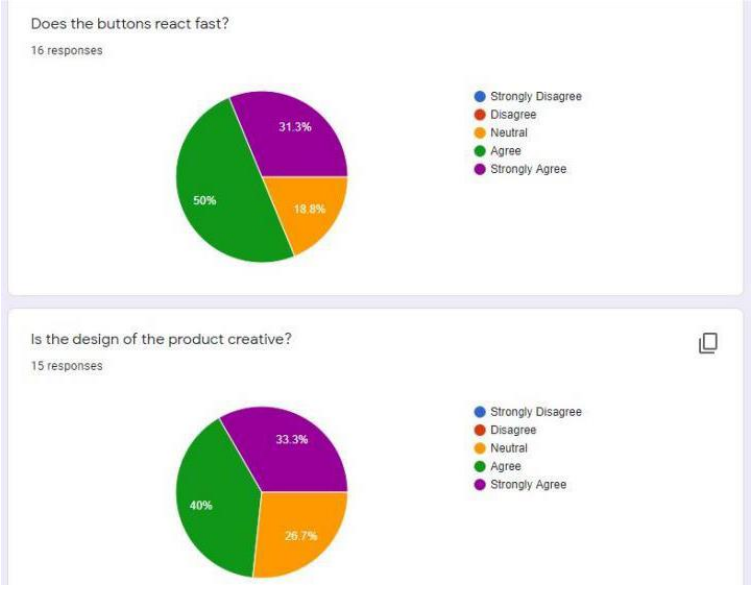

Figure 12. The first question is "Does the buttons react fast?." and the other one is "Is the design of the product creative?".

The first question answer is 50% with agree while 31.3% strongly agreed. The second question answer is agreed with 40% votes while 33.3% strongly agree and 26.7% neutral (Figure 12).

The first question answer is 62.5% with agree while 18.8% strongly agreed. The second question answer is agreed with 37.5% votes while 37.5% strongly agree and 25% neutral (Figure 13).

Figure 13. The first question is "Is it easy to get familiar with the product and to learn how to use it? "Is the app informative?".

CONCLUSION

This paper discussed the importance of Mobile AR apps to assist students to learn STEM. In this regard, AR concept is implemented because it can attract students' attention and the interactivity gives impact on their attention span and the retention level. This paper also presents the development of Fun with STEM mobile apps in which focus on the local content inspired from the Eco-Science Park, SK Kundasang. Next, a survey was done to see how effective the augmented reality app is on the students. Overall, the students agreed that the app evokes happiness and increases their attention to learn more.

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