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Fruits and Vegetables Game-Based Learning Application for Kids Using Augmented Reality

Jonald Kesniel V. Rañada[1], Patricia V. De Mesa[2], Jan Romen D. Castillo[3], Zerah-Jane M. Astoveza[4]
College of Computer Studies, Laguna State Polytechnic University-Siniloan Host-Campus, Laguna, Philippines[1,2,3,4]
zerah-jane.astoveza@lspu.edu.ph

RESEARCH ARTICLE INFORMATION

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ABSTRACT

In this digital age, the education system is transitioning toward interactive and immersive learning tools like augmented reality. AR develops contextual awareness and enhances spatial and interpretive abilities, flexible learning, problem-solving, motivation, and attentiveness. The research focused on developing a two-dimensional (2D) game-based learning system for children that facilitates the young audience's interactive learning about fruits and vegetables. It also aimed to determine the effectiveness of a game-based approach in identifying the fruits and vegetables. A descriptive and development research methodology was utilized as research design. The researchers used C# programming language and Unity game engine in developing the application. In addition, the Fisher-Yates Algorithm was applied to the exam questions to make them appear unique and more difficult for users to predict the next question. In addition, evaluating the developed application's efficacy indicated that game-based learning using augmented reality has succeeded. Despite this, the application may account for the device's capacity to handle demanding visuals, such as 3D graphics. Additionally, it could introduce more varieties of fruits and vegetables, along with elements that make healthy eating more appealing.

Keywords: *fruits and vegetables, augmented reality, e-learning, Fisher-Yates Algorithm, malnutrition*

Introduction

Consuming enough fruits and vegetables during childhood has many immediate beneficial effects, including reducing the risk of micronutrient deficiencies and various respiratory diseases (James, 2012). In the Philippines, undernutrition remains a problem among 0–10-year-old Filipino children. A survey revealed that three out of ten children aged 5–10 years are underweight and stunted, with poor dietary intake in both quantity and quality, affecting their growth and intellectual development (DOST-FNRI, 2015). Poor consumption of fruits and vegetables is one of the concerns of parents about the health of their children (De Costa, 2017) and parents face various obstacles when encouraging their children to eat fruits and vegetables (Cason-Wilkerson et al., 2015). One of the major challenges to increasing kids' intake of fruits and vegetables has been identified as food neophobia, which is the fear of trying new foods (Cole, 2017). Since childhood eating habits heavily influence adult dietary patterns, the effects of food phobia continue well beyond childhood (Rioux, 2019). Kids also lack knowledge and experience preparing (certain) veggies as well as particular fruits and vegetables were similarly likely to cause children to have poorer self-efficacy (Wadsworth, 2013).

Information technology can be used to alter food's appearance while yet preserving its nutritional value. The AR Meta Cookie is an example of how AR technology is being used in food. It adds an AR marker to a cookie and alters its appearance, such as turning a plain cookie into one that appears to be strawberry-flavored. The apparent size of meals has also been increased using the same approach (Ueda, 2020). Among new technologies, augmented reality (AR) is gaining more attention from researchers and educators because it helps them visualize abstract and complex concepts and spatial relationships (Lin, 2015; Phone, 2015). AR creates contextual awareness and improves spatial and interpretive skills, flexible learning, problem-solving, motivation, and attention (Sumadio & Awan, 2010; Aziz, 2012; Wojciechowski & Wojciech, 2013; Kun-Hung & Tsai, 2013; Bujak, 2013; Di Serio, 2013). According to the study, AR technology can be used in educational applications for kindergarten children, as it plays an important role in improving information perception and comprehension in kindergarten children (Lin, 2016). Using a randomizing function, the Fisher-Yates shuffle technique has been used in a number of case studies and methodologies (Gomathi, 2016). The efficacy of the randomization process and the algorithm's ideal complexity are its two main advantages. This approach is extensively utilized because the generated data's randomization is not uniform.

The Fisher-Yates Shuffle and Linear Congruent Method (LCM) algorithms are the most commonly used for data randomization. Fisher-Yates has advantages such as avoiding repetition and duplication but is flawed in sequential sorting. Linear Congruent Method (LCM) has a quick and straightforward random number generation function but still employs exact integers. Variation techniques have been used to generate random numbers. The LCM is a popular way to produce random numbers in computer game programs like puzzles, quizzes, and lettering game applications.

However, it is currently unknown which algorithm has a faster randomization process in terms of both data randomization speed and randomized data volume. To compare the two algorithms' performance comparison, multiple tests were conducted to assess the effectiveness of the two algorithms. The test findings indicated that the Fisher-Yates method processes data more quickly than the LCM, which is worth 11,768% more. This was closely correlated with the testing of the data volume, which might be 10, 100, 1000, 10000, or 25000 data. The researchers used the Fisher-Yates

algorithm because the Fisher-Yates method processes data more quickly than the LCM, which is worth 11,768% more.

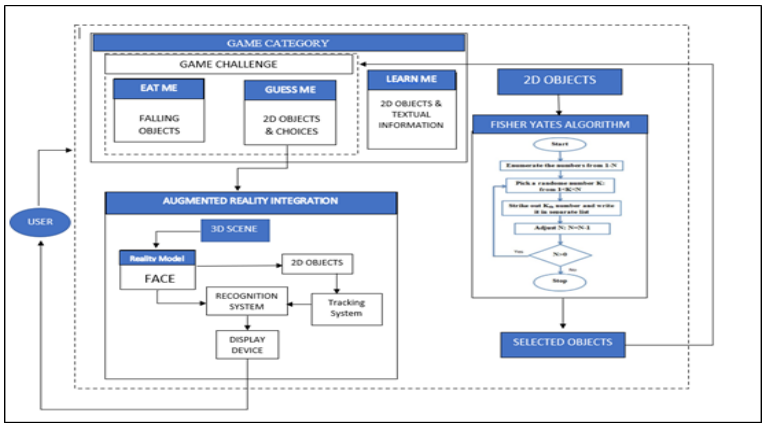

Figure 1. *Conceptual Framework*

Figure 1 shows the works of the system: these games do not need an internet connection. The play button is used by the user to see play activities like *eat me*, *guess me*, and *learn me*. The Fisher-Yates shuffle algorithm was used in *eat me* and *teach me* to shuffle each question. If the user launched and opened the application, the user would open the main menu. When the users chose the CollectMe and GuessMe games, an AR camera would appear on the screen and be applied to the detected face. If the user chose the CollectMe game, the basket would collect the random fruits and vegetables that fell and appeared on the screen using a 2D/3D model. The user would collect falling fruits and vegetables by pointing or dragging the basket. When the user chose the GuessMe game, the camera would point to the detected face and the random pictures or images of fruits and vegetables would appear on the screen using a 2D/3D model. Each picture needs to be identified as either a fruit or a vegetable. Users could choose fruits or vegetables by turning their heads left or right. The Learn Me category contained the nutritional benefits of each fruit and vegetable. This study would help the young audience to determine the basic knowledge and benefits of fruits and vegetables.

The main goal of this study was to create an Android game-based learning application for children, with the specific objectives of developing a 2-dimensional game-based application with the features of Collect Me Challenge, Quiz Game, and Fruits and Vegetables Nutritional Facts. Moroever, this study also applied the Fisher-Yates Algorithm in shuffling the game challenge and determined if there were significant differences between the results of pre-test and post-test.

Methods

The researchers applied the descriptive and developmental methods. The descriptive method looks for factual facts relevant to the current situation. This method works mainly on the description, comparison, analysis, and interpretation of existing data.

Meanwhile, the developmental method is characterized as a corpus of research literature that is directly related to instructional development, implying that output would be generated following the completion of this study. After identifying the problem, the researchers came up with the idea of having a game-based e-learning tool for the

children, and the outcome was evaluated by the respondents. Descriptive data were typically collected through questionnaires, surveys, interviews, or observations. This method emphasizes describing current conditions, practices, or phenomena (Silagan, 2004). To support this study, the researcher proposed fruits and vegetables game-based learning application for kids using Augmented Reality to help children eat fruits and vegetables and gain more knowledge about fruits and vegetables.

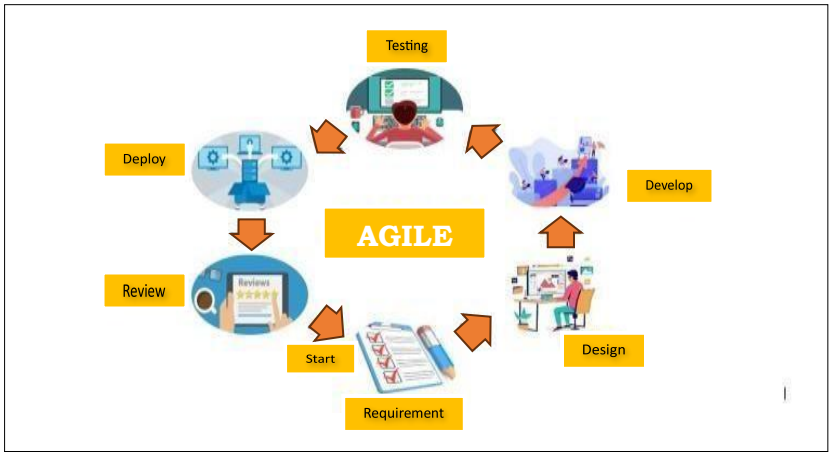

Figure 2. *Software Development Methods Using Agile*

Figure 2 is the software development model used in developing the application. This agile method is a set of actions repeated in a sequence until a condition is met. This method can save time by optimizing development tasks and reducing errors during planning.

Requirements

In the first phase, the requirements were planned and assembled. This included identifying who would use the device, its intended use, and gathering all necessary data about fruits and vegetables before beginning the project design. The researchers examined articles, books, and studies about various automotive uses to gather information. The strategy had to be precise in terms of the purpose of the study, and the researchers made decisions in all implementable goals and strategies. After that, the researchers gathered data from individuals between the ages of seven (7) and nine (9).

The developers prepared pre-test and post-test questionnaires that underwent content validation. The researchers also prepared a Likert scale form of a questionnaire that contains the usefulness, satisfaction, and ease of learning in a Google form regarding the e-learning game for their respondents. They also created an ISO 25010 survey instrument containing the system's functionality suitability, usability, reliability, and portability.

The developers needed the following tools and equipment for making the documentation and system. For the documentation of the proposed study, the first requirement that the researchers needed were the following: desktop computer, laptop, paper, ballpen, printer, mobile phones, and the internet.

Designing Phase

The second phase was designing; the needs developed during the earlier stage were introduced by the researchers. The researchers reviewed the equipment necessary to achieve the best results from the system, including software programs, programming languages, and user interface designs. It included Adobe Photoshop for the background, the C# for the scripting language, and the Unity 3D for the animation and augmentation.

Developing Phase

The developing phase often has the most extensive methodology because this is the stage of the software development process where researchers write code and convert e-design documents into preexisting software. The researchers started to develop the system by writing code using the said software application at the previous stage. The developer used C# for the script language of the system.

The developers used Unity as the development tool to create a fruits and vegetables learning Application. Also, the researchers created mobile learning games that use augmented reality. Many Google Play Store games employ the cross-platform Unity game engine, which may be used to create augmented reality in addition to games. For AR, the researcher used Marker less so that overlaying virtual 3D does not require prior environmental knowledge from the user. The developer creates a learning application for mobile devices.

Figure 3. *Unity Design Platform*

Figure 3 above shows the designing platform in Unity 3D in this phase. Researchers created the game using the Unity designing platform with the game engine. This platform made it simple for the researchers to change and manipulate each object and asset in the game, and it also included the fact that Unity is far more accurate and well-organized when creating 3D assets. Each asset in Unity was built and designed by

researchers, and some of the game objects were free assets that were already built into Unity.

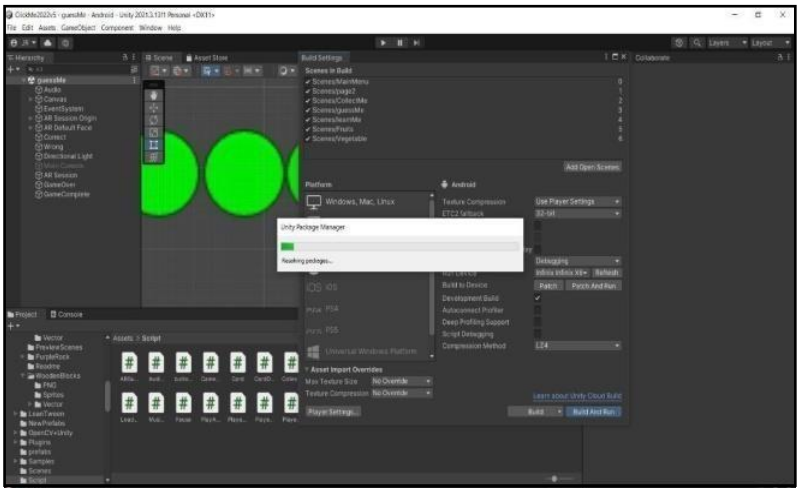

Figure 4. *Game Engine and Programming*

Figure 4 shows some of the researchers' code and the Unity gaming engine. Building games without the other components is impossible. Thus, these two procedures must be finished before moving on to the next step. This phase comprised asset building and asset design because these two processes were finished simultaneously.

Testing Phase

With the assistance of children aged 7-9, the researchers examined the system's usefulness, satisfaction, and convenience of use as well as its functionality and bug-freeness during the testing phase. The researchers ran a number of tests to make sure the code was clear and the system's objective was met. Five (5) IT professionals who are knowledgeable in this area worked with the researchers to test the system.

Deployment Phase

Users could access the system for demonstration or actual use when it was put on the servers after passing a number of tests. This was done to use the system designed for the young audience aged 7-9.

Once the system was checked and validated as an effective system that can help kids learn about FV, it proceeded to a process in specific individuals or organizations. Upon using the mobile application, the developers observed children and asked some questions if they like or enjoy playing that application. It could help the developers know what should be added or changed in the system to improve the application.

Review Phase

Once all the processes had been completed, the researchers evaluated their terms of meeting the standards. Supposed problems with the system or revisions or feature additions were necessary. In that case, the researchers addressed them by returning to issues with the system or modifications or feature additions required. The researchers

also addressed them by returning to the earlier phases. They checked all the suggestions and recommendations made by the IT experts to improve the system that the researchers have developed.

Results and Discussion

This chapter presents the results, analysis, and discussion of the research findings and the techniques and other methods used in the study.

The study was conducted to encourage the current and next generations to eat and gain more knowledge about fruit and vegetables. The use of Augmented Reality helps the kids interact more and enjoy more in using the application. Together it will create the game incorporating the game-based learning that was used as some main techniques/methods in disseminating basic knowledge and information about different types of fruits and vegetables.

The game the respondents played was developed and designed with a 3D modeling software application consisting of characters and tools that feature during the game**.**

Development of a 2-Dimensional Game-Based Application

Collect Me Challenge

The following figure is the collector gameplay setup where the player plays the application. The environments were set to be 2D models to collect fruits and vegetables that can help kids enjoy the game—every fruit and vegetable collected by the user would be converted into points. Junk foods like burgers, chocolates, chips, and candies that were collected would be deducted from the points. The researchers' adaptation of the game's design to each player's personality type increased its efficacy in fostering constructive attitudes, thereby altering behavior and self-efficacy.

Figure 5. *Collect Me Game Challenge*

In the collect me challenge, they would know that the only things they should collect are healthy foods like fruits and vegetables to get a high score, and the ones they need to avoid are junk foods /unhealthy foods to avoid points deduction (see Figure 5). These games for change have been demonstrated to encourage people to change their behavior, persuade them, and encourage learning through various persuasive techniques. However, persuasion techniques that spur on one person could deter another. In the context of a game intended to promote healthy eating habits, there is a need to demonstrate the significance of customizing games for change (Vassileva, 2017).

This game category is designed to help the user provide information and determine which is healthy and which is not.

Quiz Game Challenge

Quiz game play when the camera point detects the face, the random pictures or images of fruits and vegetables appear on the screen using a 2D/3D model. Each picture has to guess; it is either fruits or vegetables. Users choose if it is fruits or vegetables by turning their heads left or right.

Figure 6. *Quiz Game Challenge*

Figure 6 presents the development and design of the 2D models for kids. Using face tracking and augmented reality, users will enjoy answering questions more. Previous research found that using AR technology improved students' learning by developing their skills and knowledge, improving their learning experiences, and fostering collaborative learning (Chang, 2013). The model serves as an entity inside the game and one of the critical assets; these represent physical objects inside the virtual environment where the player can control their action as displayed in the role-playing game. This game challenge will help the kids to know the fruits and vegetables. According to Boeker (2013), evidence showed that game-based learning produces more excellent student performance outcomes compared to a conventional script-based educational strategy. This study showed learners who obtained GbEl mentoring not only achieved a considerably higher instructional outcome when compared to learners who discovered the same content with a storyline but also had so much fun, preferred to learn in this manner, and were more confident in their academic skills.

The following figures are the 2D models of game-based learning that provided essential information and trivia about certain fruits and vegetables. Users can see this when they click each picture; the player can see the health benefits of each fruit and vegetable so that the player will familiarize themselves with them better.

Learn Me Category

The following figures are the 2D models of game-based learning that provide essential information and trivia about certain fruits and vegetables. Users can see this when they click each picture; the player can see the health benefits of each fruit and vegetable so that the player will familiarize themselves with them better.

Figure 7. *Learn Me Fruits Information*

Figure 7 shows the different kinds of fruits, which the user can use to find out the information on each fruit found here. Each fruit has its information, and using it will help the user to know each vitamin and mineral that can be obtained from each fruit. Moreover, by playing it, the user can be encouraged to eat fruits because these are good for the body.

Figure 8. *Learn Me Vegetable Information*

Figure 8 shows the various types of vegetables. Utilizing the information that each vegetable has to provide will help the user understand each vitamin and mineral that can be gained from each fruit. Finally, playing it can motivate the user to consume more vegetables because they are healthy.

The learn me category that was designed and established enables the user to see the basic information about certain fruits and vegetables. The outcome is the result of each action taken by the player. While in this process, the player knows how to determine the fruits and vegetables by playing the quiz game. This was said to be more commonly used yet helpful on the players' skills in enhancing their decision-making.

Integration of Augmented Reality for the Game Challenge

The researcher integrated Augmented Reality by using face tracking. The application was developed to provide knowledge about fruits and vegetables using AR. The proponents used AR which sees the real world using virtual objects and is ultimately

the same as the real world so that the users can perform quickly. Kids will play the game using face tracking that helps them choose and answer every question.

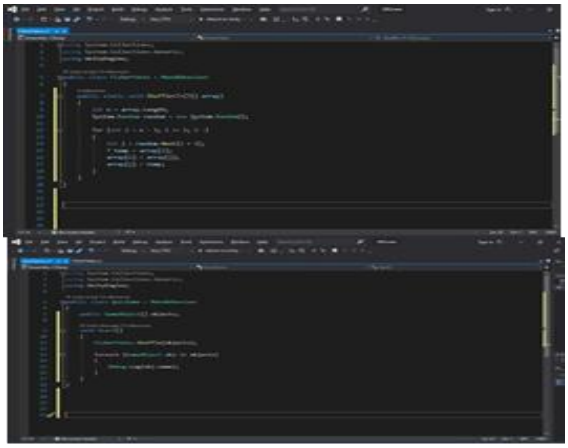

Figure 9. *Augmented Reality Integration*

The researcher integrated augmented reality into the quiz game category. In order to integrate augmented reality on mobile devices, face tracking will be used. This implementation's strategy used the face-tracking result as a marker. Then, it also used three-dimensional facial model recognition.

The proponents used AR technology that helps the kids enhance interaction, teamwork, learning, and motivation. Based on research, kindergarten-aged children can benefit from using augmented reality (AR) technology in educational settings to help them see and comprehend the content better (Neha, 2020).

Application of the Fisher-Yates Algorithm in Shuffling the Game Challenge

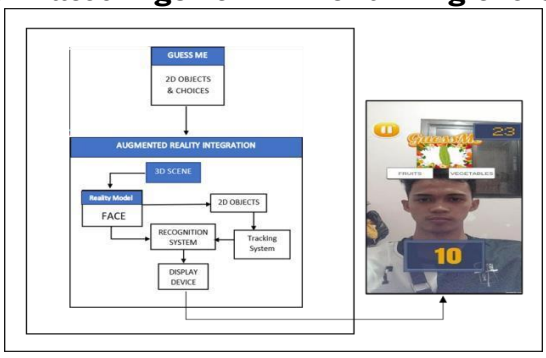

Figure 10. *Implementation of Fisher-Yates Algorithm*

The researchers decided to use the Fisher-Yates algorithm. The developer applied the algorithm to the question. The quiz part used the Fisher-Yates Shuffle algorithm, which may be used to scramble the quiz questions so that they seem different and make it harder for users to predict the next question. The focus of this game was a quiz in which each question's response must be unique and not repeated. The Fisher-Yates Shuffle Algorithm is appropriate for matching the input data's speed to rapidly display the related response to a given question over a specified period (Revano, 2018).

The Fisher-Yates shuffle algorithm, utilized for the randomization process in mobile-based e-learning systems, was developed as a result of this research. Each game would receive a distinct set of questions because algorithm testing was done on the mobile application.

The Fisher-Yates algorithm is an algorithm that blends an image into a series of numbers. It is an excellent random number generator because it produces the same array of random numbers for each permutation. It also generates random permutations that are ordered so that questions that have arisen do not appear again in the same session (Haditama et al., 2016).

Difference Between the Results of the Pre-Test and Post-Test

Table 1. Difference of Paired T-Test

	Mean	**Lower**	**Upper**	**T**	**df**	**Sig. (2-tailed)**	**Decision**
Pre-Test & Post-Test	-3.066730	-4.32984	-1.80349	**-4.965**	29	0.0000	**Reject H0**

In this population, paired samples t-test for pre-test and post-test were conducted. The researcher rejected the null hypothesis of the study. Hence, the t-test mean of -3.0667 and a 95% confidence interval of the difference means that all respondents' average weight of test scores is somewhere between the range of -4.32984 and 1.80349 and a df (degree of freedom) of 29. The table also shows that within the critical value is where the T value of 4.965 is used in the Rejection Region to show the rejection of H0 (null hypothesis); the value of p is < the value of two-tailed (P-value) which is .000028. Thus, the result is significant at $p < .05$, indicating the rejection of null hypothesis. This implies that there is a significant difference between the overall paired sample test and that the game-based learning on the game has been effective in this approach.

Conclusion and Future Works

The researchers concluded that using a game-based method to give basic information about a topic had shown significant results. The Augmented Reality game provided user satisfaction and helped them expand their knowledge about the topic. However, game-based learning tools are ineffective if the intended target user does not participate. The application may consider the device's capacity to handle demanding or high-end visuals, such as 3D graphics. On the other hand, two-dimensional models provided essential information and trivia about certain fruits and vegetables.

The researchers found that Augmented Reality learning games that should be created can be played at home to encourage kids to study more efficiently. It is recommended that future respondents use the developed system. Future research may also focus on characteristics like introducing more varieties of fruits and vegetables, adding sounds in the appropriate category, increasing game difficulty, and improving Augmented Reality's design to make it more realistic.

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