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EXPLORING GENETIC INFORMATION TOPICS BY USING AUGMENTED REALITY IN GAME-BASED LEARNING

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Abstract

This study focuses on the development of an augmented reality learning tool in the game-based learning for the foundation Biology I (PAA 10104) course, along with its effects on student performance as well as their attitude towards the software. The student has the difficulty to learn and take more time to understand the subject. The aim of this study is to explore the impact of the tool on students' cognitive performance and to gain an understanding of the various mechanisms and pathways of biological information expression. The results of the research will be used to determine the efficacy of the augmented reality software in teaching the subject matter. In this study, 85 students from UniSZA Science and Medicine Foundation Centre were involved. Augmented Reality interfaces are entirely based on the target user by applying a standard graphic user interface (GUI) in the virtual world. The students were instructed in answering the Nucleo-Beads boardgame's survey and questionnaires. From the questionnaires, the feedback from student's perceptions were analysed. The findings demonstrate that students' active involvement in hands-on activities has a particularly positive impact on their perception of enjoyment, which increases their motivation to learn. As a result, learning materials are seamlessly integrated into the environment around students in these augmented reality environments. Future research could investigate the impact by running experiments involving two or more student groups. Through game-based learning, this would give more insightful information on how to use augmented reality mobile applications.

Keywords: Educational games, Augmented reality, Mobile Application, Genetic Information, Cybergogy

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Introduction

Expression of biological information is one of the topics that are learnt by students in UniSZA Science and Medicine Foundation Centre (PUSPA) in Biology I (PAA 10104). The students need to understand these topics which have many mechanisms and pathways to be learnt throughout the semester I during this Coronavirus disease-19 (COVID-19) pandemic season. Therefore, the aim of this study is to develop an inquiry-based AR learning tool for foundation biology course, examine its effect on students' cognitive performance and compare its effects on students' achievement.

This project will assist the lecturer on how augmented reality (AR), which is the projection of virtual information onto a real-world object, can be applied in the classroom and in the laboratory. This is an alternative from the delivery method from pedagogy to the cybergogy approach in order to enhance the students' knowledge. The data will be collected among the students at the end of the course. This research is expected to increase the knowledge of student in more depth and to learn better and score in genetic information topic especially in the mechanism part via AR. The results will create a clearer understanding of perceptions on AR and inform future professional development and resources needed

to promote this evidence-based approach among university instructors locally and internationally.

In the information era, everyone is in a technological race to adopt new innovations that make life more convenient and comfortable. Modern schooling is being impacted by multimedia technology in every area of our life (Che Sulaiman & Ban, 2019). Since this educational revolution occur in this era, numerous organisations have attempted to digitize education using e-learning, online learning and so-called "light of digital afternoons" technology, which enables the creation of information anywhere and at any time (Nail & Ammar, 2017).

The current state of technology development has drastically altered the educational landscape. For instance, the use of technology has made language classes more flexible and engaging. The adjustments have made it possible for language instructors and students to communicate virtually everywhere. Interactive technology and game-based learning curriculum activities have a favourable effect on students' achievement of learning milestones, excitement for academics and interest in the subjects they are studying in class (Abdul Jabbar & Felicia, 2015; Furió et al., 2015; So & Seo, 2018; Sung et al., 2016; Wilson et al., 2009; Wouters et al., 2013).

Currently available apps or games in the market are not suitable for students as they are often too simplistic or lack the depth that is needed to teach complex concepts, such as those related to biology. Therefore, a board game such as Nucleo-Beads was developed to provide students with an engaging and educational experience. Such a game would simulate biological processes and allow students to gain an understanding the process of DNA replication, transcription process, translation process and lac operon. Furthermore, students can experience while playing about the structure of DNA, how genes are expressed and other related fundamental concepts in biology.

Methods

Study Design

There were 85 students from UniSZA Science and Medicine Foundation Centre involved in answering the Nucleo-Beads boardgame's survey and questionnaires. From the questionnaires we will get the feedback from student's perceptions.

Gameboard Application

Nucleo-Beads is designed to cater both fun and learning. This educative game would inculcate the interest in basic of life. This unique game is the combination of two types of games, which are "snakes and ladders" and "millionaire monopoly". The maximum players are 4 players. A player will have a maximum of 3 tokens in their possession. 3 difficulty levels of question and sequences are provided in 1 minute. Each player must download AR code application. The board game of Nucleo-Beads is showed in Figure 1. The box of Nucleo-Beads is showed in Figure 2. The mind map of the process in Nucleo-Beads is showed in Figure 3.

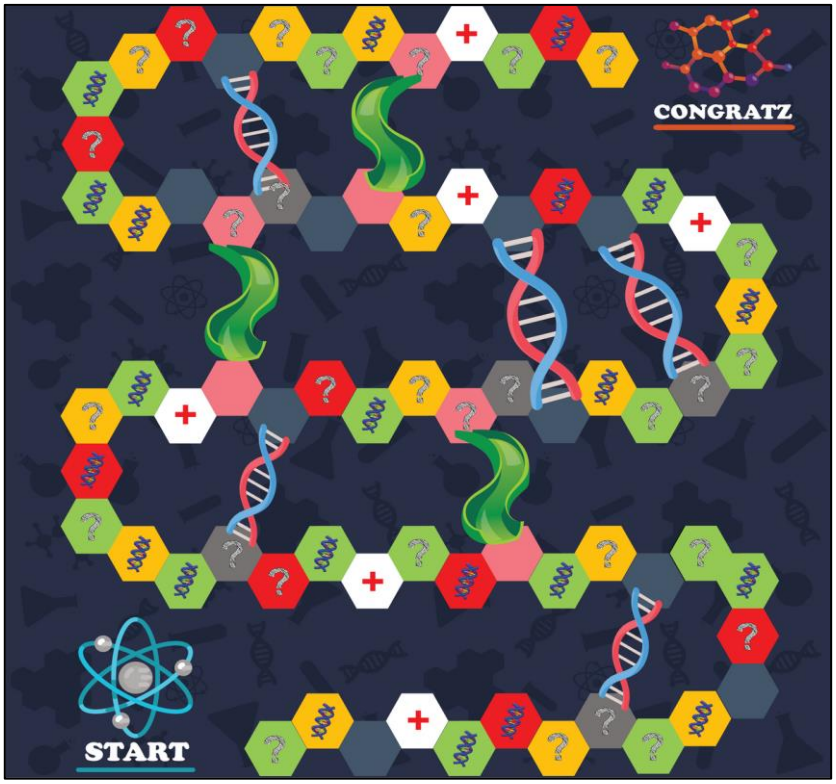

Figure 1. The board game of Nucleo-Beads

Figure 2. The box of Nucleo-Beads

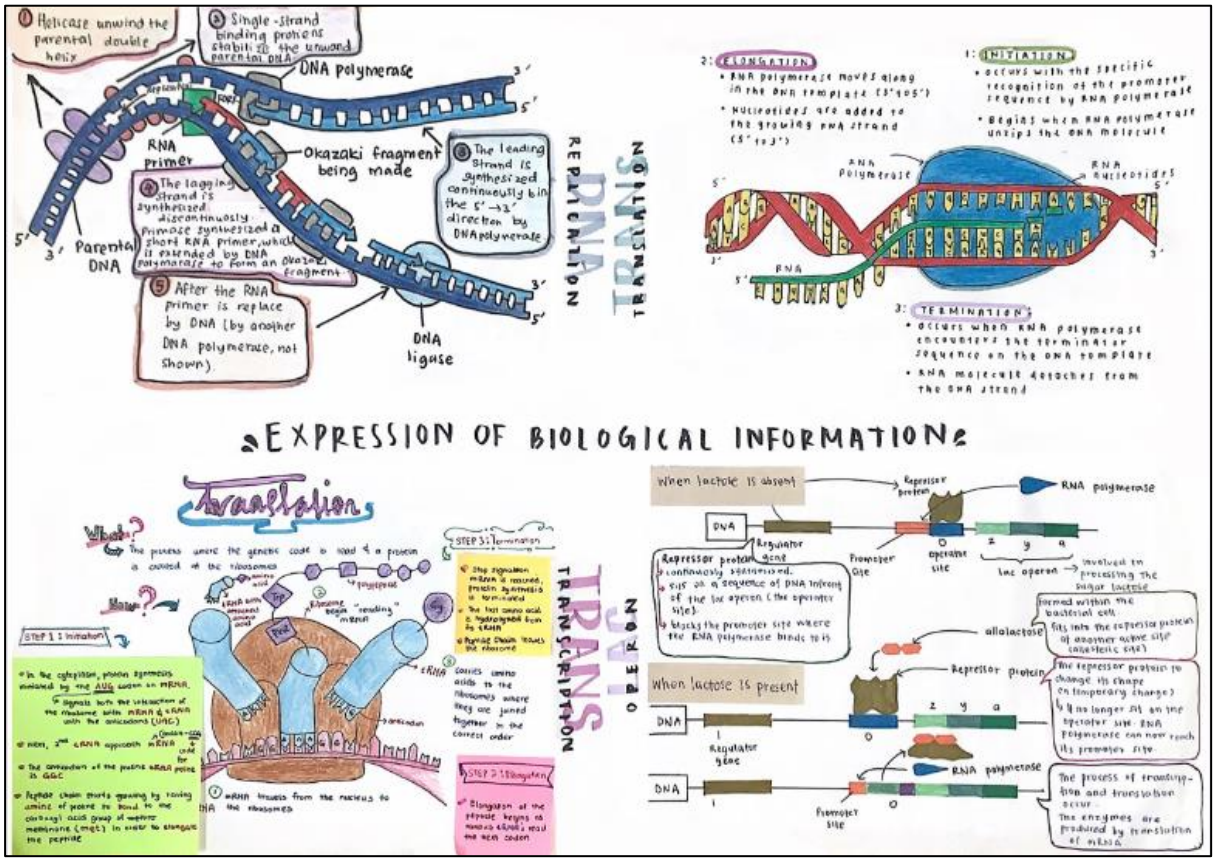

Figure 3. The mindmap of Nucleo-Beads

A token is provided to each player before starting the game. The players can roll the dice and move by their turn. “T” stands for treatment (miss 1 turn or redeem 1 token). The additional questions are for ladders (climb up) or slides (slide down). For an additional question, the player will scan the AR code using AR code application. For the sequence, a player will get a card and need to complete the task either copy the DNA or transcribe the RNA. The first player who has reached at the finishing line will be the winner.

The questions of Nucleo-Beads are showed in Figure 4. For easy questions (green cards), if the player answers the correct one, the player can move forward 1 step but if the player answer the wrong one, the player need to move backward 3 steps or redeem 1 token. For medium questions (yellow cards), if the player answers the correct one, the player can move forward 2 steps but if the player answer the wrong one, the player needs to move backward 2 steps. For hard questions (red cards), if the player answers the correct one, the player can move forward 3 steps or get 1 token but if the player answer the wrong one, the player need to move backward 1 step (Table 1).

The sequences question of Nucleo-Beads is showed in Figure 5. For easy sequences (green cards), if the player able to complete all the sequence without wrong, the player can move forward 1 step but if the player had 1 or more wrong arrangement in sequence, the player need to move backward 3 steps. For medium sequences (yellow cards), if the player able to complete all the sequence without wrong or has 1 wrong arrangement in sequence, the player can move forward 2 steps but if the player has 2 or 3 wrong arrangement in sequence, the player can stay at place without movement and if the player has more than 4 wrong arrangement, the player need to move backward 2 steps. For hard sequences (red cards), if the player able to complete all the sequence without wrong or has at least 3 wrong arrangement in sequence, the player can move forward 3 steps but if the player has 4 to 6 wrong arrangement in

sequence, the player can stay at place without movement and if the player has more than 7 wrong arrangements, the player need to move backward 1 step (Table 2).

Figure 4. The cards of questions

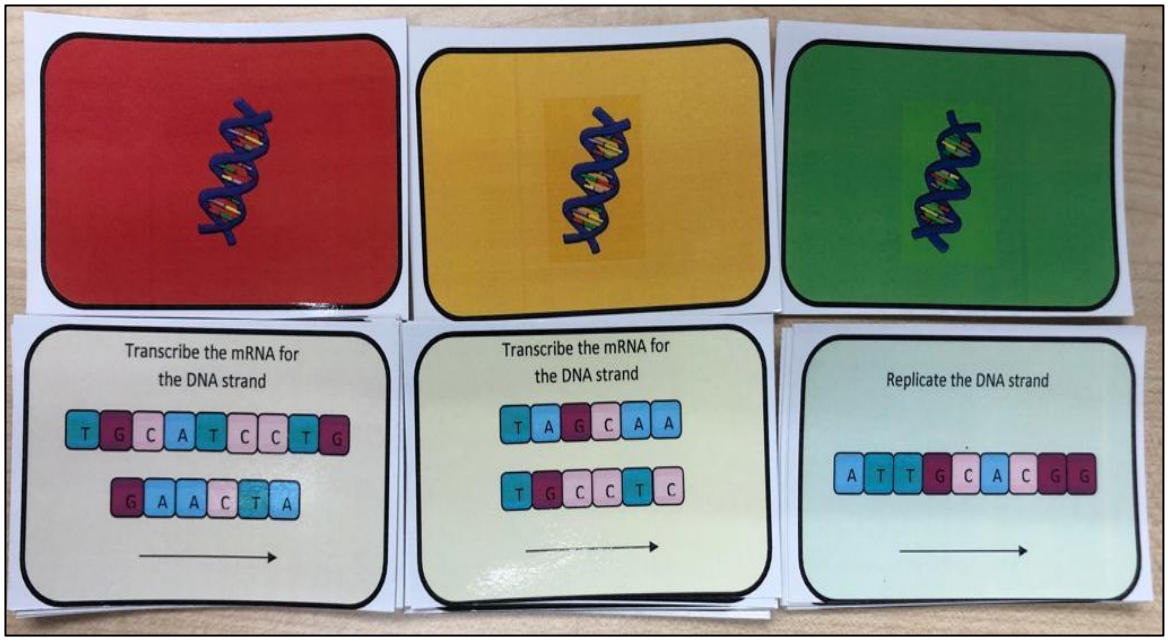

Figure 5. The cards of the sequence arrangement

Figure 6. The implementation of augmented reality using mobile application

Figure 6 shows the scanning process via augmented reality. Augmented Reality interfaces are entirely based on the target user by applying a standard graphic user interface (GUI) in the virtual world. The real-time interaction methods and augmented reality hardware integration is developed by using Unity 3D. In this phase, the 3-Dimensional environment design was converted into programming code. An appropriate programming technique was applied to solve the problem. Real-time image of an AR video projection of expression of biological information AR notecard was scanned onto a smart phone. The QR code generator method is powerful because even a single letter (or capitalization of a letter) leads to a significantly different pattern in the AR Marker. This differentiation in the AR Marker helps guide the accurate recognition of the AR notecards. It should begin to play a video shortly and student will be able to use the apps to see mechanisms for many biochemical processes associated with expression of biological information.

Table 1. The difficulty level of the question

Types of question	Correct	Wrong
Easy	Step forward for 1 step	Step backward for 3 steps/ redeem1 token
Medium	Step forward for 2 steps	Step backward for 2 steps
Hard	Step forward for 3 steps/ get 1 token	Step backward for 1 step

Table 2. The difficulty level of arrangement in replication or transcription

Arrangement	Easy sequences	Medium sequences	Hard sequences
0	Step forward for 1 step		
0-1		Step forward for 2 steps	
0-3			Step forward for 3 steps
>1	Step backward for 3 steps		
2-3		Stay (No movement)	
>4		Step backward for 2 steps	
4-6			Stay (No movement)
>7			Step backward for 1 step

Survey Analysis

The feedbacks collected from the questionnaires via online survey were analysed by using a linear scale (1-5) that indicates 1 for strongly disagree, 2 for disagree, 3 for neutral, 4 for agree and 5 for strongly agree. The mean was obtained from the findings.

Results and Discussion

The results show that the active participation of learners in hands-on activities has a particularly positive effect on the perceived enjoyment, resulting in their increased motivation for learning", as such seamless AR environments combine learning materials and the real scene around students, providing them with opportunities to manipulate the objects on their own offered an opportunity to visualize different stages of a constructive process by AR on mobile devices (Figure 1), in order to improve the understanding of the process and to investigate the relationship among the usability of the tool, students' participation, academic performance after using AR (Plunkett & Kyle, 2018; Fonseca et al., 2014).

Most of the students enjoyed this boardgame approach. The maximum score for each item in the questionnaire is five. Majority of the students score almost 5 points for each item. Table 3 shows the score of teaching and learning assessment by students. The results will create a clearer understanding of perceptions on AR and inform future professional development and resources needed to promote this evidence-based approach among university instructors locally and internationally.

Table 3. Score of teaching and learning assessment by students (n= 85)

No.	Question	Score (5)
1.	Biology as a favourite course	4.29
2.	Biology topics are interesting	4.62
3.	Teaching method in Biology by using boardgame	4.44
4.	Boardgame helps in memorising and understanding the topics	4.39
5.	Boardgame is an exciting method of learning while playing	4.46
6.	Boardgame is suitable for all students	4.47
7.	Boardgame can be used as a lesson's review toll	4.32

Research has found that playing board games can be an effective way for students to learn, with statistics showing that students who play board games in the classroom have better overall grades in their class assessments than those who do not (Che Sulaiman & Ban, 2019). Additionally, board games can increase student engagement and provide an enjoyable learning experience (Cascales-Martínez et al., 2017; Chang et al., 2014; Georgiou & Kyza, 2018). This previous study was aligned from the findings of this study. Nucleo-Beads board game was created to give students a fun and educational experience.

The game simulates biological processes, allowing students to learn about DNA replication, transcription, translation, and the lac operon. Additionally, students can gain an understanding of the structure of DNA, how genes are expressed, and other fundamental concepts in biology while playing.

A fresh perspective on how we learn is provided through game-based learning. With immersive environments, students can create materials for themselves, exchange learning experiences, and practice real-world skills. In order to develop captivating and engaging learning experiences for certain learning objectives, video games and computer programmes are used. Based on the implementation of augmented reality using a mobile application and game-based learning, students are able to develop new skills, recall the knowledge and apply their learning. With the development of new technology, educational games are becoming more popular. Their application in the aviation, military and healthcare sectors has already spread to other fields where employees are allowed to play games in a productive learning atmosphere. Schools and districts may better prepare their children for the future by using game-based instruction today.

According to the results of the study (Table 3) adding gaming components to lessons will increase student interest levels, give them more incentive to attend class and help educators achieve their goal of promoting learning. Through the usage of text, images, video, sound and animation, students can learn and performed studies that enable students to develop adaptable and unique ideas through multimedia. An environment free from anxiety is created by interactive multimedia (Kassim et al., 2014; Sanaky & Hujair, 2013).

The most important component of this study is that it uses techniques that are different from those used in prior AR to contribute to an engaging and participatory approach to the knowledge process (Che Ku Nuraini Che Ku Mohd et al., 2019). Students' motivation determines how long they are willing to try anything for, how difficult it is to try, and how closely attached they are to the activity (Rost, 2006). Several studies have documented the effectiveness of AR-based research activities to boost student motivation (Cascales-Martínez et al., 2017; Chang et al., 2014; Georgiou & Kyza, 2018; Wojciechowski & Cellary, 2013).

Conclusion

This project can help the students to better understand the topic expression of biological information through the mind map and also the game board that has been produced. The students can apply knowledge, play games about the topic practically through the game board and the affective domain is basically applied. Students' understanding of this topic was also measured through the survey conducted. Even if there were a few unfavourable opinions on the mobile app, they only make up a small portion of the overall respondents in this study. It can therefore be claimed that the good viewpoint outweighed the unfavourable viewpoints. The unfavourable reviews might be viewed as a chance to improve the mobile application even further. This research is achieved based on the aim of the study. This is a preliminary investigation on how students feel about using mobile applications to implement augmented reality. Therefore, more research is required to determine the impact of augmented reality mobile applications on students, particularly with regard to the learning of biology topics. Future research could investigate the impact by running experiments involving two or more student groups. Through game-based learning, this would give more insightful information on how to use augmented reality mobile applications.

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Author Contribution

SNS Muhammad Amin – Supervision, conceptualization, data curation, formal analysis, writing – original draft; S Jamal Mat Rosid – Writing – review & editing, formal analysis; A Abdul Malek – Writing – review & editing, formal analysis; N Mohammad Yusoff – Writing – review & editing, formal analysis; SM Aziz – Writing – review & editing, formal analysis; I Ismail – Augmented reality consultation and development.

Conflict of Interest

Authors declare no conflict of interest.

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