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THE EFFECTS OF GENETIC INHERITANCE E-GAME TO UNDERGRADUATE STUDENTS

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Abstract

The COVID-19 outbreak that is occurring worldwide has affected the education system, as the closure of education institutions has halted teaching and learning activities. Nevertheless, online education is being widely applied to complete the curriculum. As learning activities are limited by the prohibition of face-to-face classes, an E-game on genetic disease inheritance was designed and introduced to undergraduate Biomedical Science students of Universiti Kebangsaan Malaysia (UKM). In this approach, the students were divided into small groups of 5-7 students and they were required to grasp the basic knowledge of genetic disease inheritance including drawing a pedigree tree in order to understand genetic-based diseases, develop three case studies, four case studies-related questions and also provide the answer scheme beforehand. During the E-game, the Microsoft Teams online learning platform was used. Each of the groups took turns to present case studies on the topic of genetic disease inheritance and answered questions. Marks were given for each of the answers. The students' feedback was collected to evaluate the outcome of this approach. Their understanding on pedigree drawing topics, ability to draw pedigree diagram and analysing genetic inheritance case studies were significantly ($p<0.001$) increased after the e-game implementation. In addition, the e-game helped them to develop several skills such as teamwork and strategizing. Overall, the students were benefited with the approach, even though some limitations in internet accessibility and devices problems were encountered during the e-game. As conclusion, the e-game was successfully tailored to deliver the genetic inheritance topic previously outlined for face to face session.

Keywords: COVID-19; Distance Learning; Genetics; Online Learning; Undergraduate

Education

Abstrak

Wabak COVID-19 yang berlaku di seluruh dunia telah memberikan kesan kepada sistem Pendidikan akibat penutupan institusi pendidikan yang telah menyebabkan aktiviti pengajaran dan pembelajaran terganggu. Walaupun begitu, pendidikan dalam talian banyak digunakan untuk melaksanakan kurikulum. Oleh kerana aktiviti pembelajaran dibatasi oleh larangan aktiviti bersemuka, E permainan pewarisan penyakit genetik telah diperkenalkan kepada pelajar Sains Bioperubatan sarjana Universiti Kebangsaan Malaysia (UKM). Dalam pendekatan ini, pelajar dibahagikan kepada kumpulan kecil yang terdiri daripada 5-7 pelajar dan mereka diminta untuk memahami pengetahuan asas mengenai warisan penyakit genetik termasuk melukis salasilah, menghasilkan tiga kajian kes, empat kes soalan berkaitan kajian dan menyediakan skema jawapan. Semasa permainan, platform pembelajaran dalam talian Microsoft Teams digunakan. Setiap kumpulan bergilir-gilir untuk menyampaikan kajian kes mengenai topik pewarisan penyakit genetik dan menjawab soalan. Markah diberikan untuk setiap jawapan. Maklum balas pelajar dikumpulkan untuk menilai hasil pendekatan ini. Pemahaman mereka mengenai topik salasilah, kemampuan untuk melukis rajah salasilah dan menganalisis kajian kes perwarisan genetik meningkat dengan ketara ($p < 0.001$) setelah aktiviti ini dilaksanakan. Di samping itu, permainan ini membantu pelajar mengembangkan beberapa kemahiran seperti kerja berpasukan dan menyusun strategi. Secara keseluruhan, para pelajar mendapat manfaat dari pendekatan tersebut, walaupun terdapat beberapa kekangan seperti masalah akses internet dan peranti yang dihadapi semasa permainan elektronik. Sebagai kesimpulan, permainan ini berjaya disesuaikan untuk menyampaikan topik warisan genetik yang sebelumnya dijalankan secara bersemuka.

Kata kunci: Atas Talian; COVID-19; Genetik; Pembelajaran Jarak Jauh; Pendidikan Prasiswazah

1.0 INTRODUCTION

The COVID-19 outbreak has taken a huge toll in the year 2020. The worldwide pandemic affected multiple sectors such as health, economics, tourism and education. To date, there has been more than 117 million confirmed cases reported all over the world (WHO, 2020). As a control measure, governments in over 100 countries have implemented national closures that affected education institutions (UNESCO 2020). The national closure is known as the “movement control order” (MCO) in Malaysia and it restricted the movements of people and mandated the closure of all businesses except for those providing essential services (Tang, 2020). Following the government’s directive, universities were closed and face-to-face

teaching was suspended. Thus, teaching and learning activities underwent tremendous changes as it had to be conducted via the online medium (Birch & Wolf, 2020). This situation created a challenging task, as educators needed to plan and design online activities that are in line with the program learning outcomes within a limited time period.

Consequently, online learning has been emphasized in the education sector as part of embracing the Fourth Industrial Revolution (4-IR). However, online learning poses some limitations such as lack of face-to-face engagement and static communication (Longhurst et al., 2020). Thus, teaching and learning using online tools should be designed to be interactive, engaging and yet deliver sufficient knowledge to the students. One of the approaches is by integrating games to facilitate students' engagement and as a tool to improve learning outcomes (Gaalen et al., 2021). Integrating game elements in education, also known as gamification, could gain students attention, motivation and acceptance in learning (Halim et al., 2020; Khaleel et al., 2020; Mahmud et al., 2020). Educators from various fields have integrates gamification approach during COVID-19 pandemic (Arruzza & Chau, 2021; Nieto-Escamez & Roldan-Tapia, 2021;). Thus, education games (e-games) could be tailored to minimize the weaknesses of online teaching and fit in the curriculum.

In the topic of genetic disease inheritance, a pedigree is a diagram that shows a genetic inheritance of a family through several generations (NHGRI, 2020). It has been used to diagnose genetic diseases, especially in familial genetic inheritance and predicts particular genetic traits of an individual. To create a pedigree diagram, students need to understand the basics of genetic theory, the symbols used and history taking of a patient. Understanding the basis of pedigree-drawing could benefit the students as the skills are applied in the genetic field that they could embark as their profession in future.

Previously, the students were learning the basic concept on genetic diseases and been trained to draw pedigree diagrams via face to face session. As the MCO was implemented, several planned face-to-face learning activities had to be re-tooled into online learning. Thus, an innovative online learning game was designed and evaluated in this study known as Genetic Inheritance E-Game, to provide a fun activity, and gain students' interest, full engagement and understanding while learning about the topic of pedigree inheritance. Most importantly, they still could develop the skill to draw pedigree diagrams even though the session was conducted online. With full participation from the students, the E-game enabled the students to learn genetic inheritance online. The online learning is currently a new norm in the education sector to deliver learning activities as implemented in this study.

2.0 MATERIALS AND METHODS

Non-experimental study was employed to compare the effects of pre and post intervention using Genetic Inheritance E-Game on the same participants. Genetic Disease is an elective course conducted for 15 weeks of teaching and learning activities. The students need to learn about genetic diseases and pedigree drawing through Genetic Inheritance E-game project and the e-game was be conducted on week 14. Purposive sampling was used in this study. A total of 33 of fourth year students (N=33) who enrolled for Genetic Diseases course from the Biomedical Science Program, Faculty of Health Sciences, Universiti Kebangsaan Malaysia (UKM) were involved in this study. Participation of all of the students was compulsory to fulfill their degree. The students were divided into five groups that consist of 6-7 students per group.

2.1 Survey

A survey via Google form was conducted to evaluate the approach and to collect the feedback before and after the implementation of e-game. The survey was divided into section A) demographic data; B) E-game evaluation and C) challenges faced during the intervention. Students need to choose from selected answer options provided for section A on demographic data and section C for skills developed by this activity. The answer options for section B were divided into weakly agree, moderately agree and strongly agree on their understanding, ability to draw of pedigree drawing and analyze the cases.

2.2 Data Analysis

Section A and C were descriptive analysis. For analysing the data in section B, a scoring system was implemented with weakly agree (1 point), moderately agree (2 points) and strongly agree (3 points) based on the given statements. Normality test conducted and the data was not normally distributed. Thus Wilcoxon signed-rank test was conducted to compare the score before and after e-game implementation by using SPSS for Windows version 23 (IBM Corporation, USA).

2.3 Procedures

The students need to do several preparations in order to complete this e-game. The tasks were given two months before the e-game day encompass preparation of case study materials. The materials were presented during E-game day via online platform.

Case study

Case study is a process or record of the development for particular diseases and is widely used for medical diagnosis. The medical condition information collected from patients families

was presented in a case study and the students need to analyze the genetic diseases by drawing a pedigree diagram from the information given. In this approach, each of the groups was instructed to prepare three case studies and answer schemes before the game's day. The case studies cover the topics of dominant, recessive and sex link inheritance. For each of the case studies, the groups had to come up with three questions on their own. A pedigree diagram was compulsory to be drawn by the other players for all case studies. The lecturers then verified the case studies, questions and answer schemes before the game was conducted.

Each group was required to develop an online form for the other groups to answer their case study questions. The online form was created using the Microsoft Forms app which is included in the Microsoft 365 suite. The link to the form was shared on the e-game day on the Microsoft Teams chat box for the players to submit their answers.

E-Game Online Platform

The official online learning platform, Microsoft Teams, was used as the main interaction platform. Two terms were used to describe the participants roles during the e-game session: host group and play group (Figure 1). The host group was the group that presented the case study and questions to the other play groups. The play group is the group that answered the questions from the host group. Each of the groups took turns to be the host or play group. At the start of the game, the host group shared their case study by using Microsoft Teams. The questions and template for answering the questions were distributed via an online form and the URL was given through the chat box (Figure 2). The play groups had to answer the questions in 10 minutes. After the allocated time ended, the host group then conducted a discussion session for 5 minutes to discuss the answers. During this time, the host group can mark the answers submitted by the play groups. Each of the groups took turns to be the host or play groups. In total, each group needed to answer questions from four sets of case studies (play group) and present one case study (host group) in one round (Figure 3). Two rounds were conducted in this session.

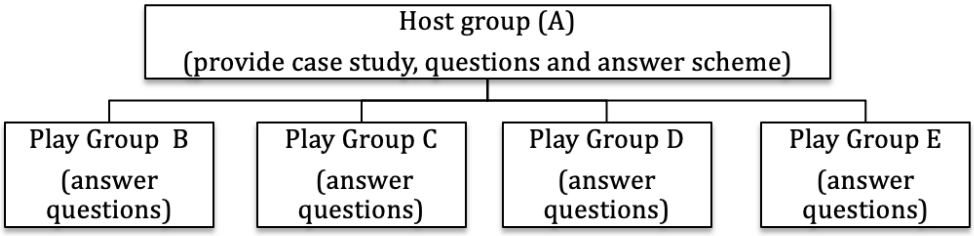

Figure 1: The roles of host and play group.

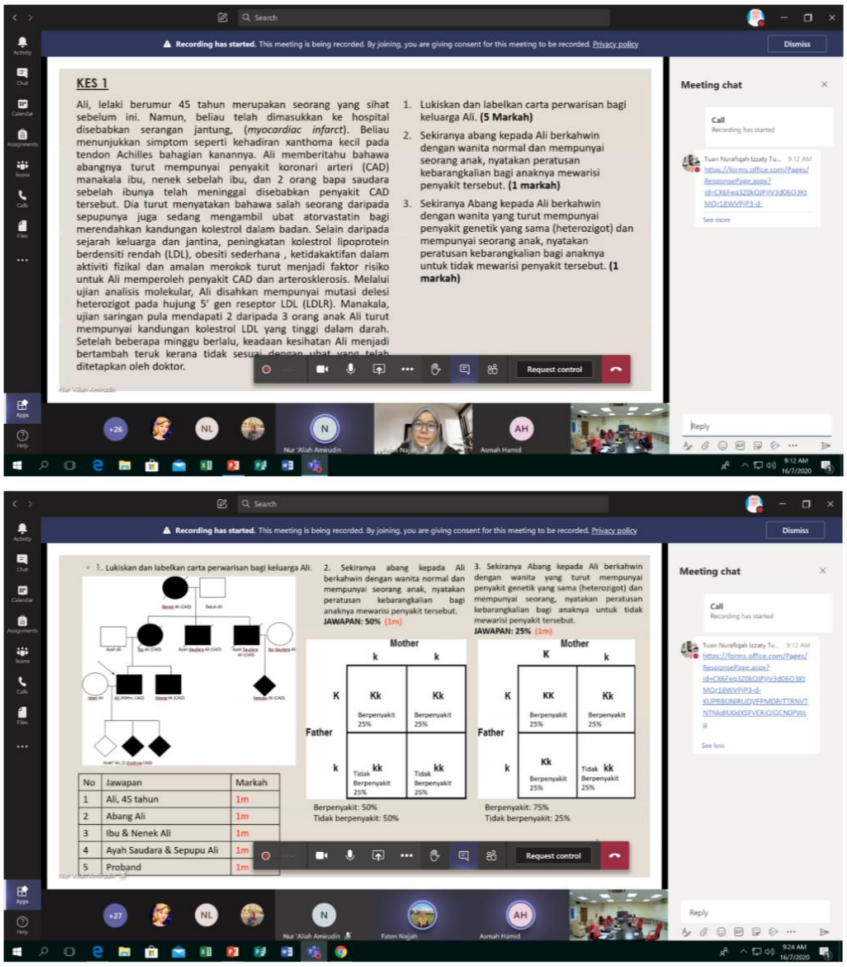

Figure 2: Example of case study and answer presentation during e-games.

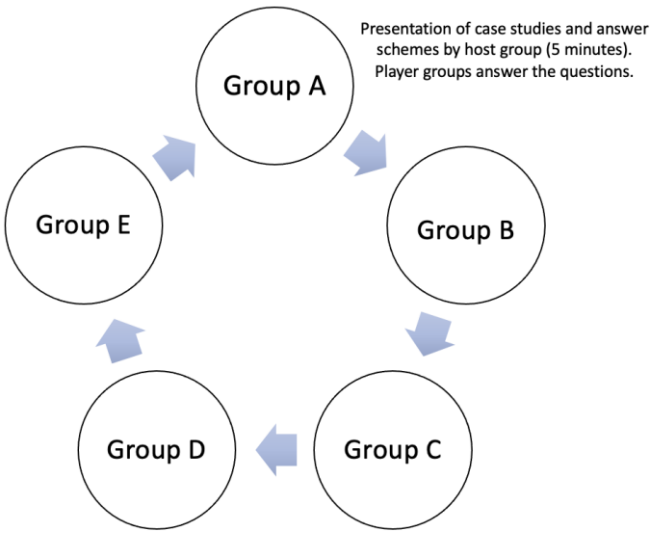

Figure 3: A schematic diagram of the game's flow.

A scoreboard to display of overall marks for each round was displayed. The marks were collected from the host groups that marked the answers submitted by the play groups. The overall marks were used to determine the ranking of each group at the end of the session. The lecturers acted as moderators in compiling the marks and controlling the time.

3.0 RESULTS AND DISCUSSION

A total of 33 students were involved in this survey. The data from the survey was analyzed to identify the students' perception on the e-game activity.

3.1 Students Understanding on Pedigree Drawing Topic

The students' perception in understanding the pedigree drawing topics was asked. A total of 28 students reported that the score on understanding the topic on pedigree drawing after e-game were higher compared to before e-game, while 5 participants reported that the score of understanding the topic on pedigree drawing were same before and after e-game. The Wilxocon signed-rank test demonstrated statistically significant ($p<0.001$) result, thus the e-game had significant greater relative influence on score of understanding pedigree drawing topic (Table 2).

Table 2: *Statistical analysis on students understanding on pedigree drawing topic*

	N	Mean	Std Deviation
Before	33	1.85	0.619
After	33	2.85	0.364
	N	Mean Rank	Sum of ranks
Positive rank	28	0.0	
Ties	5	14.50	406.00
Z	-4.963		
Asymp. Sig (2 tailed)	.0000		

3.2 Students Perception on Ability to Draw Pedigree Diagrams

A question was asked regarding their ability to draw a pedigree diagram based on genetic disease inheritance cases before and after the e-game implementation. A total of 29 students reported that score of ability to draw pedigree diagrams were higher compared to before the e-game, while 4 students reported that the score of ability to draw pedigree diagram were similar before and after the e-game. The Wilxocon signed-rank test demonstrated statistically significant ($p<0.001$) result, thus the e-game had significant greater relative influence on score of ability to draw pedigree diagrams (Table 3).

Table 3: *Statistical analysis on students' perception on ability to draw pedigree diagrams*

	N	Mean	Std Deviation
Before	33	1.79	0.619
After	33	2.91	0.292
	N	Mean Rank	Sum of ranks
Positive rank	29	0.0	
Ties	4	15.00	435.00
Z	-4.944		
Asymp. Sig (2 tailed)	.0000		

3.3 Students Perception on Ability to Analyze Genetic Inheritance Case Studies

A question was asked regarding their ability to analyze the genetic inheritance case studies before and after the e-game implementation. A total of 28 students reported that score of ability on analysing genetic inheritance diseases were higher after the e-game compared to before, while 5 students reported that the score of ability were the same before and after the e-game. The Wilxocon signed-rank test demonstrated statistically significant ($p<0.001$) result, thus the e-game had significant greater relative influence on score of ability to analyse case studies related to genetic inheritance (Table 4).

Table 4: *Statistical analysis on students' ability to analyze genetic inheritance case studies*

	N	**Mean**	**Std Deviation**
Before	33	1.73	0.674
After	33	2.70	0.467
	N	Mean Rank	Sum of ranks
Positive rank	28	0.0	
Ties	5	14.50	406.00
Z	-5.013		
Asymp. Sig (2 tailed)	.0000		

3.4 Skills Development

Several skills were instilled during implementing this activity. The e-game was found mainly instilled teamwork (36%) and strategizing (33%). In addition, the students also agreed that this approach polish their time management (6%), leadership (6%), critical thinking (6%) and communication (3%).

Table 5: *Skills developed during e-game*

Skills	% (n)
Teamwork	36 (n=12)
Strategize/planning	33 (n=11)
Knowledge	9 (n=3)
Time management	6 (n=2)
Leadership	6 (n=2)
Critical thinking	6 (n=2)
Communication	3 (n=1)

3.5 Challenges faced during the Genetic Inheritance E-Game session

Several limitations and challenges were encountered during the e-game as some of the students encountered internet connection problems (64%), devices problems (18%) and faced difficulties to conduct online discussions between team members (18%).

Table 6: *Problems encountered during e-game*

Problems	% (n)
Internet Stability	64 (n=21)
Devices	18 (n=6)
No face to face discussion	18 (n=6)

3.6 Discussions

The COVID-19 pandemic has caused a major shift in education that affected students and educators (Birch et al., 2020). Even though the 4th industrial revolution has emphasized on online learning, the MCO has forced the full implementation of online education to be inevitable. Various online teaching approaches have been introduced to support online learning such as electronic resources, online tools and online webinars (Chick et al., 2020; Chiodini, 2020; Kaup et al., 2020; Regier et al., 2020). To ensure teaching and learning activities resume despite the pandemic, an education game, based on online activity has been developed to teach biomedical science students about the topic of genetic inheritance.

To ensure the full participation of students, we made it mandatory for all groups to play both as host and play groups. Each of the groups had their own strategy by assigning specific roles to individual members. As marks were collected, it instilled a competitive mode between the group members to perform the tasks. This increased their motivation in learning and

completing this topic. Studies has shown that the gamification approach could motivate students in learning (Khaleel et al., 2018). As this approach implement hands on approach and interactive activity, it assists students' motivation and boost critical thinking skills (Rusli et al., 2019).

The e-game approach was demonstrated to increase students understanding in learning genetic inheritance topic. Genetic inheritance is a science subject that is challenging to some of the students. As students in each of the groups need to answer questions based on the case study presented, they can test their basic theory in genetics and checked at the end of the session via discussion as the correct answers were explained. The genetic diseases topics incorporated was ensured to cover all types of inheritance such as dominant, recessive and sex linked inheritance. Another important aspect in genetic inheritance topic is the ability to draw pedigree diagram. The students were required to draw the pedigree tree according to the case study and the marks were given based on the correct diagram produced. As this approach was relying on genetic disease case studies, thus the students were found to improve their analysing skill. This is very important as they might encounter the real case in future career.

The students not only gain knowledge through the games but indirectly acquire several transferable skills that are associated with the process of learning that are vital for their future career growth. For example, this approach instilled teamwork and strategizing that are important in their working environment in future. However, the educators are the one who set The students' independent learning was also improved using this student-centered e-game approach. The students were given the freedom or autonomy to choose their own case study, create questions and answer schemes while being facilitated by the lecturers rather than depending entirely on the lecturers to obtain learning materials. However, the educators still have the control by set the rules of competition and learning style. This provided a more effective experience for them to better understand and analyze the topic in depth (Dedo & Hashim, 2020). In short, the current study emphasized more on student centered approach and learning. This in turn provides real experience to the students to enable them to understand and analyze the topic more in-depth.

However, the online approach still has some limitations. The main limitation is the internet connectivity available to the students. Some of the students are staying in rural areas that have a weak internet coverage. Thus, the e-game were interrupted by an intermittent internet connection which disrupted the learning process and created challenges in doing

online activities. Internet access and affordable broadband connection are issues that have been observed with online teaching (Seymour-Walsh et al., 2020). In addition, personal devices problem also was encountered as the laptop stop functioning or freeze during the game. Nevertheless, online teaching brings challenges to educators as they need to polish their technical skills and upskill with new technologies (Longhurst et al., 2020; Sahi et al., 2020). The “sink or swim” now applies especially in the pandemic period, and ideally, an adaptation period is needed and a must for both educators and students to familiarize themselves with the system and lastly embrace the 4IR.

4.0 CONCLUSION

As the COVID-19 outbreak unexpectedly took place, it posed big challenges to educators in designing and executing teaching and learning activities while adhering strictly to the course learning outcomes. The approach of Genetic Inheritance E-Game was positively accepted by the students especially in enhancing their genetic diseases knowledge, drawing pedigree diagram, analysing skills and develop transferrable skills that are expected to be achieved during face to face learning. This approach closed the barrier faced by online learning and shall be continued to be implemented in the future or could be adapted to suit any other relevant subjects.

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