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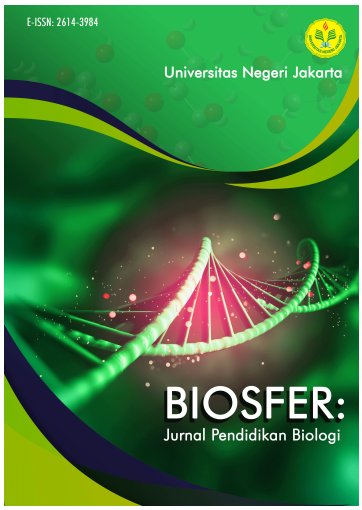

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Articles

Bekti Isnaeni, Nani Aprilia, Much Fuad Saifuddin

355-367

PDF

MENU

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PUBLICATIONS

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For Readers

For Author

For Librarians

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Game-based learning: An alternatif learning model in covid-19 distance learning

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ABSTRACT

Distance learning as Covid-19 pandemic solution has student learning boredom as a negative impact. Game application can increase students' enthusiasm and motivation to learn in distance learning. The game-based learning (GBL) model is potentially applied to create a fun learning atmosphere and overcome learning boredom. This study aims to determine the effect of GBL implementation on cognitive learning outcomes and student responses in the biological interaction chapter in Covid-19 distance learning. This research was experimental research (one-group pretest-posttest design). The research sample was 25 students. This research used one treatment group without a control group. The test questions were used as cognitive learning outcomes instruments. The questionnaire was used as a student response instrument. Game application used were classified as mobile games, single-player games, role-playing game (RPG). GBL syntaxes were pre-experimentation, experimentation, reflection, activity, and discussion. The results showed that the implementation of GBL in the biological interaction chapter in Covid-19 distance learning affected students' cognitive learning outcomes. The effect of this model could improve students' cognitive learning outcomes with 28% students of low category N-gain while 72% students of medium and high.

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INTRODUCTION

The Covid-19 pandemic has impacted all human life areas, including education. The Ministry of Education and Culture has issued Circular Letter Number 4 of 2020 concerning the Implementation of Educational Policies in the Emergency Period for the Spread of Corona Virus Disease (Covid-19). All school members' health is the primary consideration so the learning process is conducted through distance learning. This distance learning is carried out from early childhood to higher education to prevent the Covid-19 spread in schools and campus.

Distance learning as a Covid-19 pandemic solution implemented since March 16, 2020. Several studies showed the positive and negative impacts of distance learning on students. The positive impact obtained by students included learning independence (Kristina et al., 2020) while the negative impact experienced by students included learning boredom (Pawicara & Conilie, 2020). Some of the various factors that caused learning boredom were less attractive learning media, boring presentations, many tasks without an in-depth learning material explanation (Pawicara & Conilie, 2020). It caused a sense of laziness, stress, fatigue, and boredom then students lost their learning enthusiasm. The students learning boredom in distance lectures caused discomfort when attending a virtual class indicated by turning off the camera during lectures. By the off-camera, students could do other activities without being noticed by the lecturers and other students, such as playing another digital game. Other forms of boredom shown by students include reduced attendance and involvement in learning, minimal response to learning activities, minimal interaction in discussions, lack of discipline in collecting assignments (Herdiana et al., 2021).

To overcome the distance learning negative impact, Basar (2021) suggests that teachers use varied learning models so that students do not feel bored and are not burdened in distance learning. Kristina et al. (2020) also conveyed suggestions regarding the pandemic distance learning implementation, including learning that could increase students' learning enthusiasm; assignments that used varied applications that increase students' learning motivation. Some of these suggestions are in line with the learning principles in the Decree of the Minister of Education and Culture Number 719/P/2020 concerning Guidelines for Curriculum Implementation in Education Units in Special Conditions. The learning principles in these conditions are active; healthy relations between the components involved; inclusive; cultural diversity; socially oriented; future-oriented; according to the students' abilities and needs; and fun. One of the principles related to the negative impact of distance learning is the principle of fun learning. Fun learning encourages students to enjoy learning and continued to grow a sense of challenge for themselves, so they can motivate themselves, be active and creative, and take responsibility.

One learning model potentially applied to create a fun learning atmosphere is game-based learning (GBL). GBL integrates information and communication technology in learning by utilizing game applications/ digital games as learning media. Game applications used in GBL have specifically designed according to learning objectives (Li & Tsai, 2013). According to Prensky (2001), game applications compose of 12 combination elements, there were fun; play; rules; goals; interactive; adaptive; outcomes and feedback; win states; conflict/ competition/ challenge/ opposition; problem-solving; interactions; representatives and stories. (Gros, 2007) classified application games into seven main categories. The categories are action games (platform games), adventure games, fighting games, role-playing games, simulations, sports games, and strategy games. These games have classified as single-player games, multiplayer games, and massively multiplayer online games (Li & Tsai, 2013).

Game applications are specifically designed. These game applications vary in design, approach to using games, and playing ways to facilitate learning (Li & Tsai, 2013). Most learning game applications are designed to improve scientific knowledge/concept learning (physics, chemistry, biology, and earth science). Some game applications facilitate scientific processes learning, problem-solving, and socio-contextual learning (Li & Tsai, 2013). Several game applications are also designed to increase attitude, motivation, interest, student performance, and engagement (Vlachopoulos & Makri, 2017). Some game applications are designed to support students' collaboration and interaction in the virtual game world. Most game applications are deliberately designed to facilitate learning individually rather than collaboratively (Li & Tsai, 2013). Game applications designed for students to learn individually are potentially used as media in distance learning. In distance learning, students study in a separate location from the teacher. The teacher acts as a facilitator who monitors student learning progress through

applying information technology. In this case, the information technology role becomes significant to support student and teacher communication.

Game applications as one of the information technology products can be a tool that helps teachers in conveying messages to achieve learning objectives. Game applications provide a complex environment where the content, players' skills, players' attitudes play a significant role during the game (Gros, 2007). Game applications facilitate material content to become an integral component in games and facilitate affective learning, behavior, and sociocultural engagement (Perrotta et al., 2013; Plass et al., 2015). Game applications display animations and narrations that can make students interested so that game applications can build student motivation. GBL has been applied in distance learning and can create fun learning conditions (Wati & Yuniawatika, 2020; Winatha & Setiawan, 2020). Makalintal & Malaluan (2019) states that GBL is appropriate for providing visual images/models and simulations, not only in face-to-face learning but also in distance learning. According to Gros (2007), GBL implementation can be accomplished by adding other learning resources. The implementation of such GBL can provide a more immersive learning experience for students.

Pan et al., (2021) explained the difficulties of implementing GBL included the limited quantity and quality of available game applications; the lack of suitable frameworks on GBL within the curriculum; and more appropriate instructional support that integrate games and teaching. Some research had developed game applications to support the implementation of GBL. Game applications had developed on the cell cycle concept for high school students (Kanyapasit & Srisawasdi, 2014), waste and recycling concept for high school students (Abidin et al., 2020), biotechnology process for high school students (Sadler et al., 2013), and reproductive system for junior high school students (Noviami et al., 2012). A previous study by Randi & Carvalho (2013) developed a game application for undergraduate students in cellular biology. This research implemented GBL in biological interaction chapter for undergraduate students. The game application used in this study was classified as a Role Play Game (RPG). This game application was developed by researchers. To overcome the difficulties of implementing GBL (Pan et al., 2021), this study also included instructional descriptions for students and lecturers on each GBL syntax.

This study implemented GBL on biological interaction chapter in pandemic Covid-19 distance learning. GBL implementation was expected to reduce student boredom by creating a fun learning atmosphere. This study aimed to determine the effect of GBL implementation on biological interaction chapter on cognitive learning outcomes and student responses in Covid-19 pandemic distance learning.

METHODS

Research Design

This research was experimental research with a one-group pretest-posttest design. This design was the simplest in pretest-posttest designs without control groups where the researchers gather data about some outcome through a single pretest, giving a treatment, and then gathering posttest data on the same measure (Salkind, 2010). This design was used because the objective of this research about the effect of GBL on student learning outcomes. The GBL implementation effect was determined by comparing before and after treatment conditions using pretest and posttest. In this research, the GBL model was applied in the biological interaction chapter in the Applied Ecology course. This research was conducted in Covid-19 pandemic distance learning in the 2020/2021 odd semester.

Population and Samples

The research subjects were Biology Education Study Program students at Sanata Dharma University who were taking Applied Ecology Courses in 2020/2021. All of them were students of the first semester. The research objects were cognitive learning outcomes and student responses. The research sample was 25 students which consisted of 22 women and 3 men. This research used one treatment group without a control group. All students were put into the treatment group.

Instrument

The instrument used to obtain cognitive learning outcomes data was a test question (pre-test and post-test). The instrument used for student response data was a questionnaire. The test questions consisted of five multiple-choice items and two essay items. The test questions had validated in content to know which measurement variable was adequate in representing the realm related to the measured concept variable (Amir, 2015). Content validation was done by asking for an opinion (judgment) or an

evaluation from an expert panel (expert panel review) from an expert lecturer. Content validation aspects included the suitability of the item with the material coverage (depth and breadth); conformity with learning objectives and the evaluated cognitive level; representing/ reflecting the overall content of the material proportionally (Amir, 2015; Djaali & Muljono, 2008).

The questionnaire consisted of 21 statement items. Based on the validity test obtained, 17 statement items were valid, and four were invalid. The validity test had carried out by the Product Moment Pearson Correlation validity testing. The questionnaire indicator included student responses to the implementation of GBL (4 statements), attitudes (5 statements), motivation and interests (5 statements), student learning involvement (4 statements). This questionnaire was designed by researchers.

Procedure

This research was divided into four steps (preparation, data collection, analysis, and evaluation). The activities at each showed in Figure 1. This research used one treatment group without a control group. The game application was selected according to the learning objectives. The learning objectives were students could identify interactions between organisms in the game application into types of biological interactions; students could describe the interaction between organisms through playing the game; students could relate the concept of biological interaction with benefits for human life.

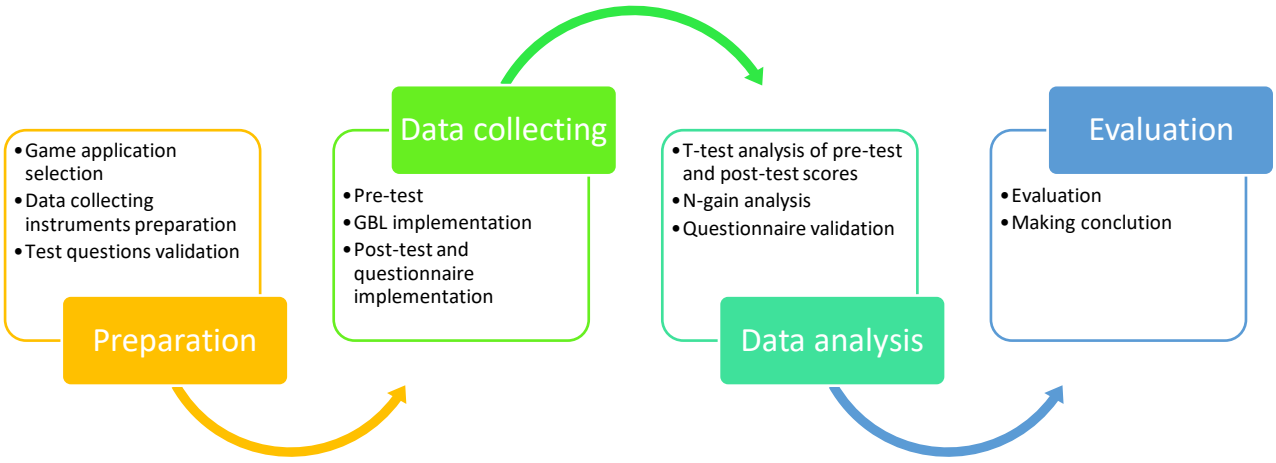

Figure 1. Research procedure

The game application selected was Dunia Diana. This game application was developed by researchers and was available on a limited basis. This game application was classified as a Role Play Game (RPG), offline mobile game, and single-player game. The student played the main character of the game, Diana (Figure 2. a). Diana was illustrated living in a village. Diana performed daily activities with the people around her. In this activity, Diana encountered various interactions between living things around her. The fictional background shown in the game include houses, yards, gardens, and rivers (Figure 2. b). Students obtained the knowledge through the flow of the game. The game application provided assignments and multiple-choice questions to answer (Figure 2.d). After answering questions, the feedback was obtained by students. If the student answers correctly, then the student gets appreciation (Figure 2. c). If the student answered incorrectly, then feedback was given through the correct answer explanation.

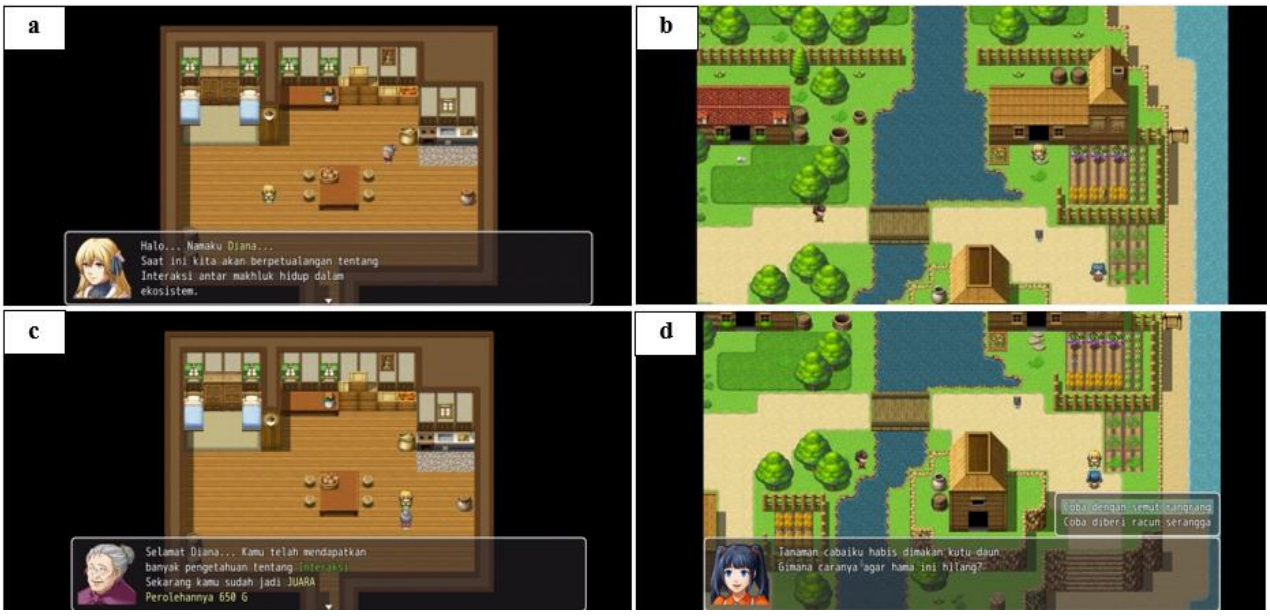

Figure 2. Dunia Diana game display: character introduction (a); game fictional background (b); final appreciation (c); multiple-choice question (d)

The biological interaction chapter was conducted into 5 hours (2 meetings). The game application was used at the 1st meeting while the discussion method was used at the 2nd meeting. The GBL syntax followed Gros (2007) and divided into experimentation, reflection, activity, and discussion. In this study, pre-experimentation was added as a preparation stage. The description of the learning syntax, time, and learning media used showed in Table 1.

Table 1
The description of the learning syntaxes, time, and learning media.

	Learning Syntax	Description	Time Allocation	Learning Media
	Pre-test	Students worked on the pre-test.	1 day before 1st meeting	www.quizizz.com (pre-test link available in LMS)
1st meeting	Pre-experimentation	Students installed the game application on their smartphones and downloaded the worksheets from LMS. Students read the game introduction and rules in LMS.	1 hour before lectures	LMS (link aplikasi game dan file lembar kerja)
	Experimentation	Students played the game and summarized the knowledge obtained by filling out the worksheets.	70 minutes	Smartphone and game aplication
	Reflection	Students discussed the summarized knowledge obtained and learning experiences from games in a group. Clarification of misconceptions and confirmation by the lecturer.	30 minutes 10 minutes	Zoom (breakout room) Zoom
	Activity	Students were assigned to discuss journal articles about the implementation of biological interaction concepts in human life.	40 minutes	LMS (assignment)
2nd meeting	**Discussion**	Students did presentations and class discussion. Clarification of misconceptions and	90 minutes 10 minutes	Zoom Zoom

Learning Syntax	Description	Time Allocation	Learning Media
	confirmation by the lecturer.		
Post-test	Students worked on the post-test.	Until 1 day after 2nd meeting	www.quizizz.com (post-test link available in LMS)

The knowledge obtained by students from the game was summarized in a worksheet table. The knowledge summarized included the type of biological interaction, the types of organisms involved in the interaction, and the interaction description. Pre-test, post-test, and questionnaires were administered online via www.quizizz.com. The pre-test could be done from the day before the 1st meeting to 1 hour before the lectures. Post-test and questionnaire could be done after the 2nd virtual meeting was completed up to 1 day later. Pre-test and post-test were done within 15 minutes. Learning management was carried out using a moodle-based Learning Management System (LMS) (https://learning.usd.ac.id/) while the virtual meeting used the Zoom application. Additional learning resources besides the game application in activity and discussion syntaxes were scientific articles. The selected article's themes were the mutualistic interactions between *Rhizobium* and *Glycine max* and their role in increasing agricultural production; mutualistic interactions between mycorrhizae and *Zea mays* and their role in bioremediation; eating competition between fish species and their role in aquaculture; parasitoid interactions and their role in pest control.

Data Analysis Techniques

The pre-test and post-test scores were used to calculate mean values and standard deviation. Indicators of increasing student cognitive learning outcomes were determined based on whether there was an increase in the pre-test and post-test scores. The pre-test and post-test scores were analyzed for normality and homogeneity and then analyzed to determine whether there was a difference between the two. The pre-test and post-test scores were used to calculate the N-gain value. The N-gain analysis followed this formula:

$$\text{N} - \text{gain} = \frac{\text{post} - \text{test} \; - \; \text{pre} - \text{test}}{\text{maximal score} - \; \text{pre} - \text{test}}$$

The N-gain values were grouped into categories based on Table 2.

Table 2
N-gain value categories.

N-gain value	Category
$g > 0.7$	High
$0.3 \leq g \leq 0.7$	Middle
$g < 0.3$	Low

RESULTS AND DISCUSSION

Student cognitive learning outcomes

Students' cognitive learning outcomes showed in Table 3. The pre-test scores range was 20-60. The post-test scores range was 40-85. The post-test score mean was higher than the pre-test (66.00 > 42.60). Accordingly, GBL implementation of in the biological interaction chapter could improve student cognitive learning outcomes in covid-19 pandemic distance learning. Similar results were obtained by Yu et al. (2014) that students who study with GBL obtained significantly higher learning achievement.

Table 3
Student cognitive learning outcomes.

Component	Pre-test	Post-test
The number of students	25.00	25.00
Lowest score	20.00	40.00
Highest score	60.00	85.00
Mean score	42.60	66.00

Component	Pre-test	Post-test
Standard deviation	10.62	11.73

The Shapiro-Wilk normality test showed that the pre-test and post-test scores were normally distributed with $p > 0.05$ (Table 4.). To find out the difference between the pre-test and post-test scores, a t-test was performed. The t-test results ($p = 0.000$) showed that there was a significant difference between the pre-test and post-test scores with $p < 0.05$. Accordingly, GBL implementation in the biological interaction chapter affected student cognitive learning outcomes in covid-19 pandemic distance learning. Similar results were obtained by Susilawati (2019), the simulation game based on virtual laboratory had a significant effect on students' cognitive learning outcomes. According to Knowles (2002) , the changes in student learning outcomes were the result of the treatment.

Table 4
The normality test of pre-test and post-test score.

	Shapiro-Wilk		
	Statistic.	df	Sig.
Pre-test score	0.944	25	0.180
Post-test score	0.925	25	0.068

The N-gain percentage based on pre-test and post-test scores was shown in Table 5. The N-gain percentage of the low category was 28% students, while the middle and high were 72% students.

Table 5
Percentage of students in each category N-gain.

Category	Percentage (%)
High	8
Middle	64
Low	28

Student response

GBL implementation in the biological interaction chapter could improve student cognitive learning outcomes in Covid-19 pandemic distance learning. GBL creates a fun learning atmosphere (Perrotta et al., 2013; Prensky, 2001b). The student response questionnaires results showed 96% of students responded agreed and strongly agreed that the learning atmosphere was fun and reduced learning boredom (Table 3.). This result has appropriated with Noviami et al. (2012) that game applications can help teachers provide learning media as material conveyers in a fun way. According to Perrotta et al. (2013), one of GBL principles is learning through intense enjoyment and fun. Hidayat (2018) states that game applications make assignments more attractive and fun. In this study, playing the game application was a part of the assignment. Students did the assignment by playing the game application then filled out the worksheets with the information obtained from the game. In this case, the assignment had packaged as more attractive and fun. Using attractive assignments and fun assignments in learning can be a good motivator for students. According to Cicchino (2015) and Perrotta et al. (2013), games increase intrinsic motivation because game applications can invite students to be involved furthermore support student-centered learning.

GBL can improve student learning outcomes because the game can motivate students to learn. In this study, student response results showed 96% of students responded agreed and strongly agreed that GBL implementation motivated them to study independently (Table 3.). Similar results are stated by Yulianto (2021) that the implementation of games as learning media can increase students' motivation and independence. According to Prensky, (2001a), the game has an element that can motivate students, namely goals. The game application goals in this study were to find all biological interaction types (14 interactions). Not all students could get all interaction types. Based on student sharing in reflection, the number of interaction types found ranged from 9 to 14 interactions. Finding out that their friends had succeeded in achieving their goals, some students who had not reached the goals said they would play the game again until they achieved their goals. This case is in line with the statement of McGlarty et al. (2012) and Plass et al. (2015) that entertainment game applications can

motivate players to engage longer in the game through goals and win states (included stars, points, leader-boards, badges, trophies). In this study, student motivation to obtain goals had a positive impact on learning motivation because learning objectives were achieved at the same time as game goals were achieved. In Cózar-Gutiérrez & Sáez-López (2016) research, GBL also received a significant positive response related to motivation and interest as well as innovation in learning.

Student responses regarding the statement of motivation to study independently are in line with Herdiana et al. (2021) that students feel independence is required in distance learning. Learning independence is one of the determining factors for the success of distance learning (Rozi et al., 2021). On the other hand, GBL implementation in this study positively impacted student learning independence. Students could study independently in self-paced activities. Students were responsible for learning activities and building knowledge from their learning activities (Department of Education and Early Childhood Development, 2011). Thus, GBL is potentially implemented to overcome the challenges of learning independence in distance learning.

Table 6
Percentage of student questionnaire responses.

No.	Statement	Percentage (%)			
		Strongly disagree	Disagree	Agree	Strongly agree
1.	The learning atmosphere in the biological interaction chapter is fun	4	0	28	68
2.	Learning this chapter inspires me	0	0	44	28
3.	I can focus on the biological interaction chapter.	0	0	68	28
4.	Playing the game motivates me to be involved in learning activities.	0	0	44	56
5.	Learning this chapter motivates me to express my opinion.	4	0	64	32
6.	This game is attractive and makes me want to know more.	0	0	28	72
7	The learning activities atmosphere is comfortable.	0	0	44	56
8.	Playing the game makes me excited to participate in learning activities.	0	0	36	64
9.	Learning this chapter motivates me to learn more independently.	0	4	44	52
10.	The game is attractive, so it makes challenges to finish the game.	0	0	36	64
11.	Playing the game makes me excited to do assignments.	0	0	44	56
12.	Playing the game can reduce my boredom in participating in learning activities.	4	0	24	72
13	Playing the game makes me more sensitive to the interactions between organisms around me.	0	4	48	48
14.	I always listen to my friends' presentations, lectures' clarifications, and in group discussions.	0	4	52	44
15	Playing the game makes me more familiar with the role of biological interactions in human life.	0	0	36	64
16.	Learning this chapter gives me more opportunities to discuss.	0	0	40	60
17.	Playing the game has trained me to try more explore.	0	0	32	68

The student response questionnaire showed positive results, including agree and strongly agreed of 100% on statements 2, 3, 4, 6, 7, 8, 10, 11, 15, 16, and 17 (Table 3). Based on the questionnaire, students responded that GBL implementation created attractive learning, inspiring learning, and a comfortable learning atmosphere. GBL implementation could motivate students to be involved in learning. GBL implementation could make students enthusiastically participate in learning, do assignments, and pay full attention to learning activities. Vu & Feinstein (2017) research found a teacher

who stated that his students focused during learning activities. Students also focused on the topics discussed and learning materials and strategies in the game.

GBL implementation can overcome the learning saturation problem indicated by the lack of student involvement and minimal response to learning activities. In this study, student responses showed 96% of students agree and strongly agree with statements expressing opinions and listening to friends' presentations, lecturers' clarifications, and group discussions (Table 3.). The student involvement in GBL depends on the game application design used (Plass et al., 2015). Cognitive involvement can be observed in the processing of information obtained by students from game applications. Students learned the biological interaction chapter based on information in the game. According to Plass et al. (2015), game applications that do not involve students cognitively are considered ineffective in achieving learning objectives. In this study, student involvement can also be observed in each learning syntaxes, especially in reflection and group discussions. Sharing summaries of knowledge obtained and learning experiences from games (strategies for achieving goals) in reflection was necessary for GBL. This syntax facilitates students to perform student self-assessment and peer assessment (Department of Education and Early Childhood Development, 2011).

GBL implementation could also train students to explore and challenge to complete the game (Table 3.). GBL implementation that involves students in learning is following the statements of Cózar-Gutiérrez & Sáez-López (2016) and McGlarty et al. (2012). According to Rapini (2012), GBL packages learning materials as learning experiences in the game world. Students learn through active experience exploring the game world. In this research, students also learn through the interpretation of their experiences in reflection and discussion.

The students had asked to make a brief comment via www.mentimeter.com (website-based application) about their feeling after playing the game application and the difficulties in playing the game. As many as 80% had no difficulty in playing the game and 20% of students had difficulty. According to the Department of Education and Early Childhood Development (2011), GBL develops student skills using Information and Communication Technology (ICT) tools as a positive impact. To play the game application, students needed to download, install and operate according to the instructions for using the game.

The word cloud displayed student comments about their feelings after playing the game application shown in Figure 3. Short comments had written by students generally represented positive comments. The comments were conveyed in diverse words such as happy, interesting, fun, exciting, helpful, adding knowledge, and confused.

Figure 3. The display student comments on the Mentimeter application

In this study, GBL implementation showed a positive impact on students in distance learning. Brown et al. (2018) stated that GBL is increasingly used as an alternative learning model to teach science in further education and higher education. A factor needed to be considered in implementing GBL is the selection of appropriate game applications. The game selection which accorded learning objectives will determine GBL implementing success. The limitation of GBL implementation causes by the limited learning game applications provided. Development researches of learning game applications are needed

to provide learning games appropriate to the learning objective. Research providing a review of learning game application examples (including objectives, learning activities, outcomes) such as research by Brown et al. (2018) and Sipiyaruk et al. (2021) are also needed to support GBL implementation in learning.

GBL implementation needs to pay attention to the availability of supporting equipment and software facilities, teachers' ICT capabilities, and teachers' beliefs about the role of game applications in learning (Kaimara et al., 2021). This study found that the GBL implementation obstacles in distance learning were the facilities owned by students, for example, the specifications of smartphone devices and the memory capacity of smartphone devices and internet networks. The game application used in this study is an android-based application that requires smartphone memory storage capacity and an internet network when downloading the application. It can be an obstacle to the application of this model in learning.

GBL is potentially implemented in Covid-19 pandemic distance learning and potentially implemented in post-pandemic learning. In fully face-to-face post-pandemic learning, all learning syntaxes are carried out in the classroom. In blended learning post-pandemic learning, GBL can be modified by conducting pre-experimentation, experimentation, and reflection as pre-class. While activity and discussion syntaxes are carried out face-to-face.

CONCLUSION

The implementation of GBL in the biological interaction chapter in Covid-19 distance learning affected students' cognitive learning outcomes. There was a significant difference between the pre-test and post-test scores. There was an increasing cognitive learning outcome with the post-test mean score higher than the pre-test (66.00 > 42.60). The effect of this model could improve students' cognitive learning outcomes with 28% students of low category N-gain while 72% students of medium and high.

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