Comparison of Individual and Collaborative Game-Based Learning Using Tablet In Improving Students' Knowledge In Primary Classroom Environment

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Abstract: In the 21st century, mobile games have become a growing interest among children, including primary school students. This can be a great opportunity for instructors to utilize mobile games approaches and students' interest in games for education teaching and learning purposes, specifically in the primary classroom environment. However, there is no study yet considering the effect between individual and collaborative game-based learning (GBL) on students' knowledge. Experimental research was conducted in a public primary school to address the issue. The present study successfully determined the effectiveness of individual and collaborative GBL using tablets in improving students' knowledge in a primary classroom environment. Three groups of Standard Five students were given a pre-test before the intervention, followed by each group were taught using different approaches of conventional learning, individual and collaborative GBL, respectively. Subsequently, the students were given a post-test after the intervention. The test of homogeneity results indicated that the model was normally distributed and could be used for the intervention. The results of analysis of covariance (ANCOVA) on students' post-test scores show the collaborative GBL had the highest mean, which was 9.324 at Day 4. Additionally, the collaborative group also had the highest mean of trials and success rate during intervention among the three groups as the days increased, which were 3.8 and 0.6, respectively. The collaborative GBL was the most effective among three different approaches. The students had a group discussion to share and organize ideas and critical thinking between their group members on what they have learned from previous intervention days into the current intervention session. The major findings of the present study revealed the potential of collaborative GBL using the tablet in the primary classroom environment in improving students' understanding, knowledge, problem-solving, communications and critical thinking skills.

Keywords: collaborative; game-based learning; primary education; teaching strategies

1. Introduction

In the 21st century, mobile games have become a growing interest among children, including primary school students. The interest in mobile games among children is due to the exciting nature of games, social media trends and the fast development of multimedia technology (Huang et al., 2020). Children spend a lot of time every day, especially during their break time, on mobile games. This is a great opportunity for instructors to utilize both the mobile games approach and students' interest in games for

education teaching and learning purposes, specifically in the primary classroom environment (Khan et al., 2021).

Researchers have indicated that educational games could be an effective way of providing a more interesting learning environment for acquiring knowledge, using the game-based learning (GBL) approach (Tuzun et al., 2009). In addition, several studies have reported that educational games could enhance students' learning interest and motivation (Burguillo, 2010). Moreover, Huang et al. (2020) reported that educational games might have great potential for improving the learning achievements of students. Besides, students are able to critical thinking about the content they are studying when used for representing knowledge (Coman et al., 2020). Previous studies have further reported that GBL is suitable in helping students organize knowledge for identifying and differentiating a set of learning targets.

Several studies have reported that instructional games may enhance the students' learning interest and motivation (Burguillo et al., 2010). Boyle et al. (2014) reported that GBL is better than traditional classroom instruction. It increased the students' motivation to learn, provided opportunities to explore, and acquired new knowledge and skills. Students' performances are scored during the gaming process. If players overcome a hindrance, they will obtain awards such as scores, advancement, and power. Educational elements can be integrated into the gameplay, which will be subconsciously acquired by the players during the gaming process. The educational games attempt to form a positive mood to encourage players to continue the play, leading to increased interest in gameplay, as well as better academic performances (Khan et al., 2021). With the increasing application of technology-assisted education, there is an urgent need to investigate the effect of GBL. In this study, an individual and collaborative GBL were applied to a primary school physical health education content. An experiment has been conducted to evaluate the effectiveness of the proposed approach by investigating the effect of the approach on students' knowledge and problem-solving skills.

1.2 Problem Statement

Mobile GBL has become a growing interest among children, including primary school students, due to the exciting nature of games, social media trends and the fast development of multimedia technology (Huang et al., 2020). It provides a hands-on simulation and multiple approaches for the student to implement the knowledge acquired by playing the games in real-life situations. Therefore, GBL has been used as an alternative teaching method to enhance the students' learning interests (Burguillo et al., 2010).

There is an increasing concern on obesity issues among primary school students. A previous study reported that approximately 19.9% of primary school students in Malaysia have obesity problems (Naidu et al., 2013). Even though there are syllabuses regarding diet and physical activities, the obesity issues among primary school students are still increasing. The small impact of the curriculum on the students is due to the traditional teaching method that is lacking hands-on and unattractive for students to tackle the obesity issue. Besides, there is not enough time allocated for conventional learning regarding the topic, which is only 30 min per week. Furthermore, students might not be able to learn about a healthy lifestyle outside the classroom due to a lack of suitable learning materials (Aivazidi and Michalakelis, 2021; Bukoye, 2019).

With the increasing application of technology-assisted education, there is an urgent need to investigate the effect of GBL on students' knowledge and problem-solving skills. This can be a great opportunity for instructors to utilize the mobile games approach and students' interest in games for educational teaching and learning purposes, specifically in the primary school classroom environment. However, it is not clear how students could learn most from the technology, particularly through GBL in the classroom. Through GBL, students would be able to solve the diet and healthy activities problems through learning alone or learning with peers. Collaborative GBL enables students to construct knowledge by working on complex problems together, including individually contributing to solving the problem, discussing the individual contributions, and arriving at joint solutions (Roschelle & Teasley, 1995). Therefore, collaborative GBL might be potentially better in improving students' knowledge and understanding.

There are researches that cover the effect of GBL on students' problem-solving skills for various subjects such as Biology and History. However, there is not much research that covers problem-solving

skills on healthy lifestyle, especially through experimental research. The problem-solving skill enables students to be adaptable in the situation that they are in and able to keep living a healthy lifestyle to ensure the quality of their health. Thus, it is significant for this research to focus on problem-solving skills for a healthy lifestyle.

An experiment has been conducted to evaluate the effectiveness of the proposed approach by investigating the following research questions:

1. How has GBL improved the students' learning regarding physical health education?
2. Do the students who learn using the collaborative GBL approach show better learning achievements than conventional learning and individual GBL?
3. Do the students who learn using the collaborative GBL approach show better problem-solving skills than conventional learning and individual GBL?

2. Literature Review

2.1 Game-Based Learning (GBL)

Games can be defined as an immersive, voluntary and enjoyable activity that involves pursuing a goal according to the game rules (Khan et al., 2021). Game-based learning (GBL) is an entertaining tool with the purpose of education, where players cultivate their knowledge and practice their skills by overcoming numerous hindrances during playing (Jaaska et al., 2021). It consists of trial and error through the learning process, where students' performance is assessed by scores (Alam et al., 2021). Recently, several studies have been conducted on alternative learning using GBL. Previous studies found that a combination of games and educational content can improve students' learning performance and provide them with interactive learning opportunities (Vlachopoulos & Makri, 2017). In addition, the GBL approach had a significant effect on students' knowledge retention and problem-solving skills (Stiller & Schworm, 2019).

2.2 Collaborative Learning

Recently, several studies have been conducted on the collaborative GBL approach. Students have discussions and exchange information with their groupmate to complete the tasks in the game during the collaborative learning. Apart from that, Khan et al. (2021) reported that collaborative learning promotes interaction among students during the gameplay, improving their learning performance. Also, Huang et al. (2020) reported that promoting interactions among students during the gaming process is helpful to students in improving their learning performance. Additionally, students may learn from each other while playing the game, students highly value the usefulness of discussion with their peers while playing the game. Besides, students do discussions with their peers while playing the game (Sung and Hwang, 2013). Hence, collaborative learning can potentially be an alternative learning approach for a primary school classroom. Working collaboratively in a group is an effective way to practice and acquire discourse competence. When learners learn in groups, they are not only engaged in the sole purpose of completing the task at hand, which can also be done individually, but they are also given the opportunity to be involved in a face-to-face interaction. This process is vital for their development of communication skill (Ariffin, 2021). Furthermore, this teaching strategy was not only enhanced, encouraged, and enable learning, but also helped student to implement constructivism in the classroom. Scaffolding in this class has helped students to become active learners and problem solvers (Hawa, 2021).

2.3 Knowledge Retention

GBL has several advantages, such as hands-on tasks and exciting learning, which helps to boost the students' learning process (Safapour et al., 2019). GBL is a learning process that uses specific game which helps to improve students' knowledge and skills. The learning approach enhances students' knowledge as it provides both contexts (theory) and scenarios (practical) during the learning session (Ribeiro et al., 2021). Studies have reported that GBL resulted in improved academic learning

achievement and knowledge retention. Furthermore, Buelow et al. (2015) reported that GBL students had a higher score compared to the control group.

The improvement of students' learning achievements can be attributed to the interesting learning environment for students to acquire knowledge during GBL (Vlachopoulos & Makri, 2017). Besides, the huge interest in games among students can be utilized for the learning approach as a GBL (Sung & Hwang, 2013). Moreover, it aims to improve students' knowledge and facilitate self-learning as a motivational factor (Trajkovik et al., 2018).

2.4 Problem-Solving Skills

Problem-solving is one of the most important cognitive skills in everyday life (Kim and Lee, 2021). Learning objects such as games serve as an alternative learning approach to improve students' problem-solving skills (Rondon et al., 2013). Problem-solving skill is not something that can be proven by test because the data indicates that the grade obtained in the examination did not reflect their knowledge in problem-solving (Parmjit, 2009). GBL is an alternative learning approach using a combination of education and games that can reduce the working memory cognitive load, thus enhancing the classroom learning process (Coman et al., 2020). It consists of a set of goals and obstacles that require players to generate new knowledge and skills in order to advance through the game (Ribeiro et al., 2021). It improves students' problem-solving skills as it requires continuous interaction between the player and the game (Safapour et al., 2019). Subsequently, Huang et al. (2020) studied on GBL reported that collaborative GBL students demonstrated better problem-solving skills compared to students in the control group, as it provided students with different possibilities to do decision-making and elaborate further strategies.

Zone of Proximal Development (ZPD), the learning development level, is determined by individual problem-solving skills and the level of potential development under guidance or collaboration with peers (collaborative) (Vygotsky, 1978; Gauvain, 2020). At the ZPD learning level, students' problem-solving skills can be determined by their scores and achievement, such as the number of trials and rate of success (Wertsch, 1984). Wherein the increase of the rate of success by represented problem-solving skills acquired by students (Gauvain, 2020).

3. Materials and Methods

3.1.1 Participants

Three classes of year 5 of a primary school in Putrajaya, Malaysia, participated in the present study. Each class had 38 students, and a total of 114 students were involved in the study. Each class was assigned for the individual learning, collaborative learning and control group (conventional learning), respectively.

3.1.2 Experimental Process

The three classes were given the pre-test before the intervention. It was to ensure the students' prior knowledge were at the same level and avoid the influence of different factors on the results. The students in the control group were taught by an instructor. Meanwhile, the individual and collaborative groups were given one tablet each and one tablet per group (of three students), respectively. The intervention was done 20 to 30 min during the class time for five consecutive days (with a total of five interventions per day). Figure 3.1 shows the experimental design of the individual and collaborative game-based learning (GBL). However, students in the control group were learning according to the allocated time, 30 min per week.

The experiment was conducted to promote a healthy lifestyle among primary school students using a GBL approach. Figure 3.2 shows the gameplay of 'Nash Nak Sihat' for the individual and collaborative GBL, which covered the primary school syllabus on physical health education. Firstly, the gameplay gave several options on how Nash (the game avatar) could be healthy, such as through diet and physical activities. Next, the students needed to improve Nash's body mass index (BMI) by balancing his diet and physical activities within the given time. Every meal and physical activities show

how much calories intake and calories reduced, respectively. Finally, at the end of the day (in-game), the game would show Nash' weight and BMI. The target was Nash to achieve a normal BMI within the given time, set by the game.

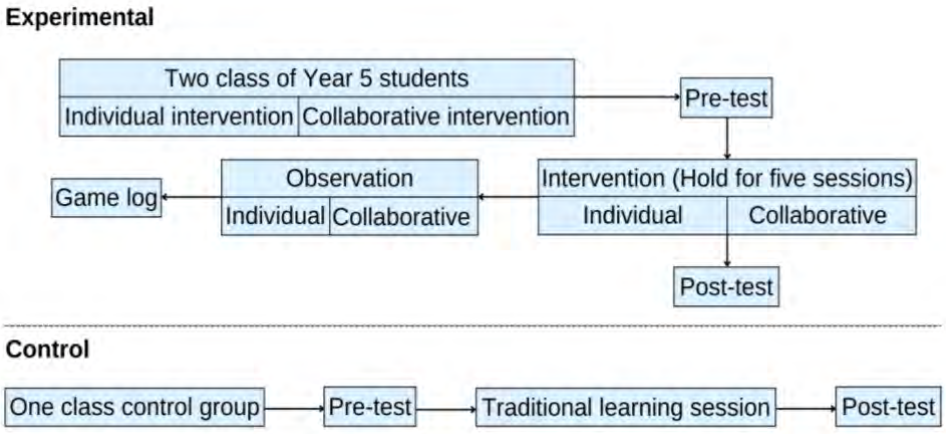

Fig. 3.1 Experimental design of the individual and collaborative game-based learning using physical health education content.

Fig. 3.2 Game-based learning of physical health education content for individual and collaborative groups.

3.3 Instruments and Assessment Measures

3.3.1 Pre- and Post-Test Assessments

The physical education content knowledge of the students was measured by the pre-and post-test assessment, which consisted of a series of 15 multiple choice questions related to the topics covered in the syllabus. The students (individual and collaborative groups) were given a pre-test before the intervention. Subsequently, the students were given a post-test after the intervention. The students' pre- and post-test scores data were collected and analysed with analysis of covariance (ANCOVA) using the Statistical Package for the Social Sciences (SPSS) software. Thus, the effects of intervention variables (individual and collaborative game-based learning) on students' physical education content knowledge were determined by the pre-and post-test assessment.

3.3.2 Physical Education Content Knowledge

The students' physical education content knowledge, specifically in a healthy lifestyle, was measured through identical pre-and post-test assessments. These items collectively assessed both basic, low-level and mid-level application knowledge. Healthy lifestyles consist of eating habits, diet and physical activities.

3.3.3 Problem-Solving Skills

The problem-solving skills of the students (i.e., understanding, brainstorming and learning outcome) were assessed using GBL through the game-log. Firstly, the students' understanding of the game character given (i.e., underweight, ideal or overweight) were observed. Next, the students' brainstorming abilities were indicated by the success rate of the game character achieved the ideal weight per session and within the allocated time. Hence, the correlation between the number of sessions and the success rate represented the improvement of the problem-solving skills were determined.

3.4.1 Data Collection

The data collection method was done using pre-test, post-test and game log by observation within five sessions. The game-based assessment was done by two assessments (external and embedded assessment). The external assessment of the game-based learning was conducted before (pre-test) and after (post-test) the intervention. Every student was given a unique code to ensure their anonymity without affecting the methods used to collect the data. For the embedded assessment, the data was collected by not interrupting the game, click-streams, game log files and information trails. The embedded assessment was utilized in the intervention, which required transcribing screen-recording from students' gameplay into a game log.

4. Results

4.1 Knowledge Retention

4.1.1 Test of Homogeneity

Levene's test is a statistical analysis used to determine the equality of population variances for a variable calculated for two or more groups (Mishra et al., 2019). In the present study, Levene's test was used to test the homogeneity of variance (equal population variance) before performing other statistical analyses such as t-test and analyzed with analysis of covariance (ANCOVA) (Mishra et al., 2019). Moreover, Curran et al. (1996) proposed a reference of substantial departure from normality as an absolute Skewness value -2 to 2 and Kurtosis (proper) value > 7. In the present study, the Skewness test normality for individual, collaborative and control groups were 1.106, -0.415 and -1.257, while the Kurtosis test, 0.824, -0.574 and 1.385, which indicated the model is normally distributed. The significance of Levene's test results shows strong evidence that the results are from a normal distribution.

Table 4.1. Tests of normality of pre-test assessment.

Groups	Skewness		Kurtosis	
	Statistics	Std. error	Statistics	Std. error
Individual	-1.106	0.434	0.824	0.845
Collaborative	-0.415	0.414	-0.574	0.809
Control	-1.257	0.409	1.385	0.798

4.1.2 Analysis of Covariance (ANCOVA)

An ANCOVA was conducted on the pre-test scores as the covariate to determine the effects of using game-based learning (GBL) on students' learning achievements and their perceptions of the learning activities. Besides, the analysis was done to exclude the impact of the pre-test on their learning knowledge. The pre-test was given to all students in the individual and collaborative groups before participating in the intervention to evaluate their basic knowledge of the education content. Subsequently, the post-test was given to students who had completed all five intervention sessions. In the present study, the pre-test scores show that there were no differences across groups in terms of knowledge, and all groups had an equivalent prior knowledge before the learning activities. From the ANCOVA results (Table 4.2), the adjusted mean of the individual, collaborative and groups was found to be 9.196, 9.324 and 8.998, respectively. The collaborative group had the highest adjusted mean indicated that collaborative GBL was the effective approach that improved the students' learning achievement.

Table 4.2. The ANCOVA results of the game-based learning achievement for the three groups.

Groups	Adjusted mean	Std. Error	95% Confidence interval	
			Lower bound	Upper bound
Control group	8.998[a]	0.439	8.126	9.871
Individual group	9.196[a]	0.465	8.273	10.119
Collaborative group	9.324[a]	0.443	8.444	10.205

[a] Covariates appearing in the model were evaluated at the following values; pre-test knowledge categories: 1.99.

The ANCOVA analysis was conducted on the post-test results, where it shows a non-significant difference of the independent variable and the covariate of the learning achievement test ($p > 0.05$) among the pre-test results of the students in the three groups. It was assumed that the regression coefficients between groups were homogeneous. After conducting the learning activity, ANCOVA was performed on the post-test results. The pre-test was the covariant, the post-test results were the dependent variable, and three groups were the control variable to examine the relationships among the post-test results of the three groups.

As shown in Table 4.2, the ANCOVA result shows that the variance between the three groups is not significant ($p > 0.05$) after the impact of the pre-test scores on the post-test was excluded. Therefore, the learning achievements of the individual and collaborative groups were comparable to the control group, whereas a non-significant difference was revealed between the students in the control groups.

4.2 Problem-Solving Skills

Figure 4.1 shows the mean of trials for the individual group increased starting from Day 1 to Day 5, with the highest mean of trials of 3.8 was observed at Day 5. In the collaborative group, the mean of trials was increased starting from Day 1 to Day 4, with the highest number of trials of 4 was obtained at Day 4. On the other hand, the rate of success for both individual and collaborative groups increased starting from Day 1, as shown in Figure 4.2. The highest rate of success of 0.5 and 0.6 were obtained in collaborative and individual groups on Day 4 and Day 5, respectively. The coefficient of determination (R^2) values for collaborative and individual groups were 0.7853 and 0.7663, which indicated that 78.53% and 76.63% of the variation in the students' problem-solving skills were explained by the number of sessions in the GBL, respectively. Thus, Figure 4.1 shows an improvement of the mean of trials by sessions among students. Meanwhile, Figure 4.2 shows significant improvement in the rate of success for both groups (collaborative and individual).

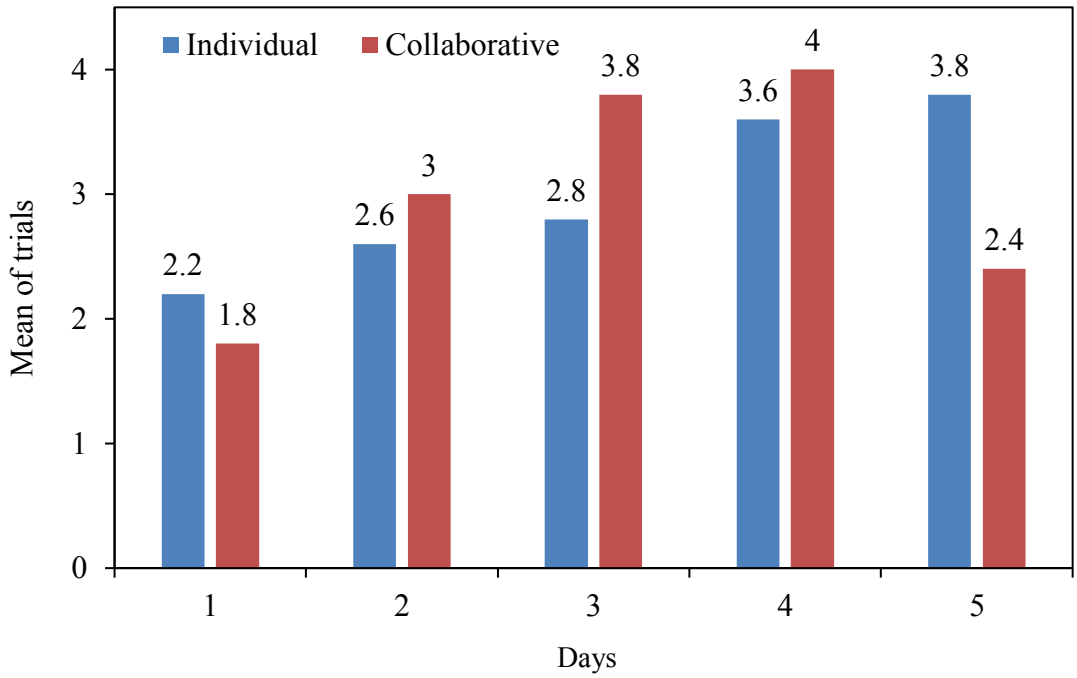

Fig. 4.1 The effect of individual and collaborative game-based learning on students' mean of trials by days.

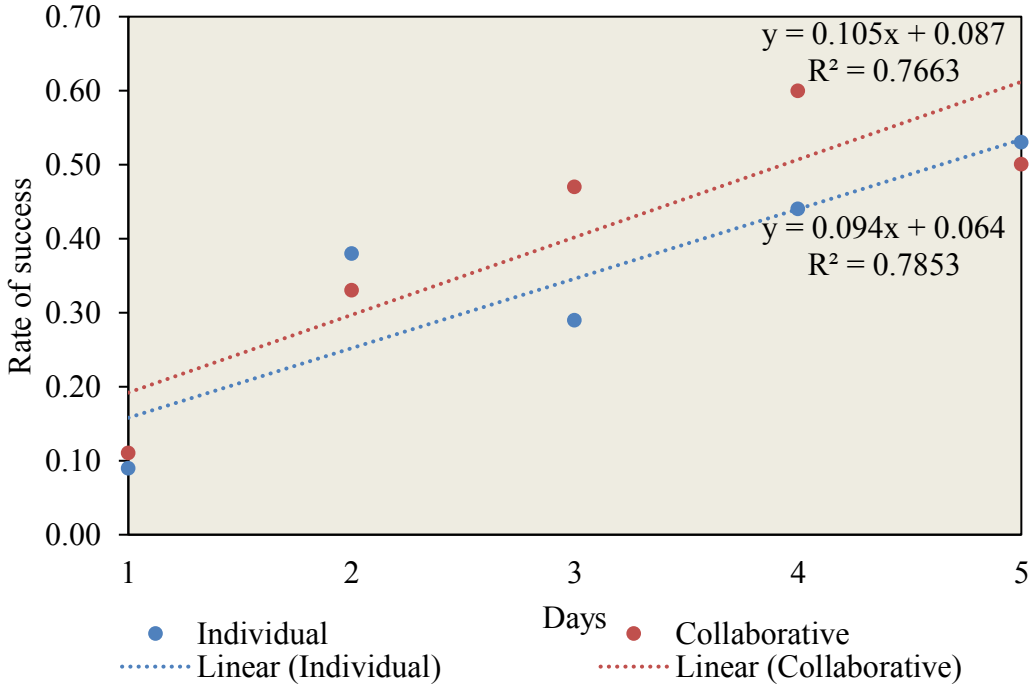

Fig. 4.2 The effect of individual and collaborative game-based learning on students' rate of success by days.

Table 4.3. Correlation between students' rate of success and number of days.

	Rate of success	**Days**
Rate of success		
Pearson correlation	1	0.860
Significant (2-tailed)	-	0.001
Sum of squares and cross-products	0.011	0.395
Covariance	0.001	0.044
N	14	14
Days		
Pearson correlation	0.860	1
Significant (2-tailed)	0.001	-
Sum of squares and cross-products	0.395	20
Covariance	0.044	2.222
N	14	14

5. Discussion

5.1 Physical Education Knowledge

Table 4.2 shows the analysis of covariance (ANCOVA) of three different learning approaches, where the collaborative group had the highest adjusted mean among the three groups, followed by the individual group and conventional learning. The adjusted mean of scores for individual, collaborative and control groups was found to be 9.196, 9.324 and 8.998, respectively. It shows that the collaborative group was helpful in improving students' learning achievements from the aspect of learning achievement, as it is a more interesting learning environment for students to acquire knowledge (Sung and Hwang, 2013; Vlachopoulos and Makri, 2017). Besides, it might be attributed to students in the collaborative group who discussed with their peers, while the individual group did self-try and error during completing the task (Nikou and Economides, 2021; Coman et al., 2020). However, the control group shows a slightly lower adjusted mean indicated that it was comparable to game-based learning (GBL) (Estriegana et al., 2021; Safapour et al., 2019).

Zone of Proximal Development (ZPD), a learning development level, is determined by individual problem-solving skills and the level of potential development under guidance or collaboration with peers (collaborative) (Vygotsky, 1978; Gauvain, 2020). At the ZPD learning level, students' problem-solving skills can be determined by their scores and achievement, such as the number of trials and rate of success (Wertsch, 1984). In the present study, the ZPD learning level of students can be observed by the number of trials and rate of success in sessions. The increase in the mean of trials shows an improvement in gameplay speed but did not fully represent the problem-solving skills. Therefore, the increase of the rate of success with the number of sessions represented problem-solving skills acquired by students, as problem-solving skills improvement is highly correlated with the number of sessions (Gauvain, 2020).

Based on Figure 4.2, the mean of trials and rate of success for both individual and collaborative groups were increased by sessions since Day 1. In each session, the students in a collaborative group possibly had a discussion for each problem throughout the game in order to win the game (Coman et al., 2020). Hence, the students became more capable of solving the game and improving their problem-solving skills (Coman et al., 2020). On Day 4, the problem-solving skills of students in the collaborative group were fully developed and automatized. Meanwhile, students in individual groups did try and error and self-taught during the session, as there was no guidance and peer discussion (Safapour et al., 2019). It has led to students in the individual group were still in a developing phase of skills until Day 5.

On the other hand, on Day 5, the number of trials and rate of success decreased because students in the collaborative group might be less interested than in the previous days. Additionally, students in the collaborative group were in a comfort zone with the game level and tried to solve the problem with potentially new solutions (Hammond et al., 2020). It might be possible that students in the collaborative group had a lesser discussion with each other and stopped seeking assistance from their group members while playing the game (Hammond et al., 2020). Hence, it can be said that students in the collaborative

group had already reached Stage IV of the ZPD phase on Day 5. However, the number of trials and rate of success for students in the individual group was still increased at Day 5. It might be due to students in the individual group was still in the developing phase of skills.

Previous studies reported that learning objects such as games serve as an effective educational alternative for students' problem-solving skills (Rondon et al., 2013). GBL, an educational strategy using tablet games, reduces the working memory cognitive load, thus facilitating the learning process (Coman et al., 2020). Besides, GBL improves students' problem-solving skills by providing them with different possibilities to do decision-making and elaborate further strategies (Huang et al., 2020).

5.2 Impacts of Game-Based Learning (GBL)

The huge interest in games among students can be utilized for the learning approach. It aims to improve students' knowledge and facilitate self-learning as it has a motivational factor (Sayan, 2015; Trajkovik et al., 2019). In the present study, the effect of individual and collaborative GBL on students' knowledge was determined, where both GBL approaches were slightly more effective than conventional learning.

GBL enables students to learn at their own pace by having direct feedback from the game in an exciting environment (Kim and Lee, 2021). This may also motivate students to self-learn topics or subjects since mobile games nowadays are widely accessible. It also boosts students' performance by reducing the working memory cognitive load (Coman et al., 2020). Besides, GBL can be utilized as an alternative approach for an instructor to prepare students with practical knowledge by providing hands-on tasks. The scores in GBL help students in monitoring their understanding. Moreover, students can improve their communication skills by interacting with each other during the gameplay, thus, to be applied in outside classroom/real-life situations (Rondon et al., 2013). On the other hand, individual GBL was comparable to conventional learning. Thus, it could be an alternative for the flipped classroom and self-regulated learning.

6. Conclusion and Recommendations

6.1 Conclusion

The present study successfully determined the effect of individual and collaborative game-based learning (GBL) using a tablet in improving students' knowledge in a primary school classroom environment. The results of analysis of covariance (ANCOVA) on students' post-test scores show the collaborative GBL had the highest mean, which was 9.324 at Day 4. Additionally, the collaborative group also had the highest mean of trials and rate of success during intervention among the three groups as the days increased, which were 3.8 and 0.6, respectively. The collaborative GBL was the most effective among the three different approaches. The students had a group discussion to share and organize ideas and critical thinking between their group members on what they have learned from previous intervention days into the current intervention session. The major findings of the present study revealed the potential of collaborative GBL in the primary school classroom environment in improving students' knowledge, problem-solving, communication and critical-thinking skills.

6.2 Recommendations For Future Research

The online GBL should be further studied to allow students to access collaborative GBL in their own house during weekends, holidays and school breaks. Additionally, the GBL should be offline to enable students who have no internet access in their own house to do GBL. Finally, a comprehensive study on motivation factors can be conducted during the intervention to determine the effect of GBL on students' motivation.

7. Author Contribution

The authors affirmed that there is no conflict of interest in this article. The authors conceived and designed the research protocols, performed the data collections, analyzed the data, authored or

reviewed drafts of the paper, and approved the final draft. Co-author contributed in designing the game and provided tablets for the experiment.

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