Game Based Learning as an Alternative During the Covid-19 Epidemic Based on K-13 for Indonesia elementary schools

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ABSTRACT

Serious-game is a new online learning approach, which is proven to increase students' knowledge and skills. During the COVID-19 period, students, especially in Indonesia, still experienced several obstacles in taking online learning using e-learning. For example, students quickly got bored. Therefore, to increase student interest in education, it is necessary to develop serious-game, with a fun element. In this study, to improve students' engagement with learning materials, we made a K-13 based serious-game. This paper describe it based on three aspects of Bloom's taxonomy and apply the activity theory model. At the validation stage, the validator consist of 20 multimedia experts, teachers, and students, respectively. In the testing phase, we tested serious-game on 60 students from elementary schools in East Java. Testing did by giving a questionnaire before playing and after playing 10, 25, and 30 times. They were testing to determine the improvement in cognitive, affective, and psychomotor students. The students' mean score during the pre-test was 58.23. After playing ten times, the students' mean score was 65.95. After playing 25 times, the students' achievement increased to 72.54, and after playing 30 times, the students' understanding rose to 79.61. The test results on 60 students stated that there was a significant positive increase. After playing, students' improvement proved to be balanced because the proposed design considered three aspects of Bloom's Taxonomy.

Keywords:*.Serious-game, K-13,Activity Theory Model, Bloom's Taxonomy.*

1. INTRODUCTION

The metamorphosis of literacy systems has enabled a new schooling paradigm known as e-learning to implement. As a result of the COVID-19 epidemic, the teaching session closure worldwide has caused 1.5 billion learners and 63 million teachers[1], [2] to change their classroom abruptly. This atmosphere revealed that schooling systems face the new challenge of ubiquitous digitalization, with their advantages and weaknesses. Berrocoso[3] points out the existing framework inadequacies and the need to access the internet universally and cheaply for education. The government should focus on the transparent and fair principles of e-learning[4].

Indonesia's e-learning research shows the lack of facilities and infrastructure and the unpreparedness of technology education[5]. Coupled with human resources, management arrangements, curriculum, and learning facilities[6], limited internet costs, limited internet quota, and slow internet [7]. From teacher perception, student learning styles tend to be visual, and teachers are less flexible in controlling student activities[8]. From the student parents' perspective, there is additional work for parents to assist their children in learning[9].

The findings of serious-game[10]:
1. Inspiring motivation[11].
2. Play is a native kind of education [12].
3. Lead cognitive stream[13].
4. Support learning-by-doing[14].

5. Enabling student's performance monitoring[3].
6. Proffer independence of movement concerning the problem[15].
7. Supporting social learning[16].
8. Allow to do experimentation safely[17].
9. Accommodate new generations of learners[18].
10. Proven success for learning[19].

Based on the findings described above, this paper contribution is proposing online education, namely a serious-game, carried out based on the activity theory model approach, which combines the learning, game, and instructional aspects[20], [21]. It also covers the three domains of Bloom's Taxonomy[22][23]. As an initial focus, we suggest that case studies of the science material used are Natural Science material, earth, and space sub-chapters for 4th-grade elementary schools in Indonesia.

2. State of the Art

In this section, the latest developments that underlie this research describe. It consists of three main pillars, namely a serious-game description, given the rapid growth of digital technology, followed by a serious-game model that focuses on the game mechanics side. Finally, the application of Bloom's Taxonomy in the e-learning sector also present.

2.1. Serious Game

Serious-game has reached an exciting point of development because serious-game can balance the functions of education, training facilities, and entertainment at the same time. Thus, it is a breakthrough to support effective and efficient learning [24]–[26].

The new approach proposed by serious-game considers the dynamics of the game players' actions and the players' motivation based on the game flow theory[27][28]. The research results have proven based on quantitative research by performing seven simulations and involving 100,000 iterations to establish the proposed model's stability. With this approach, it is possible to show the relationship between game variables and how the serious-game learning process can design a serious-game[26].

2.2. Activity Theory Model in Serious Game

This study completes several frameworks that have developed previously, namely the serious-game based on service-oriented architecture. The activity theory model-based framework outlines in detail down to a serious-game mechanic level shown in Figure 1(at the end of the page). The proposed approach is evaluated using the architectural trade-off analysis method and applies to the serious-game. Serious-game design results can involve education and entertainment elements balance in portion and fast production time. The next effect is a reduction in production costs and an increase

in the serious-game quality. Where this model has main activities, namely: play, learning, and instructional activities. Each exercise consists of three components, namely: action, device, and goal[20], [21], [24].

2.3. Bloom's Taxonomy

Bloom's Taxonomy consists of knowledge, understanding, application, analysis, synthesis, and evaluation. Furthermore, the Bloom Taxonomy has revised by adding several components, such as changing terms at each level, setting a more detailed stage, and adding the dimensions. This change applied to e-learning designs that contain online instruction. E-learning is object-based and learning outputs. The example proposed as an application is about learning grammar. Where the proposed method has considered three aspects of integrated learning, namely cognitive, affective and psychomotor aspects of the player[22], [23].

2.4. National Curriculum 13 (K-13)

The 2013 national curriculum (K-13) is a development of the existing curriculum, namely the Competency-Based Curriculum and the Education Unit Level Curriculum, which applied in 2014/2015. The K-13 emphasizes improving and balancing soft skills and hard skills, including competence in attitudes, knowledge, and agility. The position of competence, originally derived from the subject, turned into an issue developed from competence. The characteristics that differentiate it from previous curricula are as follows: the approach used in learning is scientific and integrated thematic, attitudes, competence, skills, knowledge, using authentic assessment. An accurate estimate is an assessment carried out as a whole, including student preparation, the learning process, and student learning outcomes. The learning methods used are lectures, discussions, questions, and answers, conducting experiments, solving problems, and modeling[29].

3. METHOD

The research procedure is built in five stages, as shown in Figure 1, including:
1. Identification of K-13, science material for 4th-grade Elementary School. The curriculum involves three domains of Bloom's Taxonomy, consisting of cognitive, affective, and psychomotor domains. Table 1 presents the types of 4th-grade Elementary School in science competencies. Competence can be divided into two types, competency standards and basic competencies. Competency standards consist of a) understanding the transformation of earth and space, b) understanding the change of the region and its effects on the surrounding area and c) understanding the association between the natural resources of the universe and the surrounding area. Competency standards (a) taught in the 1st-semester, competency standards (b), and (c) are given in the 2nd-semester. Identification of students'

understanding in the 4th-grade science field to determine the level of mastery of students in terms of cognitive aspects, including memory levels(C_1), knowledge (C_2, and application(C_3). Meanwhile, to find out the level of understanding of students in the affective domain, including curious behaviour (A_1), getting something new (A_2), collaboration(A_3), never giving up (A_4), asking if finding difficulties (A_5), introspection (A_6), be consistent (A_7), dare to express opinions (A_8), and discipline (A_9). Then to find out the level of understanding of students in the psychomotor aspect described as the ability to observe (P_1), be thorough and regular (P_2), classify (P_3), estimate (P_4), design (P_5), carry out research (P_6), summarize (P_7), implement (P_8), and socialization (P_9).The description of indicators for each student competency standard is shown in Table 2.
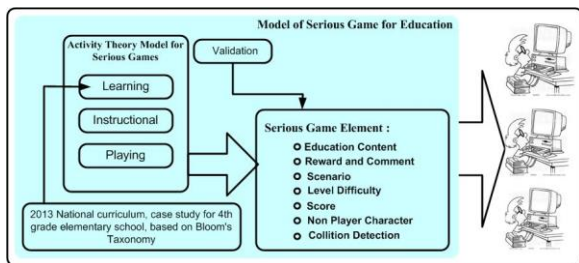

Figure 1. The proposed research block diagram.

2. Identify the activity theory model when playing games. The activity theory model is used to compile the gameplay of the serious-game created shown in Figure 8.
3. Serious-game design.
4. Validation of the serious-game beta version. The validator consists of multimedia experts, teachers, and students. Multimedia experts aim to validate from the multimedia side, among others: Ease of information, ease of play, layout, fonts used, colours, and navigation. The principal and 1st carried out validation in terms of learning materials to 4th-grade elementary school teachers. Validation based on the user side was carried out by ten randomly selected students. The student validation component focuses on comfort while playing, pleasing students, interest in games, material, and quickly capturing tasks to be completed.
5. Testing on 4th-grade students. A total of 60 elementary school students in East Java became respondents for the next test. Respondents were 34 male students and 26 female students. They test ten times, 25 times, and 30 games.

4. RESULT AND DISCUSSION

In the learning process, students will go through three phases or three processes during learning. The first stage is the cognitive phase, which is when students get material from a teacher. Students get information about what, why, and how to do the movement activities to be studied in this phase. It hoped that a motor-plan formed in students' minds, namely intellectual skills, in planning how to perform skills. The second stage is the associative or fixation phase, which is where students will exercise from the material taught in the cognitive setting[30]. At this stage of the exercise, students can do or apply the material taught as shows in Figure 2.
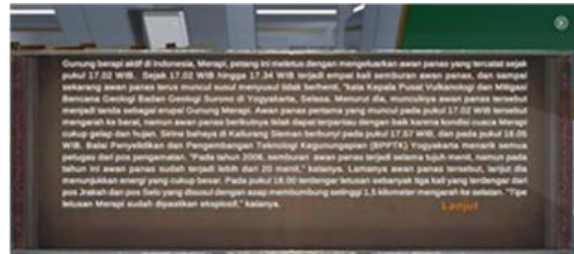
Figure 2. This is an example of a serious game proposed. Where (a) is an information that students must know, then (b) shows an example of a question related to the previous material description (a). Then, (c) students answer the question, the student's answer shows in a red box.

As mentioned in point 4, the serious-game validation was performed by 20 multimedia experts, 20 teachers, and 20 random students from 1st to 4th-grade elementary school shown in Figure 3. The multimedia experts, giving a score of 70 to 80. It means the serious-game is proper to use. In terms of learning materials, the scores obtained are 70 to 80. This score shows that the questions raised in the serious-game have met the K-13 standards and have covered the three domains of Bloom's Taxonomy for grade 4 SD students. Validation from students, giving a score of 75 to 80. This score

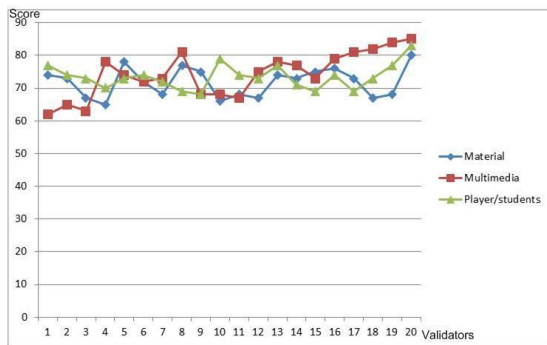shows that this serious-game provides comfort, fun, and ease of play.

Figure 3. Serious-game validation results

The pre-test and post-test on 60 students shown in Figure 4, the x-axis is the number of students, and the y-axis is the score achieved by students with a value range of 0 to 100. The experiment consists of three stages: pre-test, post-test after playing ten times, post-test after 25 times play, and the post-test after playing 30 times. The questionnaire during the pre-test and post-test after playing consisted of 20 questions. A pre-test use to find out students' understanding of science material before playing a serious-game. The post-test to determine student understanding was carried out three times, namely after playing ten times, 25 times, and after playing 30 times. In Figure 4, there is an increase in the score of each student.
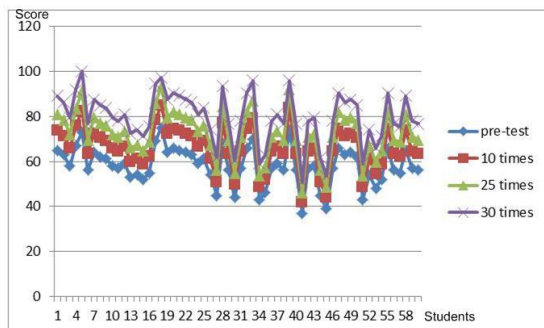

Figure 4. The results of the pre-test and post-test of 60 students

The students' mean score during the pre-test was 58.23. After playing ten times, the students' mean score was 65.95. After playing 25 times, the students' achievement increased to 72.54, and after playing 30 times, the students' understanding rose to 79.61. This score states that students enjoy the games, and students have increased the mastery of the learning material presented. The achievement of the average student score shows in Figure 5.
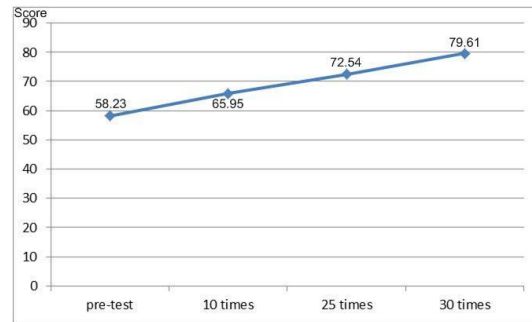

Figure 5. Improved student understanding scores

The increase in knowledge of each student view as a difference. This difference shows in Figure 6. The rise in student know-how after playing ten times state as $\Delta 1$, the increase in student scores after playing 25 times label as $\Delta 2$, and student scores after playing 30 times express as $\Delta 3$. The x-axis represents the number of students, and the y-axis is the score achieved by students. The students' average ability $\Delta 1$ increased by 7.71% after playing ten times compared to the pre-test scores from this difference in scores. In 2, after the students played 25 times, the students' average understanding increased by 14.31% compared to the pre-test score. Furthermore, in 3, after the students played 30 times, the students' knowledge increased by 21.38% compared to the pre-test score.
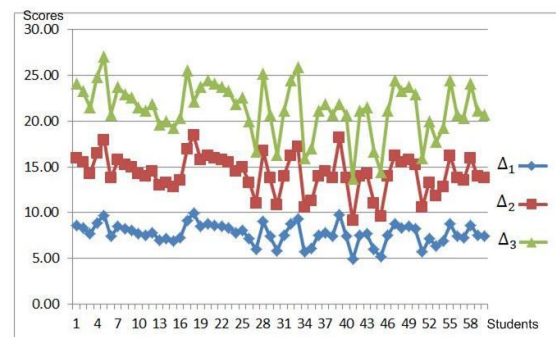

Figure 6. Difference in students' understanding scores

Assessment based on each side of learning, which is the cognitive aspects of 30%, 30% the affective, and 40% the psychomotor, was carried out by recording each student's performance. Following the description of Table 2, if the student answers correctly, then the student gets one point. If the student answers incorrectly, then his/her score is zero. The cognitive aspect's maximum points are six because the questions asked consist of six indicators students', namely C1 with two indicators, C2 consist of three indexes, and C3 with one scale. On the affective side, students' maximum points are 8 points, consisting of A1 to A8.

Meanwhile, on the psychomotor side, the maximum score a student can achieve is 9 points consisting of P1 to P9. Figure 7 shows the increase of students' performance at the pre-test after playing ten times, 25

times, and 30 times. From the cognitive side, during the pre-test, students' mean score was 0.12; after playing ten times, the score went up to 0.27, then after playing 25 times, the score became 0.36; after playing 30 times increased sharply to 0.44. This score shows that on the cognitive side, the performance is a significant positive increase. From the affective side, during the pre-test, the mean score was 0.14; after playing ten times, the score became 0.22; after playing 25 times, the student score became 0.32; after 30 times, they developed to 0.41. The affective side is also experiencing positive developments. From a psychomotor perspective, during the pre-test, the mean score achieved was 0.16; After playing ten times, the mean score of students crept to 0.24, then after playing 25 times, the mean score of students spread to 0.30; after playing 30 times also boosted to 0.35. This condition states that the skills of the students have improved significantly.
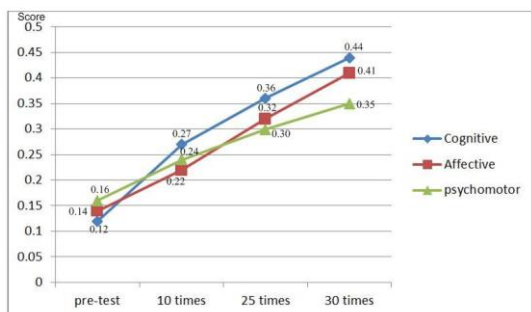

Figure 7. The students' achievement of cognitive, affective and psychomotor aspects

The minimum learning completeness standard is that students achieve a value of $\geq$ 75. The number of students who attain the classical completeness criteria is $\geq$ 85% of the students' total number. In this study, we compared the number of students who managed to meet the mastery learning standards after learning using e-learning [1] and the serious-game. The test was three times on each media. In e-learning, it is named pre-cycle, cycle one, and cycle 2. Whereas in the serious-game it is called pre-play, playing ten times and playing 25 times.

In e-learning, Table 3 shows that the pre-cycle learning outcomes are 14 students (48.3%) completeness and 15 students (51.7%) incomplete. These results do not meet the predetermined completeness criteria, so they continue to cycle I. In the learning outcomes of a cycle I, 24 students (82.8%) complete, and five students (17.2%) are incomplete, with the percentage of classical completeness, only 82.8%. These results do not meet the predetermined completeness criteria, so their research continues to cycle II. In the second cycle, classically, students who get a score bigger than 75 (the amount of teaching and learning activities) reach 89.7% of the total students. The percentage of results has surpassed the entire students' classical completeness criteria to complete their studies[31].

While the learning outcomes using the serious-game, before playing, were 12 students (41.38%) completed, and 17 students (58.6%) did not complete. These results do not meet the predetermined completeness criteria, so students continue to play ten times. After students played ten times in the learning outcomes, 25 students (86.21%) completed, and four students (13.79%) did not complete, with the percentage of classical completeness reaching 86.21%. The rate of results has matched the classical completeness criteria, namely $\geq$ 85% of the total students. After playing 25 times, it confirmed that the classical completeness criteria reached 93.10%.

From these comparisons, it appears that the use of serious-games increases the achievement of the minimum learning completeness standards that must fulfill and the classical completeness criteria.

Table 3. The comparison between e-learning and serious-game

e-learning			
Cycle	Category	Sum	Percentage
pre-cycle	Completed	14	48.3
	Not Completed	15	51.7
Cycle I	Completed	24	82.8
	Not Completed	5	17.2
Cycle II	Completed	26	**89.7**
	Not Completed	3	10.3
Serious-game			
Pre-play	Completed	12	41.38
	Not Completed	17	58.6
10 times play	Completed	25	**86.21**
	Not Completed	4	13.79
25 times play	Completed	27	**93.10**
	Not Completed	2	6.89

5. CONCLUSION

From the description of the results and the previous discussion, several conclusions can be drawn, such as the validation by multimedia experts, teachers, and students shows that the serious- game has fulfilled the educational and entertainment side. The test results on 60 students stated that there was a significant positive increase. After playing, students' improvement proved to be balanced because the proposed design considered three aspects of Bloom's Taxonomy.

However, the results still show some weaknesses. The weakness assumes it is the education material side. Most of the question is multiple choice with one correct answer only. Thus it may boredom the player. There is also the possibility that while playing, students give solutions that are not intentionally correct, or the answers given are the result of a friend's solution rather than the student's thought. The appearance of the

questions is still static, so students easily memorize them. The game scenario is still passive, so it is possible for students to get bored quickly. Changes in-game difficulty has not been explored more deeply, so players can quickly master the game soon. The number of respondents used is still small, so there is always a possibility that the types of students who play are homogeneous.

From the observation of these weaknesses, further development can focus on several points. For example, the questions posed would be better if more than one correct answer develops students' abilities. The problem is present by increasing the number of items for the same outcome indicator to avoid answering the right answer inadvertently. The static problems were replaced by applying artificial intelligence to the question generator to adapt to students' abilities. Game scenarios need to add with autonomous scenario generators. Changes in-game difficulty also needs to be made more diverse and made different at the beginning of each game; this can be done by embedding machine learning in the serious game to hope that players will always feel challenged. Increasing the number of respondents from different primary schools can provide diversity in the types of students.

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Tabel 1. Elaboration of 4th-grade elementary school science competencies

| Competency standards	Basic competencies
a. understanding the transformation of earth and space	1. Describe the transformation of the earth's surface 2. Describe the appearance of the planet each day and the position of the moon
b. understanding the change of the region and its effects on the surrounding area	1. Explain the causes of environmental transformation 2. Describe the effect of environmental change on the earth 3. Tells how to prevent environmental damage
c. understanding the association between the natural resources of the universe and the surrounding area.	1. Describe the association between universal resources and the surrounding area 2. Formulate the association between adaptable resources and technology 3. Describe the impact of natural exploitation on world conservation
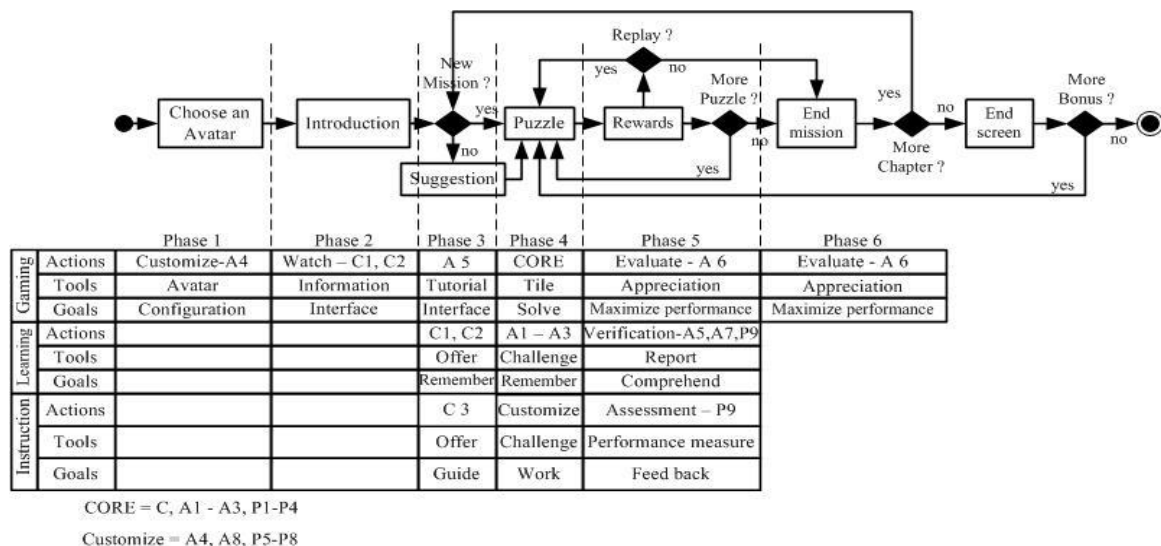
Figure 8. The identification of K-13 to serious-game.

Tabel 2. Learning identification based on Bloom's Taxonomy

	Learning indicators in the serious-game	Cognitive (30 %)	Affective (30 %)	Psychomotor (40%)
1	Identify the transformation of the earth's surface	C_1		
2	Identification of the appearance of the planet each day	C_1		
3	Explain the causes of environmental transformation	C_2		
4	Describe the effect of environmental change on the earth	C_2		
5	Tells how to prevent environmental damage	C_2		
6	Describe the association between universal resources and the surrounding area	C_3		
7	Repeating the experiment		A_1	
8	Get involved in assignments		A_2	
9	Help each other in simulation		A_3	
10	Free thinking		A_4	
11	Ask questions if you're having trouble		A_5	
12	Learning indicators in the serious-game		A_6	
13	The consequences		A_7	
14	Implement a safe experiment		A_8	
15	Complete question and assignment sheets			P_1
16	Discipline			P_2
17	Separating types of environmental transformation			P_3
18	Crafting environmental change on the earth puzzles			P_4
19	Estimating the possible transformations during the experiment			P_5
20	Planning a simulation to reduce the impact of a disaster			P_6
21	Planning the impact of natural exploitation on world conservation simulation experiment			P_7
22	Carry out miniature natural exploitation on world conservation experiments			P_8
23	Presenting the results of environmental damage simulation			P_9