Case-based games learning strategies to improve conceptual understanding in mathematics

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Abstract. Case-Based Games Learning (CBGL) is a strategy of active learning in which the students implement knowledge and analytical skill related to the real complex situation (contextual) and relevant with subject lessons. Give case-based task or question routinely can help students to solve case-based mathematics problems. This study aims to analyze the effectiveness of CBGL using Quizizz dan Case Base Learning (CBL) without Quizizz based on students’ conceptual understanding in mathematics by finding out the percentage of the correct answer. Students were grouping by using a purposive sampling method based on the conceptual understanding indicator. The result of this study is the average conceptual understanding CBGL using Quizizz application strategy is more effective than CBL without Quizizz application in evaluating student work results quickly, precisely, and accurately. Therefore the use of Quizzes application with CBGL was more effective than CBL in assessing the work result quickly, right, and accurately.

1. Introduction

The world development enters industry 4.0, which is indicated by the trend of advanced technology. Technology mastering is highly related to mathematics because technology can be mastered if we have good competence in mathematics [1]. Unfortunately, mastering the mathematics material was still low. It was considered from the achievement of a national examination in 2019, which places mathematics as the subject with a low average score compare to other subjects with a national average score of 46.56. For South Sulawesi, the average score was 42.60, and in Bone Regency, the average score of mathematics was 49.64 [2]. The competence of graduate especially in mathematics with the category of low [3], thus it needs a method which suitable with the lesson gave and interesting way so that the students has interest to mathematics which will affect the understanding level of the material [4].

The mastery of the material will be optimal if students well understanding the concept; therefore, a learning strategy that can increase the students’ understanding level is needed by relating students’ knowledge with the concept they learn. Case-Based Games Learning (CBGL) strategy is one of the solutions in solving the problem of the weak students’ conceptual understanding. This strategy emphasizes the combination of knowledge and analysis ability related to complex and relevant real situations (contextual) with the lesson that strengthened through the game. The ability of conceptual understanding can be improved by using a learning strategy which trains students logic by relating...
their knowledge and question in the form of students daily problem [5][6]. The advantage of implementing a case-based learning strategy is this strategy can help develop an interesting, effective, and active lesson. It eases the learning process and strengthens students’ understanding. The result is that it helps the student to develop logical thinking and interpretation, and students be more challenged in finishing the question given [7][8][9].

To train students’ conceptual understanding in mathematics need to be attempted the habituation and train to solve the mathematical problem [10]. However, the slow of the teacher in evaluating students evaluation make the student do not understand their mistake. The rapid development of technology in the learning field answers the problem of slow manual evaluation. The open-source application is easily found with the basis of android or PC. One android based quiz application which is very easy in using and giving the needed in evaluation in class or outside class in the form of data and statistic about students’ performance is Quizizz. Quizizz is a very interactive android based application. It is interesting and effective in obtaining student’s tasks on the subject’s evaluation with the evaluation report in a digital form so that it eases the teacher in finding out students’ improvement in learning within minutes. Besides, Quizizz can be used to create an interactive quiz game that can be accessed by students anytime and anywhere. The technological integration in the learning process generates active involve and increase students’ learning experience [11].

Based on observation results in SMP Negeri 1 Kahu, it shows the mastering of mathematics, especially 8th-grade students on the lesson of Pythagoras with the average percentage of conceptual understanding as 45.90%, so that most of the students’ score was still under average. The usage of learning applications with CBGL strategy in Pythagoras lessons is expected to affect student’s study methods in a better way so that students’ conceptual understanding is more optimal. Routine giving of case-based questions can help students to be familiar with problem solving or mathematic in the form of cases. The usage of application Quizizz can help the teacher evaluate the result of students’ question answering wholly and quickly.

2. Methods
This study is an experimental study in which the study method was used for finding the effect of certain interventions toward another variable in controlled conditions. This study involves 2 (two) groups, an experimental group, and a control group. For the experiment group, the learning was conducted by using Quizizz with CBGL strategy; meanwhile, the control class implements Case-Based Learning (CBL) without using advanced technology. CBGL procedure was carried out by using the Quizizz application used in improving students’ conceptual understanding shows in table 1 [7].

The design of this study is a non-equivalent control group. This design was used because this study involved two groups, the experimental group and the control group were given different treatments. The experimental design is described in figure 1.

The population in this study was the grade 8 students of SMP Negeri 1 Kahu, which consisted of 9 (nine) classes located in the Kahu sub-district, Bone regency. The sample was part or representative of the population [12]. The sample in this study consisted of Experimental class and Control class; those are 28 students each of class, while the student grouping method was conducted using purposive sampling. The research instrument was a test of conceptual understanding in mathematics. The test form was a diagnostic test with a multiple-choice format. The instrument models through multiple choices form were able to provide feedback for students to find out their learning difficulties [13]. Multiple choice questions can measure more complex abilities. Therefore they are often used for measurements with national standards. This type of test can capture information about students’ mistakes in understanding the concepts (misconceptions) [14]. The test consists of three questions about the ability to understand concepts based on 3 (three) indicators. The indicators used in this study are restating a concept and classifying objects according to the concept (a), giving examples and presenting concepts in the form of mathematical representations (b), and Study and applying a concept and selecting procedures in solving problems correctly (c) [7].
Table 1. The procedure of Case-Based Learning with Quizizz application.

| Step | Case-Based Games Learning (CBGL) |
|------|----------------------------------|
| 1    | Delivering the objective and motivating students by *icebreaking* |
| 2    | The teacher is presenting an information base done true story and relating the concept with the daily problem. The teacher conduct question and answer activities or 2-way discussion. The teacher is motivating students to ask questions about concepts. The existence of concept reinforcement is learned by sending various examples. |
| 3    | The teacher is providing student guidance in working on worksheets or questions with small discussions in the form of groups or compatriots. Students collect data, analyze data, relating procedures for problem-solving with the concept of the lesson. |
| 4    | After completing the worksheet, each team was instructed to carry out group evaluations and review the answers to the refinement of the answers. |
| 5    | The teacher is evaluating the conceptual understanding with games in the form of a team quiz using the Quizizz application. Forming the evaluation by giving questions in turn for each member within a predetermined time. Each team member completes two questions. |
| 6    | Giving direction to students from the questions and provide rewards to the team with the highest number of correct answers. |
| 7    | Instructing to make an outline resume of the lesson and the end of the activity is given a final evaluation in the form of individual quizzes using the Quizizz application. |

![Figure 1](image-url)

Figure 1. The experimental study design consists of O1 = initial test on experiment class, O2 = final test on experiment class, O3 = initial test on control class, O4 = final test on control class, X1 = teaching method using Quizizz application with CBGL, X2 = treatment method with CBL implementation without using Quizizz applications.

Test Indicators of conceptual understanding that given consists of 3 (three) questions to determine the students’ concept understanding ability. Analysis of test referring to the conceptual understanding reference criteria to find out the percentage of misconceptions in the students’ answers in answering the questions. Each student’s response was analyzed to see the percentage to see conceptual understanding. There are three criteria. “Understand the concept (DU)” criterion is taken from correct-correct answer (BB). “Misconception (MI)” criterion is taken from the correct-wrong answer (BS) and wrong-correct answer (SB). “Do not understand the concept (UN)” criterion is taken from the wrong-wrong answer (SS). Student answers are obtained from a two-level multiple-choice test divided into multiple choices for 20 minutes. In the next 40 minutes, the description test contains the results of the
reasons and problem-solving. Both of these tests are to compare the suitability of student answers so that the percentage of students' conceptual understanding was obtained.

The data analysis used in this study is descriptive statistics. Descriptive statistical analysis was used to describe the students’ understanding of mathematical concepts in each selected group. Descriptive statistics include the data presented through tables, graphs, mean, median, mode, standard deviation, and percentage calculation [15]. The criteria for conceptual understanding used table 2 [16].

### Table 2. Percentage of students’ conceptual understanding.

| Achievement indicator  | Percentage (%) |
|------------------------|----------------|
| Very low (SR)          | 0 ≤ P < 20     |
| Low (RD)               | 20 ≤ P < 40    |
| Average (SD)           | 40 ≤ P < 60    |
| High (TG)              | 60 ≤ P < 80    |
| Very high (ST)         | 80 ≤ P < 100   |

3. Result and discussion

Analysis of conceptual understanding of mathematics is described in three parts, namely learning conditions, differences in conceptual understanding, and comparison of the conceptual understanding of the control class and the experimental class. The explanation for the three analyzes is as follows.

3.1. Learning condition

Based on the students’ initial conditions, it shows that the implementation of learning activities is still centered on or dominated by teachers, both in the experimental and control classes. The teachers always explained in detail the material, such as providing formulas and examples of questions in detail. The teacher mostly carries out the example by his self. The students only imitate the way to get solutions. In learning activities, students’ involvement was low. This condition caused only a few students who enthusiastic about taking part in the lesson. Even most students seemed bored, joining the process of mathematics learning. After treatment, it showed that students who were reluctant in learning began to be motivated to learn, especially in learning accompanied by competition in the form of teams by using Quizizz, so students were challenged in working on the questions. The fundamental difference between the two classes (experiment class and control class) shows that students in working on the concept of the understanding test in the control class are still less motivated in solving the problem. It seems that only a few students or group leaders are enthusiastic about solving the problem. This situation was quite different in the experiment class where students were given a review of the results of the quiz evaluations and worksheet when they finish working on the questions and become the basis of the teacher in explaining the concepts and procedures starting with the level of errors in applying concepts and procedures. Students know the mistake is applying the concept and using procedures to answer the questions. It is the reason that the conceptual understanding of the experiment class higher than the control class. Also, the student activity, enthusiasm for learning, and confidence to answer the questions increased in experiment class. These internal factors help students achieve optimal learning achievement.

3.2. Differences of conceptual understanding indicator score results of two classes

The student’s conceptual understanding results are presented in figure 2. In the control class, the average of the correct answer from the pretest was 51.2%, and the average of the wrong answer was 48.8%. The highest number of the wrong answer is indicator c, then followed by indicators a and b. The highest number of the correct answer was indicator b, then followed by indicators a and c.
The data analyzed were divided into a correct answer of control classes in the pretest (T PreK), the wrong answer of the control class in the pretest (F PreK), the correct answer of the experiment class in the pretest (T PreE), Wrong answer of experiment class in the pretest (F PreE), the correct answer of control class in post-test (T PostK), the wrong answer of control class in post-test (F PostK), the correct answer of experiment class in post-test (T PostE), the wrong answer of experiment class in post-test (F PostE). Indicator of concepts understanding: classifying objects according to the concept (a), Presenting concepts in the form of mathematical representations (b), study and applying a concept, and selecting procedures in solving problems correctly (c).

After treatment in the control class, the average answer was 65.47%, while the wrong answer was 34.53%. The students’ highest number of the correct answer was on the indicator (a), followed by indicators (b) and (c), while the highest number of the wrong answer was the indicator (c), followed by indicators (b) and (a). In the experiment class, the average number of the wrong answer was 19.03%, while the answer with the correct level was 80.97%. The most correct answer indicator is on the indicator (a) then on the indicators (b) and (c) while the error indicator on the concept of understanding the indicator (c), followed (b), and indicator (a).
Based on the analysis of differences scores in control class and experiment class related to indicators of conceptual understanding, it appears that the use of CBGL using Quizizz applications is different from the improvement of students’ conceptual understanding by applying CBL without the use of Quizizz applications. The average score of conceptual understanding of the experimental class students was higher than the control class. This shows that the average conceptual understanding with CBGL using Quizizz applications was higher than CBL without Quizizz applications.

3.3. Comparison of the concept understanding ability of control class and experiment class
The percentage of students who understood the concept before treatment, on indicator a, was 28.6% in the control class, and 35.7% in the experiment class (in figure 3). The percentage of students who experienced misconceptions was 71.4% in the control class, and 21.4% in the experiment class. The percentage of students who did not understand was 64.3% in the control class and 42.9% in the experiment class. On the indicator of conceptual understanding (b) students who understood the concept was 7.1% while the experimental class was 3.6%, students who experience misconceptions were 10.7% in control class while 96% was from the experimental class did not understand the concept of the problem. In solving questions related to the conceptual understanding indicator (c) most of the students did not understand (96.4%) and had misconceptions was 3.6% while the overall experimental class of students did not understand the concept of the question. After treatment (post-test) in the control class, on the indicator (a), 92.9% of students understood the concept with a 7.1% misconception. Compared, The experimental class, on average, 100% of students understand the concept. For indicator (b) in control class, students who understood the concept was 32.1%, had misconception was 28.6% and did not understand the concept was 39.3% while the experimental class the students who understood the concept was 50%, had misconception was 28.6%, and did not understand was 21.4%. On the indicator (c) student who understood the concept was 17.9%, had misconceptions was 32.1% and did not understand 50% while the experiment class students who did not understand the concept was 32.1%, had misconceptions were 14.3%, and the average student who understood the concept was 53.6%.

The results of this analysis indicate that indicators (a), (b), and (c) in experiment class with CBGL using Quizizz application compared to control classes, which only use CBL without Quizizz in evaluating the results of student questions. Of the three misconceptions, criteria are associated with indicators of conceptual understanding obtained results that students who did not understand the concepts were highest on the indicators (c) then on indicators (b). On indicator classifying objects according to the concept (a), the average student has understood the concept of working on the given problem. Analysis Criteria for students give the wrong answer upon the questions were associated with indicators of understanding concepts presented in the following table 3.
Figure 3. Analysis of students’ conceptual understanding consisting of Not Understand (DU), Misconception (MI), and Understand (UN) is associated with indicators (a), (b), and (c). The analysis was divided into Control Classes (A, C, E) and Experiment Classes (B, D, F). Control class consist of pre-test (preK) and post-test (postK). The experiment class consists of pretest (preE) and post-test (postE).
Table 3. Percentage error analysis of conceptual understanding indicators.

| Class    | Test   | Number of answers | Indicator | Percentage (%) | Level of achievement |
|----------|--------|-------------------|-----------|----------------|----------------------|
|          |        |                   | a        | b              | c                       |
|          |        |                   |           |                |                        |
| Control  | Pre-test| ΣBB               | 28,6     | 10,7           | 0                      | 13,1                  | SR<sup>e</sup> |
|          |        | ΣBS               | 3,6      | 7,1            | 3,6                    | 4,77                  | SR           |
|          |        | ΣSB               | 0        | 0              | 0                      | 0                     | SR           |
|          |        | ΣSS               | 67,9     | 82,1           | 96,4                   | 82,1                  | ST<sup>b</sup> |
|          | Post-test| ΣBB              | 92,9     | 28,6           | 17,9                   | 46,47                 | SD<sup>c</sup> |
|          |        | ΣBS               | 3,6      | 28,6           | 28,6                   | 35                    | RD<sup>d</sup> |
|          |        | ΣSB               | 0        | 3,6            | 0                      | 20,27                 | RD           |
|          |        | ΣSS               | 1        | 39,3           | 53,6                   | 31,3                  | RD           |
| Experiment | Pre-test| ΣBB              | 35,7     | 3,6            | 0                      | 13,1                  | SR           |
|          |        | ΣBS               | 17,9     | 0              | 0                      | 5,97                  | SR           |
|          |        | ΣSB               | 3,6      | 0              | 0                      | 1,2                   | SR           |
|          |        | ΣSS               | 42,9     | 96,4           | 100                    | 79,77                 | TG<sup>e</sup> |
|          | Post-test| ΣBB              | 100      | 50             | 53,6                   | 67,87                 | TG           |
|          |        | ΣBS               | 0        | 21,4           | 14,3                   | 11,9                  | SR           |
|          |        | ΣSB               | 0        | 3,6            | 0                      | 1,2                   | SR           |
|          |        | ΣSS               | 0        | 25             | 32,1                   | 19,03                 | RD           |

<sup>a</sup>Very Low (SR)<br><sup>b</sup>Very High (ST)<br><sup>c</sup>Medium (SD)<br><sup>d</sup>Low (RD)<br><sup>e</sup>High (TG)

The percentage of errors in each aspect of the concept of understanding indicators (table 3) is described as follows.

3.3.1. Indicator (a). The indicator classifies objects according to the concept, in control class when the pre-tests of the majority of students did not understand of the completion of the given questions (67.9%), in the post-test, the average student answers are correct, or the answer was in criteria of understanding the percentage 92.9%. Likewise, with the experimental class, when the pretest, the number of students' responses in the criteria or did not understand was 42.9%. After treatment, the number of students who understood became 100%. The error level after treatment, both the experiment class and the control class, increased on the indicator restates a concept and classified the object according to the concept. It means that most students can know as well as the types of objects and their groupings based on concepts they understand related to Pythagoras.

3.3.2. Indicator (b). The indicator presents the concept in the form of mathematical representation shows that the error analysis of students in the control class decreases to 39.3%. However, the results of the experimental class were decreased by 50% than the control class. This percentage shows that students who study with CBGL, along with feedback, have been able to present a form of mathematical representation of everyday problems related to Pythagoras.

3.3.3. Indicator (c). Indicator reviewing and applying a concept and choosing the procedure in solving the problem correctly. The control class students almost all made errors (96.4%) in working on questions related to this indicator as well as in the experimental class (79.9%), students made errors in applying the concept and choosing the procedure to work on the problem. After giving the treatment, it appears that the application of CBGL with the application of Quizizz in learning improves the level of student understanding in responding with a percentage of 67.87% compared to the control class, which
is only applied by CBL with a conceptual understanding of only 13.1%. This indicator shows the average student in the experiment class has been able to describe the concepts sequentially in a mathematically. On average, they have been able to review the requirement that relates to the concept. The students have been able to solve the problem according to the procedure. Although the average in the experiment class increased, it has not been felt optimal due to limited research time. So, the shortcomings in this indicator must be corrected by giving case-based questions regularly and accompanied by deep-rooted evaluation in reviewing and applying a concept, and selecting procedure in solving problems can be improved.

The observations results in the experimental class, the provision of case studies accompanied by the use of Quizizz applications, made students more interested in following the teaching and learning process because of the rapid evaluation of teachers [11] from the beginning to the end of learning and especially students able to find out the assignment given. So in the next task, they have been able to revise the errors in the procedure [8]. However, for students taught by giving only case studies without a touch of technology such as the use of applications, student involvement in the teaching and learning process was not significant. Using the Quizizz is useful for stimulating the brain but also as a way to reduce the level of saturation in learning and is a material delivery process that is effective in increasing students’ learning desires [17][18]. The involvement of students was also influenced by the lack of evaluation of the tasks given. So they did not understand the material presented. The existence of case-based games learning accompanied by the use of an android-based application provides experiences for students to develop critical thinking, problem-solving, reasoning, and effective analysis, which are characteristics of an in-depth approach to meaningful learning [7][9][10]. The use of case-based games learning strategies indicates an increase in student confidence. It provides a deeper understanding of subject lessons [5][9], which eventually trains critical thinking skills and develops problem-solving skills from identified case experiences [20][21]. Case-based games learning also relates to essential concepts and facts in the context of real-world situations that reinforce conceptual understanding [4] through games that are framed by learning to be fun.

4. Conclusion
The average conceptual understanding CBGL using the Quizizz application strategy is more effective than CBL without Quizizz application in evaluating student work results quickly, precisely, and accurately. The average students’ concept understanding based on student answers with indicators of the conceptual understanding answers students of correct class answers (80.98%). It was higher than the control class (65.47%). The average percentage of answers based on an indicator of understanding the concept that is on the indicator (a) classifying objects according to the concept with students’ correctness level in control class (92.9%) meanwhile in experimental class (100%), indicator (b) presenting the concept in the form of mathematical representations with students’ correctness level in answering questions based on these indicators, in control class (28.6%) meanwhile in experimental class (50%), indicator (c) examining and applying a concept and choosing the procedure in solving the problem correctly, on an average score of students with the correct level of answers or understand in control class (17.9%) meanwhile in control class on average students understood (53.6%). Therefore, the application of Case-based games learning (CBGL) with the use of Quizizz applications is necessary to increase in developing students’ conceptual understanding in mathematics.

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