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Comparative Analysis of Students' Biology Learning Outcomes: Memory and Understanding Aspects

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ABSTRACT

Purpose of the study: This research aims to analyze the learning outcomes of 11th-grade students by examining how they answer questions using memory aspects, evaluate the overall learning outcomes of the class, and identify the differences in learning outcomes between students who use memory aspects and those who use comprehension aspects to solve questions.

Methodology: This study is a true experimental study. The population in this study were all students of Public High School 6 South Bengkulu totaling 142 people. The sample was taken using a random sampling technique of 42 people was obtained. This study used a learning outcome test instrument in form of multiple choice questions. Data analysis techniques used include descriptive statistics and inferential statistics.

Main Findings: The analysis shows that students' abilities are in the moderate category. Biology learning outcomes are in the high category. The results of the hypothesis test show that the significance value is less than 0.05, so Ho is rejected and Ha is accepted, which means that there is a significant difference in the learning outcomes of class XI science students at Public High School 6 South Bengkulu who use memory and understanding aspects in answering questions.

Novelty/Originality of this study: This type of study can provide valuable insights into the effectiveness of both cognitive abilities in understanding and remembering information in the context of learning Biology subjects. In addition, this study can also provide information to educators about more effective ways to help students learn and remember subject matter better.

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1. INTRODUCTION

Education is an important thing that every individual needs to pay attention to and have in order to advance the welfare of the nation and state [1]–[3]. If a nation wants to see its country develop and progress, then education must be improved and improved first. Education also supports the quality or not of human resources in various sectors in the world of work. The responsibility of education in creating quality human beings, especially in preparing students to become increasingly active subjects, displaying strong, creative, independent, professional and productive excellence in their respective fields, is something that is not easy and straightforward [4], [5]. Education can be obtained through family, community and school education. One way to assess the development and achievement of students' competencies is through the students' learning outcomes.

Student learning outcomes include three aspects, namely cognitive, affective and psychomotor [6], [7]. Specifically for the cognitive aspect, student learning outcomes can be determined through a series of tests given to students in the form of daily tests, mid-semester exams and final semester exams. Student learning outcomes can be obtained through exam tests by answering several questions given. This assessment is used to assess students' competency achievements, prepare learning progress reports, and improve the learning process [8]–[10]. The important principles for assessing learning outcomes are that they are accurate, economical and encourage improvement in the quality of learning. In solving problems, students can solve them based on their respective abilities, both based on aspects of memory and understanding.

Memory is a power that can receive, store and reproduce impressions/responses/understandings [11], [12]. Memory plays an important role for students in learning, especially in mastering subject matter and solving questions, both daily, mid-semester and final semester exams, as well as storing what they have learned, which is then applied when needed. Apart from the memory aspect, the understanding aspect also plays an important role in the student's learning process. Training your memory can be done in various ways, one medium that can help improve memory is by making notes, which is done during the learning process [13], [14]. The note-taking method will be able to help students remember the material provided by the teacher, because students have some additional information.

The aspect of understanding plays an important role in the learning process, especially when students face test questions at school [15], [16]. The ability to understand questions is a skill that is very necessary to find and understand the essence of the questions asked. Whether it is a daily test, mid-semester or end-of-semester questions, students' understanding ability is reflected in their ability to answer questions according to the intended context, as well as being able to formulate answers that are appropriate and relevant to the questions given. Thus, good understanding helps students not only answer questions, but also understand in depth what is asked in each question they face.

The study of biology offers a broad window into the wonders of life around us line with [17], [18]. It is a subject that studies the essence of life, from small structures such as cells to the complexity of global ecosystems. Through biology, we explore how living organisms interact with each other and their environment. This subject not only explores scientific facts about living organisms, but also builds an understanding of the concepts underlying life processes, such as evolution, genetics, ecology, and more. Biology not only stimulates curiosity, but also provides a deep understanding of the complex relationships between humans and their environment, providing a solid foundation for the understanding of health, medicine, the environment, and many other areas of science.

This research is urgently needed considering the importance of understanding the factors that influence students' biology learning outcomes. The main objective of this study is to compare two important aspects of students' biology learning outcomes, namely memory and comprehension. By deepening our understanding of how memory and comprehension influence learning outcomes, this study is expected to provide valuable insights for the development of more effective curricula and teaching strategies in biology education. The learning outcomes obtained by students are sometimes uncertain, most students find it difficult to obtain good and satisfactory results [19]–[21]. Factors that cause this to happen include student readiness which includes; mastery of the material, ability to analyze test questions and appropriateness of question construction prepared by the teacher (the domain that will be measured based on Bloom's taxonomy.

When the questions created by the teacher are not in accordance with the design in the learning process that has been prepared then this can cause good learning results to be difficult to achieve, as well as a mismatch in the aspects that will be measured by the use of operational verbs in the sequence. Bloom's taxonomy in making learning outcomes test questions. When giving students tests at school, students are sometimes found who answer questions that do not match the context required by the questions. This can show a comparison of learning outcomes which are of course very different, this difference is of course influenced by what domain plays a role in answering questions, whether domain C1 (memory) or domain C2 (understanding).

2. RESEARCH METHOD

2.1 Research Type

This study employs a true experimental design, specifically a Posttest Only Control Group Design. This design allows for the isolation and control of variables, ensuring that the differences observed in students' biology learning outcomes can be attributed to the independent variables: memory (X1) and understanding (X2) aspects. By focusing on final test results after interventions, this approach offers insights into how differing cognitive abilities impact learning achievements among high school students.

2.2 Population and Sample

The research was conducted at Public High School 6 South Bengkulu, involving class XI students specializing in natural sciences. The total population consisted of 142 students distributed across four classes.

The technique used in sampling uses proportional sampling, which is the method used if the population conditions of each region are not the same, then the sampling is carried out in a balanced or proportional manner, proportional to the size of the population [22], [23]. So, there were 42 people who would be the sample in this research. The research instrument used was a learning outcomes test.

2.3 Data Collection Technique

The primary instrument utilized in this study was a learning outcomes test designed to assess students' abilities in both memory and understanding aspects of biology. The test items were structured according to specific indicators related to cellular structures, functions, and comparisons as outlined in the Ministry of Education and Culture's guidelines. This instrument not only measures factual recall (memory aspect) but also comprehension and application of concepts (understanding aspect) among students.

The following is a grid of instruments regarding memory aspects and understanding aspects.

Table 1. Instrument Grid for Memory Aspects (C1) and Understanding Aspects (C2)

Basic competencies	Indicator	Memory Aspect (C1)	Understanding Aspects (C2)	Amount
1.1 Describe the chemical components of cells, structure and function of cells as the smallest unit of life.	1. Make microscopic observation preparations of plant cells and animal cells.	19,20	-	2
	2. Drawing structures based on the results of microscopic observations.	1,2	3	3
	3. Compare living cells and dead cells.	8.9	4.5	4
	4. Compare the structure of plant cells and animal cells.	-	6,7	2
	5. Explain the structure and function of the cell membrane, cytoplasm, and cell nucleus.	-	10,11,12	3
	6. Describe the differences in the structure of prokaryotic and eukaryotic cells.	12,14	15,16	4
1.2 Identify the organelles of plant cells and animal cells.	1. Mention the names of cell organelles in the cell picture.	-	17	1
	2. Explain the function of cell organelles.	18	-	1
Amount		9	11	20

For the learning outcome categories, standard categorization techniques established by the Ministry of Education and Culture (2006) are used, as follows:

Table 2. Learning Outcome Score Categories

Percentage	Category
0 – 20	Very low
21 – 40	Low
41 – 60	Currently
61 – 80	Tall
81 – 100	Very high

2.4 Data Analysis Technique

Following data collection, the analysis proceeded with descriptive and inferential statistical techniques. Descriptive statistics were employed to summarize the overall performance of students in each aspect (memory and understanding), while inferential statistics allowed for deeper insights into the relationships and differences between the independent variables (X1 and X2) and the dependent variable (biology learning outcomes). These analyses provide a rigorous framework for interpreting the impact of memory and understanding on students' academic achievements.

2.5 Research Procedure

The study began with identifying the research design and selecting the research site and participants from Public High School 6 South Bengkulu. Proportional sampling was then implemented to ensure a representative sample from the student population. Data collection involved administering the learning outcomes test designed according to the instrument grid provided in Table 1. Post-test data analysis included both descriptive summaries and inferential statistical tests to evaluate the effects of memory and understanding aspects on students' biology learning outcomes. This systematic approach ensures the reliability and validity of the findings, contributing valuable insights to educational practices in biology instruction.

3. RESULTS AND DISCUSSION

3.1. Results

Based on the results of research carried out at Public High School 6 South Bengkulu, researchers collected data through learning outcomes tests in the form of multiple choices with "cell" biology material which were filled in by class XI Science students who were then given a score for each question item. The following is a table of the results of descriptive analysis of data on the ability to solve questions on the memory aspect of students at Public High School 6 South Bengkulu:

Table 3. Descriptive Statistics on the Ability to Solve Questions on Memory Aspects of Students at Public High School 6 South Bengkulu

Statistics	Statistical Score
Sample	42
Lowest score	3
Highest score	9
Average	6.57
Standard Deviation	1.62

Based on the table above, it can be seen that the highest score obtained was 9, the lowest score was 3, with an average value of 6.57 and a standard deviation of 1.62. The average value when viewed from the categorization is in the medium category. For more clarity, it will be discussed in the respondent score category section below.

To make it easier to determine the level of ability to solve memory aspect questions, a breakdown is made according to value categories. These details include three categories, namely: high category, medium category and low category. For more details, see the description below:

Table 4. Categories of Ability to Solve Questions on Memory Aspects of Students at Public High School 6 South Bengkulu

NO	Intervals	Frequency	Category	Percentage (%)
1	$x < 4.95$	6	Low	14.3
2	$4.95 \leq x < 8.19$	31	Currently	73.8
3	$8.19 \leq x$	5	High	11.9
Amount		42		100

Based on the data obtained in the table above, by looking at the 42 students as a sample it can be seen that 6 people (14.3%) are in the low category, 31 people (73.8%) are in the medium category, and 5 people (11, 9%) are in the high category. Meanwhile, if you look at the average value obtained which is 6.57 when included in the three categories above, it is in the medium category so it can be concluded that the students of Public High School 6 South Bengkulu has the ability to solve problems on the memory aspect which is moderate

Based on the results of research carried out at Public High School 6 South Bengkulu, researchers collected data through learning outcomes tests in the form of multiple choices with "cell" biology material filled in by class XI science students. The following is a table of the results of descriptive analysis of data on the ability to solve questions on aspects of understanding:

Table 5. Descriptive Statistics on the Ability to Solve Questions on Understanding Aspects of Students at Public High School 6 South Bengkulu

Statistics	Statistical Score
Sample	42
Lowest score	3
Highest score	11
Average	7.95
Standard Deviation	1.84

Based on the table above, it can be seen that the highest score obtained was 11, the lowest score was 3, with an average value of 7.95 and a standard deviation of 1.84. The average value when viewed from the categorization is in the medium category. For more clarity, it will be discussed in the respondent score category section below.

To make it easier to determine the level of ability to complete questions on the understanding aspect, a breakdown is made according to value categories. These details include three categories, namely: high category, medium category and low category. For more details, see the following description:

Table 6. Categories of Ability to Solve Problems on Aspects of Understanding of Students at Public High School 6 South Bengkulu

NO	Intervals	Frequency	Category	Percentage (%)
1	$x < 6.11$	6	Low	14.3
2	$6.11 \leq x < 9.79$	34	Currently	81
3	$9.79 \leq x$	2	High	4.8
	Amount	42		100

Based on the data obtained in the table above, by looking at the 42 students as a sample it can be seen that 6 people (14.2%) are in the low category, 34 people (81%) are in the medium category, and 2 people (4.8%) is in the high category. Meanwhile, if we look at the average score obtained at 7.95 when included in the three categories above, it is in the medium category, so it can be concluded that the students of Public High School 6 South Bengkulu has the ability to solve questions on moderate aspects of understanding.

Based on the results of research carried out at of Public High School 6 South Bengkulu, researchers collected data from learning achievement tests through daily tests on Biology subjects for class XI Science students. The following is a table of descriptive analysis results of Biology learning outcomes data for Public High School 6 South Bengkulu students:

Table 7. Descriptive Statistics on Biology Learning Outcomes of Students at Public High School 6 South Bengkulu

Statistics	Statistical Score
Sample	42
Lowest score	35
Highest score	100
Average	72.61
Standard Deviation	15.15

Based on the table above, it can be seen that the highest score obtained is 100, the lowest score is 36, with an average value of 72.61 and a standard deviation of 15.15. The average value when viewed from the categorization is in the high category. More details will be discussed in the following section.

To make it easier to find out the level of learning outcomes, a breakdown is made according to value categories. Details of student learning outcome categories using standard categorization techniques as follows:

Table 8. Biology Learning Outcome Categories for Public High School 6 South Bengkulu Students

NO	Mark	Frequency	Category	Percentage (%)
1	21 – 40	1	Low	2,4
2	41 – 60	10	Currently	23.8
3	61 – 80	19	Tall	45.3
4	81 – 100	12	Very high	28.5
	Amount	42		100

Based on the data obtained in the table above, by looking at the 42 students as a sample it can be seen that 1 person (2.4%) is in the low category, 10 people (23.8%) are in the medium category, 19 people (45.3%)) is in the high category, and 12 people (28.5%) are in the very high category. Meanwhile, if we look at the average score obtained at 72.61 when included in the four categories above, it is in the high category, so it can be concluded that the students of Public High School 6 South Bengkulu has high Biology learning outcomes.

The data normality test means whether the data used is normally distributed or not [24]–[26]. The following are the results of the normality test obtained from the results of the SPSS program processing of the variables tested.

Table 9. Normality Test Results

Variable	K-SZ	Sig.	Information
Ability to solve memory aspect questions	1,137	1.51	Normal
Ability to solve questions on aspects of understanding	1,038	0.231	Normal
Learning outcomes	0.713	0.689	Normal

Based on the normality test using the Kolmogorov-Smirnov test above, the KSZ value obtained for the variable ability to solve questions on the memory aspect was 1.137, for the variable ability to solve questions on the understanding aspect it was 1.038, and for the learning outcome variable it was 0.713. Asymp.Sig value. (2-tailed) for the variable ability to solve problems in the memory aspect, it was 0.151, for the variable the ability to solve questions it was 0.231, and for the learning outcomes variable it was 0.689. The results obtained are greater than 0.05 (>0.05), so it can be concluded that the data is normally distributed.

The homogeneity test aims to see whether the data in the two groups have the same variance (homogeneous) or not [27]–[29]. The table below is the results of the hypothesis test.

Table 10. Hypothesis Test Results

		Sum of squares	df	Mean square	F	Sig.
c2	Beetwen groups	118.888	12	9.907	13.671	0.000
	With Groups	21.017	29	0.725		
	Total	139.905	41	.		
c1	Beetwen groups	139.905	12	7.272	10.035	0.000
	With Groups	21.017	29	0.725		
	Total	108.286	41			

With the testing criteria being if Sign $_{.count}$ < 0.05 then H1 is accepted and H0 is rejected, meaning there is a significant difference between the learning outcomes of class XI science students at Public High School 6 South Bengkulu who solve questions using memory and understanding skills. The contribution of the ability to solve problems in the memory aspect was 72.9%, this shows that memory plays an important role in solving questions in the medium category. In the learning process and especially in terms of evaluation, the intelligence factor influences the achievement of good cognitive learning outcomes, where in terms of intelligence the memory aspect is included. Intelligence is basic intelligence related to cognitive processes, learning (intellectual intelligence) tends to use mathematical-logical and language abilities, generally developing cognitive abilities (writing, reading, memorizing, calculating and answering).

This intelligence is known as rational intelligence because it uses the potential of ratios in solving problems. Intelligence assessment can be carried out through tests or examinations of memory, reasoning power, mastery of vocabulary, accuracy in calculating and ease of analyzing data [30], [31]. In this research, there are research results that show that there are students who answer only a few questions on the memory aspect of the number of questions available. This is not because the student's memory is bad or good, but there are several factors that cause this, one of which is the way the learning process is emphasized. less precise.

The contribution of the ability to solve problems in the understanding aspect was 79.0%, this shows that understanding plays an important role in solving questions in the medium category. In the learning process and especially in terms of evaluation, factors that influence learning outcomes apart from the memory aspect, understanding aspects also influence it. The understanding aspect is the second level after the knowledge (memory) aspect in Bloom's taxonomy, the understanding aspect has a higher level of difficulty than the memory aspect. If we look at the level of difficulty of the questions, the contribution to the ability to solve questions in the memory aspect should be greater. However, in the results of this research the contribution of the understanding aspect is greater. The researcher concluded that this was because there were some students who had difficulty remembering the lesson material that had been taught to answer memory aspect questions.

Based on the significance value which shows that the value is sign. < 0.05 (0.00 < 0.05), this shows that there is a difference between the learning outcomes obtained based on the ability to solve problems in the memory and understanding aspects. In the analysis prerequisite test, data was obtained on the ability to solve memory aspect questions with learning outcomes normally distributed because the sig value. > α respectively, namely (1.51 > 0.05) and (0.689 > 0.05). Based on the description above, it shows that there is a significant difference in learning outcomes between the ability to solve questions on aspects of memory and understanding of class XI science students at Public High School 6 South Bengkulu. The contribution of the ability to solve questions on the memory aspect is 72.9% and the contribution of the ability to solve questions on the understanding aspect is 79.0%, this shows that understanding contributes in a very high category so that the learning outcomes achieved meet the standards that have been set. Ability to solve questions on aspects of memory and understanding of class XI Science students at Public High School 6 South Bengkulu contributes

positively by 99.96% to learning outcomes. The remaining 1% is another factor that was not examined by researchers. This is in accordance with the operational definition put forward by the author who states that the memory and understanding aspects are aspects with a relatively low level of difficulty, so it is normal for these two aspects to make a high contribution to achieving learning outcomes.

For the reason that the level of difficulty of the questions is still relatively low, this is what causes the contribution to the ability to solve questions in the aspects of memory and understanding to be very high. The low level of difficulty makes students able to answer almost all the questions. In this research, researchers are oriented towards aspects of memory (knowledge) and understanding. At the level of knowledge (memory) is the student's ability to remember. This statement means that questions for the knowledge level are asking students to recall or recognize facts, terms, symptoms, and so on [32]–[34]. Meanwhile, understanding is the level of ability that expects students to be able to understand the meaning or concepts, situations and facts they know [35], [36].

In creating questions to measure student learning outcomes, the researcher was guided by this explanation, where to measure the ability to complete the memory aspect the researcher prepared the questions using operational verbs in Bloom's taxonomy aspect C1 (Memory), while to measure the ability to complete questions in the understanding aspect the researcher using operational verbs in Bloom's taxonomy aspect C2 (Understanding), for understanding the researcher prepared questions with a low level of understanding, namely understanding translation, both translation in the true sense such as explaining the meaning of cells which are said to be structural units. This explains the results of the research found, that why the contribution of these two aspects is so high, namely because the level of difficulty of the questions used is relatively low because they are only based on aspects of memory and low level understanding.

This research is in line with the research conducted by [37]. which discusses biology learning outcomes memory and understanding aspects. However, the research did not conduct an in-depth analysis like this research. So this research is a novelty from previous research. The above is also because these two aspects are included in the cognitive domain, where this domain has become an absolute thing that influences the achievement of learning outcomes. This can be seen from the average learning outcomes when tested with multiple choices. The average student learning outcome using multiple choice is 65.52. When given an essay test, students who have high cognitive abilities have the ability to express, organize and combine the ideas they have with their own words.

This study makes a significant contribution to deepening the understanding of the influence of memory and comprehension aspects on students' biology learning outcomes at the secondary school level. By using a true experimental design and focusing on questions specifically designed to measure both aspects, this study fills the knowledge gap by highlighting significant differences between these two cognitive abilities in the context of biology education. The results provide a strong empirical foundation for the development of a more holistic and evidence-based learning approach to improve students' conceptual understanding and memory capacity in learning biology.

The implication of this study is the need for a balanced learning approach between developing memory skills and conceptual understanding in biology learning at the secondary school level. The results showed that both the ability to remember factual information and in-depth understanding of biological concepts contribute significantly to students' academic achievement. Thus, teaching that combines strategies to improve both aspects can help improve the effectiveness of biology learning. However, there are several limitations in this study that need to be considered, such as the limited sample size and focus on one school in one particular location, so the generalization of the results may be limited to the same context. For future research, it is recommended to expand the scope of the sample and study location and integrate additional variables to further explore the factors that influence students' biology learning outcomes.

4. CONLUSION

Based on the results of the study at Public High School 6 South Bengkulu on grade XI science students, it can be concluded that there is a significant difference in learning outcomes between students who work on questions related to memory and understanding aspects in biology lessons. Student learning outcomes in the memory aspect are in the moderate category with an average score of 72.9%, while in the understanding aspect it reaches 79.0%. This shows that although students have a fairly good understanding of biological concepts, the ability to remember factual information also plays an important role in their academic achievement. These findings provide important implications for the development of more effective curriculum and teaching strategies in improving students' biology learning outcomes, by considering both cognitive aspects in a balanced manner.

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This research is expected to provide new insights in the development of biology learning strategies that consider both aspects of memory and understanding in a balanced way. These findings can be a basis for

increasing the effectiveness of biology education in secondary schools by optimizing both of students' cognitive abilities holistically.

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