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# Enhanced Cognitive Abilities Through Lesson-Based STEM Lesson Study on Environmental Change Materials

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***Abstract:***
***Background****: The advancement of science and technology is changing and becoming more competitive. It necessitates a learning process that facilitates rather than inhibits cognitive abilities by carrying out learning processes that allow learners freedom in the thought process or learning process. The purpose of this research is to analyse the influence of lesson study-based STEM learning on cognitive abilities .*
***Materials and Methods****: The quasi-experiment method was used in this study. The study included 90 students from two high schools in South Aceh Regency. The cognitive abilities are measured by calculating the normalization of gain (n-gain). The instruments used to measure cognitive abilities are pretest and posttest in the form of multiple choice questions. Data analysis for cognitive abilities and learning outcomes is evaluated using two-point tests (t-tests).*
***Results****: The results showed that the experimental class's n-gain cognitive ability of 0.81 was in the high category, while the control class's n-gain cognitive ability was 0.71. At a 95 percent significance level, the n-gain difference between the two classes against learning outcomes differed significantly. The N-Gain results for both classes showed a t-count of 3.46 > t-table 1.98, indicating a significant difference in improved learning outcomes between the control and experimental classes.*
***Conclusion:****This study found that lesson study-based STEM learning significantly improves cognitive abilities.*
***Key Word****: Cognitive Abilities, STEM, Lesson Study,.*

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## I. Introduction

In the twenty-first century, competition is fierce in a variety of fields, including education. The weak learning process in Indonesia cements the "vocal teacher, silent teacher" philosophy[1]. The learning process in the Education unit is held interactively, inspiringly, fun, challenging, and motivating learners to participate actively, as well as providing sufficient space for initiative, creativity, and independence according to talent, interests, and physical and psychological development, according to PP no.19, 2005 on National Standards of Education Article 19 paragraph 1Learning should be concentrated on thought processes or mental processes, not merely results, according to the implications of Piaget's theory[2]. Many learning procedures continue to rely on "the important there is learning," resulting in learners' cognitive talents not being realized. When students are confronted with challenges that require them to think, cognitive development becomes critical.

Anderson and Krathwohl[3] divide the cognitive sphere into six levels, according to Bloom's taxonomy: remembering, understanding, applying, analyzing (parsing), evaluating (assessing), and creating (creating). These are steps or levels that must be completed one by one, with the upper aspect including all lower aspects. To advance to a higher level of cognitive capacity, learners must be able to or have passed the previous level of cognitive ability.The same thing applies to learners who can understand a material if they have some prior understanding of it. Cognitive abilities are approaches of receiving and reasoning about different stimuli. Differences in cognitive abilities may describe why students choose various solutions[4].Cognitive ability, also called as thinking ability, refers to the accomplishment of two types of cognitive processes. First, low-level cognitive skills include remembering, understanding, and applying information. Second, high-level thinking abilities allow you to analyze, evaluate, and create[5].

STEM (science, technology, engineering, and mathematics) learning is a combination of science, technology, engineering, and mathematics that is intended to help students succeed in the twenty-first century[6].Becker and Park[7] found that STEM learning can help students improve their cognitive, ability, and affective skills. According to Suwarma et al[8]., STEM in science learning can boost creative thinking skills in problem solving with increased posttestand N gain results.Teacher preparation in designing, implementing, and assessing learning activities is another something that teachers must consider in the learning process, in addition to learning methodologies. Lesson study is a way for collaborating and planning learning as well as assessing the effectiveness of teaching strategies that have been applied in order to improve the learning process and acquisition of learners.Lewis[9] defined lesson study as "the simple idea of studying lessons through a complex process, backed by collaborative goal formulation, careful data gathering concerning learners' learning, and protocols that permit meaningful dialogue about tough subjects."

Based on field observations from the assignment of case study courses and educational innovation in several high schools, as well as discussions with teachers of MGMP Biology members in the Meukek sub-district, it was discovered that during biology class X of the 2019/2020 study, students only listened and paid attention to the teacher's explanation of the material. The average learning outcome for biological learning was only 59.26, indicating that learners had problems understanding it. The average learning outcome is still below the applied Minimum Completion Criteria of 76, and learners' cognitive abilities are rarely measured.In another study on cognitive abilities delivered by Sumarni, et al[10]., that STEM approaches to learning were able to improve the understanding of learners' concepts. In line with previous research that the implementation of STEM education in science learning is very popular because it can hone cognitive skills, manipulative, design, utilize technology, and application of knowledge[11], as well as the ability to combine cognitive and psychomotor knowledge.

Based on the foregoing explanation, more research into improving learners' cognitive abilities and learning outcomes through STEM learning based on learning lessons learned in environmental change materials is required in order to resolve the topic of how to develop cognitive abilities.

## II. Material And Methods

This research uses a qualitative and quantitative approach with the type of applied research, applied research is research based on problems that develop in society which aims to solve problems and the results can be used for the benefit of the community.

**Study Design:**Quasy-Experimental Design

**Study Location**: State High School (SMA) of Meukek District, Aceh Selatan, Aceh, Indonesia.

**Study Duration:** Even semester of the 2020/2021 academic year from April to June 2021

**Sample size:** 90 students consisting of 2 class X science at SMAN 1 Meukek (Class control) and 2 class X science at SMA InsanMadani (Experimental Class).

**Subjects & selection method**: All students of class X majoring in Science at Senior High School (SMA) in Meukek District. The selection of schools was based on an A accreditation score, so that two high schools in Meukek sub-district were selected as research locations, namely SMAN 1 Meukek and SMA InsanMadaniMeukek.

**Procedure Methodology**

A test instrument in the form of a multiple-choice test with five answers is used to assess cognitive abilities in the form of a pretest and posttest. The questions have been designed to reflect the cognitive ability criteria and indications. A score of 1 is assigned to each correct response, while a score of 0 is assigned to each incorrect answer. The questions used to collect data on learning outcomes have been modified to reflect the cognitive indications that must be met.Cognitive indicators include C1 (remembering), C2 (understand), C3 (apply), C4 (analyse), C5 (evaluating), and C6 (create).There are two basic requirements in the process of cognitive achievement. To begin, low-level cognitive talents include remembering, comprehending, and applying information. Second, high-level cognitive talents are capable of analyzing, evaluating, and creating.

**Statistical analysis :**

Tabulating was used to start the data analysis in this investigation. The presenting of data in a tabular format is known as tabulation. The experimental and control classes' pretest scores were tabulated, and the experimental and control classes' post-test scores were tabulated.

Data on cognitive ability was collected before learning in both the control and experimental groups (pretest). This is done in order to determine the students' basic cognitive ability in both sessions. After students have been offered several types of learning, they are given a posttest at the end of the lesson. Assessing student responses using the rubric that has been created.

The data from the results pretest and posttest of students' cognitive ability were calculated as N-Gain scores and normalized. To determine the significance of the difference, a statistical test was performed. The data was then tested for normality and homogeneity. After being tested for normality and homogeneity, it was continued to test the difference of two averages with the t test. The t-test used is free sample t-test or separate (Independent Sample t-Test), but if the pretest, posttest and N-Gain values have values that are not homogeneous and are not normally distributed. The statistical test used was the Man Whitney Test with a 95% confidence level.

The data was tabulated for analysis by calculating the average pretest and posttest scores of cognitive ability outcomes in experimental and control class pupils using the findings of the initial ability test (pretest) and the final ability test (posttest). After that, the Gain score is calculated and normalized (N-Gain) using the algorithm from Hake (2014).

$$\textbf{N gain} = \frac{\textbf{Score of Posttest} - \textbf{Score of pretest}}{\textbf{Maximum score of class} - \textbf{Score of pretest}}$$

**Description:**
**High : N-Gain >0,7**
**Medium: 0,3 ≤N-Gain≤ 0,7**
**Low : N-Gain < 0,3**

Average pretest scores and N-Gain normalized were taken as data to compare students' cognitive abilities between the control class and the experimental class. The difference in the average score of gain in cognitive abilities of students is determined if the distribution is normal and homogeneous, then the two average differences tests are continued with the t test. The t-test used is the free sample t-test or separate (Independent Sample t-Test). If the data is not normally distributed or not homogeneous, then the average difference test is carried out using a non-parametric test using the Mann-Whitney test. The t-test can be calculated by the following formula:

$$t = \frac{X_1 - X_2}{\sqrt{\frac{(n_1-1){s_2}^2+(n_2-1){s_2}^2}{n_1+n_2-2}\left(\frac{1}{n_1}+\frac{1}{n_2}\right)}}$$

Description:
$\overline{X_1} =$ Mean of first sample
$\overline{X_2} =$ Mean of second sample
$n_1 =$ Number of first sample
$n_2 =$ Number of second sample
$s_1 =$ Standard deviation of first sample
$s_2 =$ Standard deviation of second sample

The following are prerequisite tests before performing the t test, namely normality test and homogeneity test:

a. Normality

Test The normality test is a test carried out as a prerequisite for conducting data analysis. The normality test was carried out before the data was processed based on the proposed research models. The data normality test aims to detect the distribution of data in one variable that will be used in the study. Good and feasible data to prove the research models are normal distribution data. The normality test used is the Chi Square test. The formula Chi Square test is as follows.

$$X^2 = \sum_{i=1}^{k} \frac{(o_i - e_i)^2}{e_i}$$

Information :
$X^2$ = the number of *Chi Squared* ($X^2_{count}$) sought
$o_i$ = observation frequency for category i
$e_i$ = frequency of expectation for category i
degrees of freedom (DB) = k-1
$X^2_{count} > X^2_{ttable}$ then there is a significant difference ($H_o$ is rejected and $H_1$ is accepted)
$X^2_{count} < X^2_{table}$ then there is no significant difference ($H_o$ is accepted and $H_1$ is rejected)

b. Homogeneity Test

Homogeneity test is used to determine whether several population variants come from populations that have the same variation or not

## III. Result and Discussion

**Cognitive abilities**

Data on students' cognitive abilities is obtained through tests in the form of multiple choice questions consisting of 20 questions and containing six cognitive indicators based on Bloom's taxonomy, namely C1 (remembering), C2 (understanding), C3 (apply), C4 (analyze), C5 (evaluate), and C6 (create) in environmental change material. To find out the cognitive abilities of these learners is done at the beginning of learning (pretest) and after being given different learning (posttest). Recapitulation of Ngain control classes and experiments in working on the cognitive abilities of learners can be seen in Figure-4.1 .

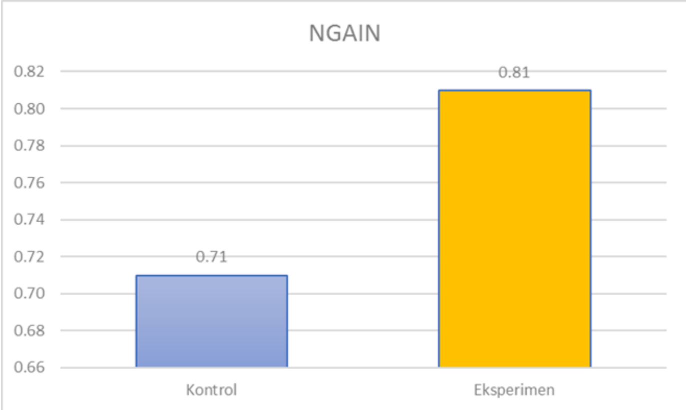

Figure-4.1: NGain Cognitive Ability Graph

Based on the graph above, it can be seen that there is an increase in the NGain cognitive abilities of learners between control classes, where their NGain increases from 0.71 to 0.81 in the experiment class.It may be concluded that using STEM-based Lesson Study to develop learners' cognitive capacities is a good idea. In keeping with prior study, Hikmaningsih, et al (2015)[12] used STEM-PJBL to improve cognitive abilities, with the result being an increase in cognitive ability in learners. The success of students in the classroom after they have received instruction and have been evaluated demonstrates cognitive ability. This is the result of a STEM learning experience that was interrupted.The results of the test analysis can show that learners are able to solve problems that contain limited information by practicing science concepts during learning, learners answer questions as expected. Based on the results of Sumarni's research (2019)[13], it appears that every aspect of STEM equips learners to acquire knowledge and creative cognitive abilities. If integrated, each STEM aspect helps learners solve problems more comprehensively and provides training to learners to form knowledge about the subject studied better understood.

Furthermore, data obtained from Ngain's cognitive ability control classes and experimental classes were tested using t-tests. Based on the results of the t-test test, it was obtained that t-count amounted to 3,46 and t-table with a significantization (α) of 5% of 1.98. The results of the calculations showed that Ho was rejected and HI was accepted, which means there is a difference in average Ngain, so it can be concluded that the application of LESSON STUDY-based STEM approaches to environmental change material affects the cognitive abilities of learners.

The results of cognitive ability tests based on indicators can be seen in the following table-4.2.

| Class | | N | (C1) | (C2) | (C3) | (C4) | (C5) | (C6) |
|---|---|---|---|---|---|---|---|---|
| Kontrol | Pretes | 44 | 100 | 97 | 44.875 | 28.41 | 4.55 | 4.55 |
| | Postes | | 100 | 100 | 96.25 | 86.36 | 42.05 | 13.07 |
| | Rata-rata | | 100 | 98.47 | 70.26 | 56.69 | 22.67 | 9.01 |
| | N_Gain | | 0 | 0.09 | 0.86 | 0.80 | 0.39 | 0.08 |
| Eksperimen | Pretes | 46 | 90.22 | 85.60 | 58.97 | 23.37 | 4.35 | 5.43 |
| | Postes | | 100 | 100 | 98.57 | 92.93 | 58.70 | 13.07 |
| | Rata-rata | | 95 | 93.01 | 78.66 | 57.78 | 31.11 | 25.83 |
| | N_Gain | | 0.20 | 0.33 | 0.92 | 0.90 | 0.57 | 0.43 |

Table-4.2 Average Score indicators of Learners' Cognitive Abilities

Based on the table above, we obtained an analysis of the average score data of learners after working on multiple choice problems, as many as 20, where each problem contains the stages of Bloom's cognitive abilities randomly. Both classes fall into the category of very good. At the understanding stage (C2), the control class obtained an average score of 98.47 and the experimental class scored 93.01, so that it entered the category of very good. For the Understanding (C3) stage, both classes fall into the good category, where each score averages a control class of 70.26 and an experimental class of 78.66. At the analyzing stage (C4), both the control class and the experiment class fall into the category of quite because the average score is 56.69 and 57.78. While at the stage of evaluating (C5) and creating (C6), both classes fall into the category of failure because both classes get an average score of below 40.

From the written test results, cognitive ability obtained the highest average was in the cognitive aspect of knowledge and comprehension level with an average score of 100 in and for the lowest average cognitive aspect score of 9.01 at the reasoning level in the control class. While in the experimental class, the highest average score in cognitive aspects of knowledge and comprehension level was 95, and the lowest average score at the level of reasoning obtained was 25.83. This happens because there are many factors that affect cognitive development, including hereditary and environmental factors (Susanto, 2011)[14].In line with research conducted by Purnama Sari, et al (2017)[15] revealed that learners who have good abilities at the stage of remembering, understanding, applying, and analyzing will get a comprehensive understanding of the material and further research is needed to find solutions to find cognitive abilities that match bloom taxonomic stages. Based on a lesson study-STEM learning applied to material changes in the environment appears to have an influence where the cognitive abilities of learners in control classes and experimental classes increase, especially in experimental classes that apply STEM-based As Rizki (2020) said in his research, one of the causes of the low cognitive ability of learners is learning that is still centered on teachers, while learners only listen to the information conveyed.

The dimensions of hocs cognitive processes, according to Lorin Anderson and David Krathwohl's (2001) taxonomy, include analyzing (C4), evaluating (C5), and creating (C6). The extensive use of the mind to uncover new difficulties is classified as high-level cognitive ability (Lestari, 2021)[16].

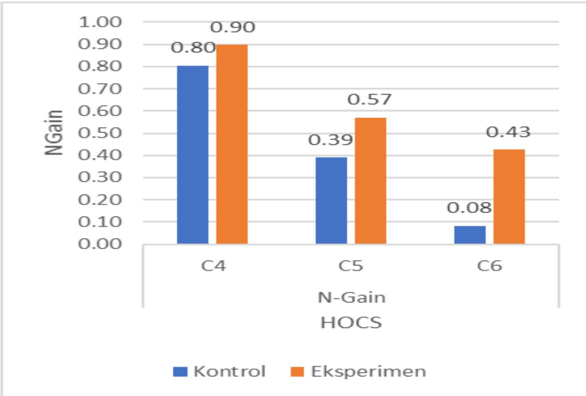


Figure-4.2 Average High-Level Cognitive Ability (HOCS)

Each cognitive stage analyzes (C4) the highest compared to the assessment stage (C5) and creates (C6) in either the control class or the experimental class, as shown in the graph image of Ngain's average on high-level cognitive ability (HOCS) in environmental change material. However, where Ngain stage C4 is included in the High category, C5 and C6 in the average category, the improvement in the experimental class is more prominent. According to the Ngain Hake category level, the C4 control class is in the high category, C5 is in the low category, and C6 is in the stable category.There are many levels of understanding and absorption of concepts. Some people can understand quickly, while others can understand slowly (Purbaningrum, 2017)[17]. Learners are pushed to interpret, analyze, or manipulate information in high-level cognitive learning by either expanding incomplete arguments and rearranging information to influence new interpretations or by progressing through a sequence of interrelated phases. Lewis and Smith (Lewis and Smith, 1993)[18].

The application of STEM-based Lesson study in learning in the ekpserimen class is able to increase the HOCS of learners even though the category level of each cogntif stage is different but better than the control class. This is evidenced by the Ngain average T Test test from HOCS with signification of α = 5% where the results of Thitung calculations >Ttabel so that it can be concluded there is a difference between the average Ngain HOCS control and Ngain HOCS

| Class | N | Pretest | Postest | Ngain | $T_{calculation}$ | $T_{tabel}$ |
|---|---|---|---|---|---|---|
| Kontrol | 44 | 13 | 47 | 0.43 | 42,98 | 1,98 |
| Eksperimen | 46 | 11 | 66 | 0.63 | | |
| | | | | | | (α=0,05) |

Table-4.3 Average NGain HOCS Learners

The focus of learning is on a discipline's essential ideas and concepts, involving students in exploration, problem solving, and other relevant task activities, allowing them to work independently in developing their own knowledge, and eventually achieving their peak to produce genuine products (Thomas, 2000)[19]. Learners are given the opportunity to increase their expertise in digging for information, assessing a problem, actualizing their thoughts, and identifying and solving a problem in their own way when they apply STEM to their learning. Learners actively study, evaluate, and build on the material of curve change as seen during the learning process.

The causative factor of low cognitive ability of high levels of learners is not used by students in working on high cognitive level problems or other international studies. This is in line with previous research where the ability of teachers in making assessment instruments used is still the cognitive level of C1-C2 (Putri, 2018). Furthermore, to improve the ability to think at high levels of learners, teachers should familiarize learners with assessment instruments that are at the cognitive level C4-C6, so that learners are not only trained.Memorize and convey what he memorized, but learners are able to solve problems in new situations, think critically, and transform knowledge and experience directly.

## IV. Conclusion

It can be concluded based on the findings of data analysis and findings when study improves learners' cognitive abilities and learning outcomes through lesson-based STEM learning on environmental change materials:

1. There was a substantial difference in cognitive ability improvement between the experimental class and control class, i.e. t count> t table (3,46>1.98).

2. Similarly, where N-Gain HOCS controls 0.43 to 0.63 for N-Gain experiments, there is an increase for HOCS learners..

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