The Impact of Problem Solving Method to Improve the Critical Thinking and Science Process Skills in Physics

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Abstract: This research was to know the level of students' critical thinking and science process skill after applyingthe problems solving method. Themethod used in thisresearch was pre-test and post-testnon-equivalent control group design. Sample of this research is the students of Junior High School in Medan.Class VII 1 was as the experimental group and class VII 2 was as the control group. Test instruments and statistical analysis collected the data. The tests of this research areanalysis of variance test, normality test and homogeneity test.The result of the research showed that (1) there are difference of critical thinking and science process skills among learners who learn to use problem solving method with learners who learn by using conventional learning method in experiment class (62%) and in control class (38%) (2) There is an increase of approximately 24% in the experimental class.

1 INTRODUCTION

Education has become a very influential aspect in promoting generationswho are capable of dealing with problems in this global era. However, the quality of education in Indonesia is still in the low category, including in science especially in Physics Higher Order Thinking Skills (Phy-HOTS).

This was revealed through the results of a survey of the Program for International Student Assessment (PISA) organized by the Organization for Economic Cooperation and Development (OECD) and Trent in Mathematics and Science Study (TIMSS), which showed that a reading ability was of 396, amounted to 496.

The obtained scores of scienceswere 386. It was below the average score of 501.Similarly, TIMSS results obtained by Indonesian students were of 397. It was below the average value of 500. The low quality of education in Indonesia can be seen from the results of research conducted by Trent in Mathematics and Science Study (TIMSS) designed to examine the trends in knowledge and math and science skills of children aged 14 years along with other information coming from students, teachers, and principal. The result of TIMSS 1999showed that Indonesia occupied the 32nd position of 38 TIMSS participating countries in IPA (Martin MO, 2000). In TIMSS 2003, Indonesia was at 37th out of 46 countries TIMSS participants in IPA (Martin MO, 2004). In TIMSS 2007, Indonesia occupied the position of 35 out of 48 countries participating in TIMSS IPA (Provasniket al. 2009). This fact identifies that the demand of science, especially Physics in the form of mastery of concepts and even the application concept cannot be reached optimally.

Lasmawan (Lasmawan,2004) identifies several educational problems as: (1) education emphasizes the development of cognitive aspect with the orientation of mastery of science as much as possible and ignores the development of affection and connectivity aspects. (2) It lacks of education to develop process skill, critical thinking skills ability, and creative. (3) Less education provides real experience through integrated curriculum and learning approaches. Sagala (Sagala,2009) also argues that learning taking place in schools tends to show (1) teachingis more than lecturing, (2) learning management tends to be classical and learning activities are less varied, and (3) teachers and books are as learning resources.

In addition, a review of the counselling revealed that only a fewstudies have explicitly attended to the problem-solving process (Heppner, 1978). In short, it has not developed a technology for helping clients

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with problem solving and decision making (Horan, 1979).

Most of schools do not encourage learners to expand their thinking by creating new ideas and rethinking existing conclusions.In the learning process, learners are also less stimulated to be able to expend their ideas in science, especially Physics. Jacqueline and Brooks show that many successful students complete their assignments, do good exams, and get good grades, but they do not learn to think critically and creatively. They both believe that school only produces students who only think very superficially. They just study the surface of a problem. They do not extend thinking and do deep thinking.

Sagala(Sagala,2009) said that most learners do not get the overall learning because they still get their education conventionally. Consequently, they are not trained to solve problems, so that their critical thinking cannot improve properly. It is also explained by Aryana (Aryana,2006) that one of the causes of low ability of thinking of learners is the use of lesson model or method of giving the opportunity to learners to empower their thinking ability and to actively involve them in the learning process.

According to John W Santrock (John W Santrock,2010, p. 359) that critical thinking is reflective and productive thinking. Itinvolves evaluation of evidence.Another opinion is put forward by Halpen. According to Halpen in Achmad (Halpen in Achmad,2007, p. 1), critical thinking is empowering skills or cognitive strategies in setting goals. So, in order to be able to increase critical thinking of learners, we can use the appropriate learning method.

Problem solving method is right example method to improve the critical thinking skills for learners. There are three main characteristics of problem solving (Suwito, 2010): 1) problem solving ina series of learning activities. Itmeans that in its .application problem solving, there are a number of activities to be done by the learners. Learners not only listen, record, and memorize the material but also actively think, seek, process data, and conclude the task, 2) learning activities directed to solve problems, 3) problem solving is done by using thinking approach scientifically.

However, problem solving not only develop the critical thinking ability of learners but also develop science skillsprocess of the learners. Skills process is a set of skills that scientists use in conducting investigations (Qomariyah et al. 2014). Skills process is a set of skills used in conducting an inquiry to find a concept/ principle/ theory. IPA process skills are divided into 2 groups: basic skills and integrated skills. Basic process skills consist of observing, classifying, measuring, communicating, interpreting data, predicting, using tools, experimenting, and concluding.

Integrated process skills include formulating problems, identifying variables, describing relationships among variables, controlling variables, defining operational variables, obtaining and presenting data, analyzing data, formulating hypotheses, designing research, and conducting investigations (Kemdikbud, 2013, p. 6). KPS (Toharudin, 2011, p. 35) states that, Scientific process skills are all scientific skills used to discover concepts or theories in order to develop existing concepts or deny previous findings. Process skills are required to acquire, develop, and apply the concepts of legal principles and theoretical science. One can perform the process as experienced and done by scientists as they attempt to solve the mysteries of nature through the skill of the process of science.

Hamalik (2005) also points out that the understanding of process skills in the field of natural science is the knowledge of concepts in principles that learners can gain when they have certain basic skills that are the scientific process skills required to use science. Scientific attitudes are aspects of behavior that cannot be taught through particular learning, but are behaviors captured through positive examples that must be continuously supported, nurtured, and developed so as to have students (Bundu, 2006).

Based on the background that has been described above, the authors want to examine “The Impact of Problems Solving Method to Improve the Critical Thinking and Science Process Skills in Physics”.

2 RESEARCH METHODS

This is an experimental research. Sugiyono (Sugiyono,2015, p. 107) states that the experiment researchmethod is to find the effect of certain treatment against controlled conditions. Joseph (Joseph, 2014, p. 77) states that the researcher can control the condition of the experimental group and the control group.

The object of this research is the influence of problem solving method (X) on the critical thinking ability (Y) and the science process skill of learners (Y). This research uses non-equivalent control group design.

This design uses 2 groups, namely experimental group and control group. Experimental group is the group that received treatment in the form of application of problems solving method while the control group is the group that is not treated class. In this design, the experimental group or control group is not selected randomly. Sugiyono (Sugiyono,2015, p. 116) states that non-equivalent control group design is described as follows

Table 1: Nonequivalent control group design.

Group	Pretest	Independent Variable	posttest
Experiment	O1	X	O2
Control	O1	-	O2

Annotation:
O1: pretest value
O2: the value of posttest
×: treatment given

2.1 Variable Observed

Each of the resulting products will be applied to one classroom and the results are compared with one control class. Field test using experimental method with one-way is ANOVA design. In this study the variables are:

1. Variable in this research is learning method using problem solving and conventional media.
2. Dependent variable is critical thinking and it is also tested separately.
3. ControlVariables in this study are educators, teaching materials, number of hours Lesson, and learning time.

2.2 Sampling, Data Collection and Data Collecting Instruments

2.2.1 Sampling

Sampling technique in this research is probability sampling technique. Thus, the strategy is that there is no classroom discrimination. The determination of experimental group classes is done randomly by drawing technique.

2.2.2 Data Collection Techniques

Data processing techniques are the means used to collect data. The techniques used in this study are as follows:

1) Acquire preliminary data of students' critical thinking skills by providing critical thinking skills tests before improving the first and second experimental classes. The same is done for process skills.
2) Apply different activities in the two groups of students in which one group used problem-solving methods and experimental groups both with conventional learning
3) test critical thinking skills of students by providing critical thinking skills tests in the first and second experimental classes. The same is done for process skills.

This is done naturally, because students are taught directly by their own educators to get the intended learning objectives.

2.2.3 Data Collection

1) Test critical thinking skills
   The technique of collecting data is done through the written test to measure student's critical thinking skill. The test is given at the beginning and at the end of the session to see students' critical thinking skills. The questionnaire indicator refers to the student's skill indicator.
2) Test the science process skills
   The technique of data collecting is done through the written test to measure skill of science process of student. The test is given at the beginning and end to see students' science process skills. The questionnaire indicator refers to the student's skill indicator.

2.3 Instrument Validity

Testing the validity of the content by expert judgment, with the aim to know whether the compiled instrument has measured accurately. Experts are asked to provide feedback on the instruments that have been prepared.

The validity test was done empirically (through trials) in groups of students who had parallel class with the experimental class. They are not the students who were as the subjects of the study.

Validation is to test every item that has been created. The scores on the item are correlated with the total score. The grain score is viewed as the X value and the total score is viewed as the Y value. To test the correlation between the grain row scores with the total score, the product moment correlation of Pearson is used.

The result of product moment correlation is then consulted with table (r_{xy}) at 5% significance level. The item is said to be valid if $r_{count} > r_{table}$, or the questionnaire is said to be valid if its significance is

less than 0.05. Grain validity test is done with the help of SPSS 20.0 for windows software.

2.4 Instrument Reliability

The reliability measurement uses a critical thinking test and a science process skill. Reliability is used to indicate the extent to which the measurement can give relatively no different results when re-measured against the same subject. The high reliability of the instrument is illustrated by the reliability coefficient in a number.

Testing instrument reliability is done internally consistency, then the data obtained is analyzed using a certain technique to test its consistency to various items in the group.

The procedure used to measure the reliability level of a scale test can be done by a retest or alpha coefficient (Alpha Cronbach). Unqualified tests in terms of reliability will be discarded or revised. This reliability measurement is reliable if the r value obtained is greater than 0.5. Instrument reliability test is done with the help of SPSS 20.0 for windows software. As a benchmark high low reliability coefficient used interpretation scores as follows: Category Reliability Test(Arikunto, 2010).

Table 2: Interpretation of reliabilities degree test.

Range	category
$0{,}800 < r_{11} \leq 1{,}00$	Very high
$0{,}600 < r_{11} \leq 0{,}800$	High
$0{,}400 < r_{11} \leq 0{,}600$	Enough
$0{,}200 < r_{11} \leq 0{,}400$	Low
$0{,}00 < r_{11} \leq 0{,}200$	Very low

2.5 Data Analysis Technique

Description of data is done through descriptive analysis. The data described is the data obtained from measurement on research variables that is critical thinking ability and science process skill. The data that has been obtained is calculated using the help of SPSS program.

2.5.1 Inferential Analysis

Test Assumption Analysis

a) Multivariate Normality Test
The normality data test aims to test whether data from each research variable is normally distributed or not. Normality testing was performed using Kolmogorov-Smirnov technique with the help of SPSS version 20.0 for Windows.
If the significance is below 0.05 means the data to be tested has a significant difference with the normal raw data, it means that the data is not normal. If the significance is above 0.05 then there is no significant difference between the data to be tested with normal raw data, so the data can be said to be normally distributed.

b) Homogeneity Test of Variance
The homogeneity test was conducted to find out whether the data in the two experimental groups had homogeneous variants or not.
1. Test the Equation of Variance
Homogeneity test of variant is done for dependent variable that is mastering the concept and ability of digital literacy. By using Levene's test with SPSS version 20.0 for Windows.
If the significance is below 0.05, it means that the population variant is not identical or different. If significance above 0.05, then Ho is accepted the mean identical population variance.
2. Test of Variant-Covariance Matrix Equations
To know the homogeneity of two-group variant-covariant matrix with each dependent variable and independent variable, the homogeneity test of Box-M was done. In order to know the homogeneity of two groups variance, Levene's homogeneity test was done by using SPSS 20.0 for windows.
The decision criterion for homogeneity test is if the significance value <0,05 then the data come from population with nonhomogeneous variant, if significance> 0,05 then the data come from population having homogeneous variant.

c) Correlational Test
Correlation test is used to know the relationship between each independent variable with dependent variable and to know the relation between each of independent variable. If the requirement to perform the test,*Manova* has to be fulfilled

d) Regression Slope ((Homogeneity of Regression Slopes)
Regression test is used to test the similarity of slope between treatments, It uses SPSS 20.0 for windows. The decision criterion for the regression test is if the significance value <0.05 then Ho is rejected; if the significance is > 0.05 or in other words there is a similarity of slope to the treatment.

3 RESULT AND DISCUSSION

Table 3: Data description of pretest critical thinking Skills.

Data	Score
Deviation Standart	12.07341
Variance	145.7672
Average	55.71429
Minimum Scores	30
Maximum Scores	75

The data above can be seen that the standard deviation value is 12.07341, the value of variance still shows 145.7672, the average value of pre-test is 55.71429, the minimum value of the learners is also very low with a value of 30, and the maximum value of learners only reach the basic score only. For that, it is still very necessary to be given appropriate learning methods to be able to improve the value and critical thinking skills of learners.

a) Description posttest of critical thinking skills

Table 4: Data of posttest critical thinking skills.

Data	Score
Deviation Standart	9.251055
Varians	85.58201
Average	71.78571
Minimum Score	50
Maximum Score	90

From the data given in the table above, it shows that there is a significant increase in the post test (test done after given the method of learning with problem solving) compared with the tests conducted before the problems solving learning method was given.

It can be seen that the average score of the learners who originally only 55.71429 to 71.78571, when viewed from the minimum score of learners at the time of pre-test is 30 after post-test to 50, although the minimum score of the students after the post test is still low because not yet reached the value of basic score but already 50% improvement, and if we see the maximum value of learners at pre-test only 75 rose to 90.

This shows that the method used is very suitable to improve the critical thinking skills of learners.

b) Description pretest of science process skills

Table 5: Data of pretest science process skills.

Data	Score
Deviation Standart	8.749177616
Varians	76.54810896
Average	47
Minimum Score	33
Maximum Score	67

The data above shows that the science process skills of learners is still very low. This can be seen from the average score of learners at the time of pre-test performed. The average score of learners did not reach the KKM or basic score that was very low at 47, the minimum score of the learner was still very low at 33, and the maximum score of the learner only reached 67 under the basic or KKM score.

From the data, it can be concluded that we must find the right solution to be able to improve the skill of science process of learners, that is by designing the model or method suitable and appropriate for the learners so that skill of science process learners increase.

c) Description post-test of science process skills

Table 6: Data post-test of science process skills.

Data	Score
Deviation Standart	10.28084
Varians	105.6957
Average	78
Minimum score	61
Maximum score	94

From the post test data in the table above that there is an excellent or significant improvement in the time before the learning with problem solving and learning stages with problem solving.

Attended by the average learner whose previous score is only 47 now becomes 78. The minimum value at the time of pre-test is only 33 to 61 and the maximum score of learners previously only 67 to 94.

This indicates that the methods provided are well suited to improve the performance of the student.

1) Data pre-test and post-test process skills Students.

Skills of the students' scientific process are assessed from the test answers. Skill of science process which form of essay matter as many as 6 problem. The instruments used have been validated and tested before they are used to retrieve data. Science process skill tests are performed.

The action is done before and after following the learning by applying problem solving learning method on material and followed by X-1 class

(experiment class) consisting of 44 students and X-3 class (control class) which amounted to 43 students.

Scientific process skills used are basic science process skills consisting of six skills: observation, classification, communicating, measuring, forecasting (predicting) and inferences. The pre-test and post-test values of the students' learning process skills are presented in the following pie chart.

From the results shown on the diagram shows that there is an increase in the ability of the learners about 12%. This can be seen on the pie chart, is at the time of pre-test or test performed before the treatment is done with the problems solving method, the average of the average participants only reached 44%, but after the settlement of the problem occurs about 12% in the value of learners in the post test, is 56%.

Pretest loop diagrams and posttest science process skills.

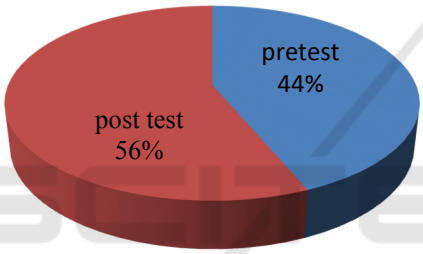

Figure 1: Percentage pre-test and post-test of critical thinking skills.

2) Data pre-test and post-test process skills Students.

Pre-test loop diagrams and post-test critical thinking skills

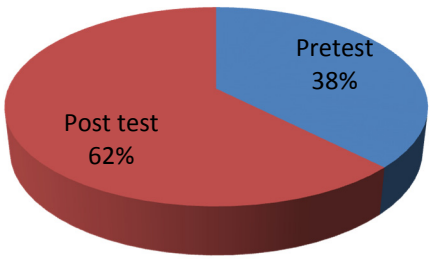

Figure 2: Percentage pre-test and post-test of critical thinking skills.

The pie chart shows that there is a good improvement of test results before being treated with problem solving method(pre-test) with tests performed after the treatment of problems solving method (post-test).

There is an increase of about 24% in the diagram above, it can be seen that the percentage depicted in the circle diagram at the time of pre-test only reached 38%, but after being treated with problem solving method (post-test) then increased to 62%. The conclusion that we can draw from the diagram above is that the method of problem solving is very good in use to improve the critical thinking ability of learners and improve the ability of science process learners.

3.1 Homogeneity Test

Homogeneity Levene's Test (Test of Homogeneity of Variances) is a test used to determine the homogeneity of experimental class science process skills and control classes in this study, with the criteria of testing if the value significance> 0.05 then the homogeneous data whereas if significance <0.05 then the data is not homogeneous.

The result of homogeneity test of science process skill data and critical thinking of experiment class and control class show that sig difference by using Microsoft Excel it can be concluded that Ho is acceptable or there is a significant difference between the learning result used using problem solving method with conventional method, because P = 1.0725>α = 0,05.

3.2 Normality Test

Test of normality of science process skill data is used to know the distribution of data of critical thinking ability of experimental class and control class. The Kolmogorov-Smirnov is One-Sample normality test with test criteria if significance> 0.05 then the data is normally distributed, whereas if the significance <0.05 then the data is not normally distributed.

Test data of normality of critical thinking and ability of science process using SPSS.

From the Figure 3, it can be concluded that post-test data critical thinking and process style between control class and experiment class is normal data, because the distribution of data shown the data in the form of bells. Similarly, the data is normal data.

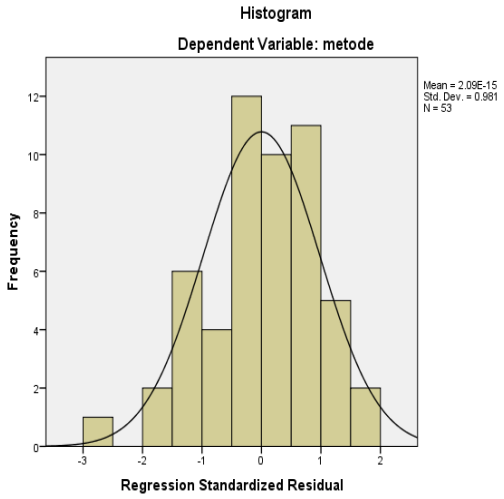

Figure 3: Normality test of critical thinking and science process skills.

4 CONCLUSIONS

Based on the results of the data analysis and discussion obtained, then the following conclusions can be taken that Improving the science process skills of experimental class learners is very significant, seen from the average score of learners who previously only 47 to 78.

Improvement of critical thinking ability of experimental class learners also significant, seen from the average value of learners from pre-test and post test results that only 55.71429 to 71.78571.

There is a significant difference in the science process skills of learners who are taught by problem solving method compared to students taught by conventional method, with P = 1.0725>alfa = 0,05 so, Ho is acceptable.

For the best future, teachers are expected to use learning methods that involve activeness and can develop students' thinking skills in the learning process, one of which is problem solving.

For teachers and others who will apply problem solving method in learning activities, should arrange the time precisely because this method takes a longer time.

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