The application of scientific approach to improve scientific literacy on domain competency at secondary school on dynamic electricity topic

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Abstract Scientific literacy is the ability to make decisions which are used to solve many problems in society based on knowledge and understanding concepts and processes of science. This study is advance research that adopted previous learning designs which are using scientific approach to improve scientific literacy in domain competency. The method of research is using pre-experimental design with one group pre-test-post-test design. The sample is taken by using non-probability sampling with the type of purposive sampling. Essay test that has validity 0.4-0.7 and reliability 0.75 is used to determine the improving of scientific literacy competence on the Dynamic Electricity topic. Scientific literacy is measured on three competencies: explain phenomena scientifically, evaluate and design scientific enquiry, also interpret data and scientific evidence. The result of this research shows that each competencies has improve with n-gain: 0.8; 0.68; and 0.61.

1. Introduction
Science and technology has given a significant contribution to personal life and society. Physics is the science that is closely associated with the influence of variables or between physical quantities [1]. Many of the curricula for school science are based on a view that the primary goal of science education should be the preparation of the next generation of scientists [2]. Conceptual understanding is one of the most important aspects in the study of Physics because of it useful to understand principles behind certain phenomenon which happened [3]. To achieve conceptual understanding one of all the ways is scientific approach [4]. Nowadays, scientific literacy is a purpose of the science teaching [5]. It implied that science has been a key to face several problems and global challenging. Individual which has a scientific literacy competencies will has a good self-adaptation in knowledge and technology both in life and society. Scientific literacy can help individual to aware their potency in understanding and using science to face many problems and can make a best decisions to solve the problem. On the other hand, Oxford University said in term of preparation a leader, they must learn how to use evidence to decide something and political policy [6].

School as an educational institution should facilitate the students to obtain scientific literacy competencies, but the facts show that science learning process in school still implemented using verification method which mean students did not learn about how to determine variables in the experiments, how to interpret data using graph or table [7]. It can be proved that the result of that research showed the student’s scientific literacy competencies has a lowest level. Furthermore, the result of PISA...
The previous research produced not only profile of student’s scientific literacy but also learning design at many topics using scientific approach (Temperature, Pressure, Heat, Energy, Dynamic Electricity) [7]. The didactic design is the learning plans that include the ways to teach certain concepts through the students’ responses on a draft action learning provided [10]. Furthermore, another research showed that students in inquiry labs demonstrated a significant improvement of science literacy skills and process skills [11]. According to many research which have been done by many researchers above, this study is advance research that adopted previous learning designs which are using scientific approach. Electricity topic has been chosen cause that is a general topic which can be found easily in daily life, perhaps many problems can be solved by using scientific literacy. Researchers placed this research position as a second research. Many suggestions from researchers above are used as reference in order to train scientific literacy optimally.

2. Method
The purpose of this research is improving scientific literacy competencies using scientific approach in learning design. This learning design is adopted from previous research which has been done by Utari’s. Researcher make some arrangement in previous learning design with National Curricula appropriate.

Design of experiment method which is used is pre-experimental design. One group pre-test - post-test design is used because this research will compare the result before and after research object which is given the treatment [12]. Before students are given the treatment, they are given pre-test. Therefore, the treatment (learning process is using scientific approach) is given for three times. When the treatment finished, students are given post-test. The result of that tests is used as a reference to know the increasing of scientific literacy in three competencies. That competencies are: explaining phenomena scientifically (K-1); evaluating and designing scientific enquiry (K-2); and interpreting data and scientific evidence (K-3).

According to framework PISA 2015 that the study of scientific literacy is proposed to students in 15 years old. Electricity which is the topic of research is studied in secondary school in the last year. Cause of that, researcher choose 120 students in secondary school at one of the school in Kabupaten Bandung as population. Based on specific purpose of the research that want to know how immediate responses of the given treatment, sampling technique which is used is purposive sampling. For experiment and causal study, the samples which are recommended are minimum 30 individuals per group [13]. On this research, samples are 37 students. It means the result of research can be generalized for the population.

To measure the increasing of scientific literacy, test is used as an instrument in this research. Essay test is an appropriate tool to measure the ability of student in organizing, integrating, analyzing data [13]. Essay test was made by the PISA reference. That questions are not measured in each indicator on three competencies of scientific literacy. Indicator which has been measured in K-1 is recalling and applying appropriate scientific knowledge, in K-2 is proposing the way of exploring given question scientifically and indicators in K-3 are: analyzing and interpreting data and drawing appropriate conclusion; evaluating scientific arguments and evidence from difference sources.

The good of instrument will determine the quality of data [14]. To obtain the valid and reliable data, that instruments must be valid and reliable. Valid means that the instrument can measure what will be
measured. Reliable means that instrument for many times will produce similar data. The validity of instrument on this research is using content validity and construct validity. The essay test has validity 0,4 until 0,7. Reliability is measured by using internal consistency and then will be analyzed by using Alfa Cronbach technique. The reliability of test obtains around 0,75. The improving of scientific literacy is showed using n-gain which has developed by Hake [15]. Percentage of pre-test and post-test is represented by Arikunto [16]. To find the responses of scientific approach implementation, researcher use the LKS (worksheet) and activity sheet of teacher and students.

3. Result and discussion
This research is proposed to improve a scientific literacy on three competencies. Table 1 interpret the increasing of scientific literacy in three competencies (K1,K2,K3) on indicator that are measured.

| Table 1. Increasing of scientific literacy. |
|--------------------------------------------|
| Category     | % Pre-test | % Post-test | n-Gain |
|-------------|------------|-------------|--------|
| K1-1        | 25.14      | 84.86       | 0.80   |
| K2-1        | 26.26      | 76.40       | 0.68   |
| K3-2        | 23.47      | 72.97       | 0.65   |
| K3-5        | 7.7        | 60.68       | 0.57   |

Notes :
K1-1: Recalling and applying appropriate scientific knowledge.
K2-1: Proposing the way of exploring given question scientifically.
K3-2: Analyzing and interpreting data and drawing appropriate conclusion.
K3-5: Evaluating scientific arguments and evidence from difference resources.

The data shows the percentage of pre-test and post-test then the improving of these competencies is calculated using gain score. Overall, the competency in explaining phenomena scientifically has a highest increases than other competencies.

In the term of explaining phenomena scientifically, students has been given the essay test which measure that indicator (K1-1) on three questions. That questions are about counting the price of home electrical use, the meaning of lamp specification that they usually see and how solar cell working on lighting bulb. On pre-test, the tendency of student’s answer was most of students did not answer correctly especially in counting the price of home electrical use, they could not use mathematics as a tool to solve the problem. Furthermore, there were two students could answer the meaning of lamp specification correctly. In addition, there were no students knew about how the solar cell work in lighting the bulb. There is a significant increases in K1-1 after the treatment has been given. On post-test most of students can use mathematics as a tool to solve the problem on that questions and answer correctly on the question of meaning lamp specification.

The essay test which measure K2-1 consist of three questions. The question are about how the students choose the way in exploring the question that given. Students must solve the problem in question using the scientific procedure. The tendency of students answer can be analyzed that almost all of students did not know how to determine the variables in experiment that they could do, so proposing the procedure of experiment were not complete. After treatment has been given, the significant increases obtained too although is smaller significant increases than K1-1. The student’s post-test answer showed that they can propose the way of exploring question that given although the answer still not perfect score.

In the term of K3, there is two question for K3-2 and K3-5. The questions to measure K3-2 is analyzing characteristic of electrical circuits. The tendency of the answer on pre-test is most of students only able to describe the difference of electrical circuit based on what they see on the picture without analyzing about current and voltage characteristic. On measured K3-5, questions that were given is about how students give the arguments to the statements. The result of pre-test showed that most of students did not answer that question. On post-test result, almost all of students can give their arguments to
answer that question although still not complete and systematic. Overall, K3 have the smallest increases of scientific literacy competence.

Researcher not only look the tendency of answering questions in pre-test and post-test but also analyze the teacher and student activities as a part from learning design implementation. The Table 2 show the learning activity which are train the scientific literacy related to teacher and student’s activity.

![Table 2. Implementation of learning design.](image)

On the learning process, competency K1-1 has been trained in introduction and observation activity. At introduction activity which are in appreciation and motivation activity, researcher gave the general phenomena about dynamic electricity in daily life such as the function of switch, the specification of lamp which usually they see, electrical circuits, and ‘power bank’ that is something used to charge batteries as an utilization of solar cell. Showing the phenomena with demonstration, videos or photos can give the students a chance to understand phenomena easily.

To get the strength competencies, researcher also trained student about: how to determine hypothesis such as making hypothesis to know relating of current and voltage; how to make a prediction to save energy; how to make the representation model to differ electrical circuits. Because of many activities can stimulate students to improve the competency of explaining phenomena scientifically, this competency obtains the highest score of n-gain. The ways on training this competencies considerably good to improve the competence of explaining phenomena scientifically. The phenomena which was showed on ways that trained to students can facilitate them to improve explaining phenomena scientifically well.

The percentage of learning design implementation in introduction is 100%. It means all of the step on this learning design has been done well in term of training scientific literacy competencies. On the test which has been given, 27 from 37 students can answer correctly the question which is measured recalling and applying appropriate scientific knowledge. This question is about how to measure the finance in using electricity home energy. This explanation show us that the success implementation can increase the result of test, so gain is also increase in high category.

In the term of evaluating and designing scientific enquiry competency, students need not only the knowledge of content but also knowledge of procedural. It means this competence needs more knowledge higher than the first competence. The percentage of pre-test that showed in Table 3 represents that students have a poor competence to evaluate and design scientific enquiry, in fact there are no students can determine variables of experiment exactly [17].

To obtain the high increases, this competence trained in asking question activity. Even though the percentage of teacher and student activity show 100 %, but the evaluation of this activity on LKS (worksheet) do not show the similar result. On the LKS, students still has a difficulties to asked scientific questions. The answer sheet show that students asked not about how to solve the problems. It represented that students do not know what they should do.

Therefore, in this activity researcher not only guide students to get some variables in their experiment but also in creating electrical circuit using sketch in whiteboard, software simulation, and also demonstrating. So in this activity students can improve how to make their experiment well. Indicator which has been measured is proposing the way of exploring given question scientifically. The essay test which is given on this indicator is about how students design an experiment. The tendency of answer
that question show that around 50% students can answer correctly. Even though that percentage is not high but it improve better than pre-test result. The high percentage at post-test can be a proof that after the treatment has given in evaluate and design scientific enquiry students have this competence with gain 0.68 in sufficient category. Although at other research can get a higher increases using the similar way, it can be differ in different topic.

In the term of last competencies that is interpreting data and scientific evidence. For overall data, this competence has a lowest increases compare to another competencies. Competency to interpret data and scientific evidence need a highest knowledge another than competencies. Those who possess this competency should be able to interpret the meaning of scientific evidence and its implications to a specified audience in their own words, using diagrams or other representations as appropriate. This competency requires the use of mathematical tools to analyze or summarise data, and the ability to use standard methods to transform data to different representations [18].

To improve their ability in this competence, researcher guide students to represent data using graph, chart, and table. On the LKS (worksheet), tendency of the answer sheet on the question of this competency is around 90% students can represent data from table to graphic. This implied to their percentage of post-test that students show the increasing of this competence at 72.97% which are good category.

To stimulate students in evaluating arguments and scientific evidence, researcher train this competency in communicating activity. Students make some presentation to explain their experiment then make some discussion with other a researcher is a guide for that. Table 4 showed that teacher’s activities has a lowest percentage in training K3, that implied students activity has a lowest percentage too. On this activity, students are rarely asking the question. It implied in discussion session, there is a little bit of discussion in the classrooms. To make some discussion researcher asks some question to students, so that way can help students analyze the data that they get, interpret data and make a conclusion.

4. Conclusion

According to this research that has been done, the increasing of scientific literacy in explaining phenomena scientifically obtains gain 0.8 which means high category. The competency of evaluating and designing scientific enquiry increases with gain 0.68 in medium category. The increasing of interpreting data and scientific evidence in two indicator which are : analyzing and interpret data and drawing appropriate conclusions gets gain 0.65 with medium category; evaluating scientific arguments and evidence from different sources also get 0.57 with medium category. Overall, that data shows that using scientific approach can improve scientific literacy in three competencies.

There are many suggestion to train scientific literacy on the less competence. Future researchers must be focused on the third competence especially in evaluating arguments and scientific evidence. Researchers must give students the chance to explore many resources, so they can compare many data to evaluating their experiment.

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