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Scientific Approach to Enhance Scientific Literacy of Junior High School Students: Domain of Competence

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ABSTRACT

Scientific literacy (LS) is the ability to engage with science-related issues, and with the ideas of science, as a reflective citizen. Thus, some developed countries provide policies, making that LS capabilities are provided to school curricula. However, some research reveals that this alleged ability has not been optimally provided in science learning, thus, students' LS abilities are still low. Pre-experimental research with a one-group pre-test-post-test design aims to get an overview of increasing LS capabilities in the competency domain through the application of a scientific approach. The study was conducted in one of the public schools in the city of Bandung using 30 samples taken randomly. The effectiveness of the increase was measured using the normalized gain value <g> on 20 essay questions with validity test results of 0.77, and reliability of 0.87. The results showed an increase in the K1 aspect (explaining scientific phenomena) <g>= 0.75 (high category), an increase in the K2 aspect (evaluating and designing scientific research) <g>= 0.46 (medium category), while an increase in the K3 aspect (interpreting data and evidence) <g>= 0.15 (low category). This shows the need for a mentorship process to build epistemic knowledge in analyzing and inferring experimental data in a scientific approach.

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1. INTRODUCTION

Scientific literacy (LS) is the ability to engage with science-related issues, and with the ideas of science, as a reflective citizen. This ability is important for a person to have to determine innovative solutions related to solving problems in life (Gormally *et al*., 2012). Innovative solutions are obtained from scientific thinking that requires LS competencies. Scientific literacy (LS) is a key competence and LS is described as the ability to use knowledge and information interactively, an understanding of how science changes a person's way of adapting, changing mindsets to be able to make decisions based on scientific considerations and using this to solve problems and achieve broader goals (Vieira & Tenreiro-Vieira, 2016; Holliday *et al*., 1994). Thus, a person who has good Scientific Literacy will be able to read, understand and be responsible for the problems in his life (Keefe, 2011). As a basis competency that must be possessed by the people, scientific literacy becoming an important competency to be trained and learned in education, so that, currently, this competence being a goal in science learning (Wenning, 2006). Furthermore, in some developed and developing countries, scientific literacy becomes the direction of education curriculum (Hobson, 2008).

The LS in the framework of PISA (Programme for International Student Assessment) 2015 consists of four domains, namely, the context domain, the competency domain, the knowledge domain, and the attitude domain. Based on a survey conducted by the OECD (Organization for Economic Co-Operation and Development) through the PISA scientific literation assessment, from 2000 to 2012 Indonesia always occupied the bottom position with a score below the international average score in all three aspects (reading, science, and mathematics) (Yildiz, 2020). The low scientific literacy of students is also shown from the profile of scientific literation ability in the knowledge domain and the competency domain of 628 students from 5 different schools is still low (Li & Guo, 2021). Indonesian student is consistent at the bottom of the board in the last four periods of scientific literacy assessment from PISA. The analysis results indicate that Indonesian student have a weak understanding of concepts, reasoning abilities and weak knowledge of contexts to science concepts.

Research to enhance scientific literacy competence has been carried out, through the implementation of level of inquiry/LoI (Arief, 2015), scientific approach, and inquiry with reading infusion/RI (Fang 2010; Maulidia, 2019), and the findings demonstrate that these instructional strategies could enhance students' scientific literacy levels but were still fluctuating. However, research reveals that inquiry learning is basically able to train SL, but not optimal yet. Learning with inquiry is learning by inviting students to conduct scientific process as scientists study nature, allowing pupils to use all their skills to confidently find the concept itself (Nugraha, 2016). The profile of the results of Utari's research (2015) in Bandung states that learning does not present real phenomena and experimental activities using experimental guides are cookbooks. Experimental activities in science learning with experimental guidance in the form of cookbooks cannot directly facilitate to train Scientific Literacy (LS). LS in students it is necessary to increase student interest and develop the ability to ask questions through learning with experiments of an inquiry nature. Therefore, learning activities are needed that can train LS to improve LS.

In learning activities with a scientific approach, some steps can train LS competencies. So, the learning used to train LS uses a scientific approach.

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2. METHOD

This study aims to see an overview of the effectiveness of using a scientific approach to improve students' LS abilities in the competency domain on pressure topics in junior high schools. Therefore, the research method used is pre-experimental with a one-group pre-test-post-test design research design. The population of this study was class VIII at one of the junior high schools in Bandung with a sample of 30 students taken using random sampling techniques.

The percentage of correct scores on each aspect of the competency domain is calculated using the following equation (1).

$$Average\ percentage = \frac{\Sigma score\ of\ all\ students}{maximum\ score} \quad (1)$$

The results of the percentage are then interpreted as shown in **Table 1**.

The effectiveness of the increase in the average percentage of the LS score is measured using the normalized gain value <g> expressed by Hake using the following equation (2).

$$< g > = \frac{\%posttest\ score - \%pretes\ score}{Max\ score - \%pretest\ score} \quad (2)$$

to express the effectiveness of the improvement using the categories in **Table 2**.

Table 1. Percentage interpretation.

Percentage (%)	Interpretation
80-100	Very well
66-79	good
56-65	Enough
40-55	Less
0-39	less once

Table 2. Learning improvement categories.

Normalized Gain Score	Category
0.00 < <g> ≤ 0.30	Low
0.30 < <g> ≤ 0.70	Middle
0.70 < <g> ≤ 1,00	High

The instruments used to see the effectiveness of improvement are 20 essay question tests (developed based on the PISA 2015 framework on the competency domain) that have been tested for content validity through expert judgment using triangulation techniques. Furthermore, testing was carried out in the field using the Pearson product-moment correlation equation with a score range of 0.77 in a high category, and reliability was tested using the alpha formula with a score of 0.87 in the very high category. To see the implementation of learning using a scientific approach, it is used in the observation format and the results of the student's work in the form of LKS.

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3. RESULTS AND DISCUSSION

The results of the LS test carried out before the learning activity (pre-test) and after the learning activity (post-test) are shown in **Table 3**. Overall, the results of pre-test and post-test LS research samples in the competency domain have increased.

Table 3. Percentage of LS capabilities on the competency domain.

Value	Acquisition
Pre-test	44 %
Pos-test	73 %
<g>	0.52 (Middle)

According to the category of the effectiveness of the increase put forward by Hake (1998) (**Table 2**) this increase belongs to the moderate category. This shows that learning activities with a scientific approach to the topic of pressure have not been able to facilitate all aspects of the LS competency domain. The competency domain consists of three aspects, namely, explaining scientific phenomena (K1), evaluating and designing scientific research (K2), and interpreting scientific data and evidence (K3). Some of these aspects have not been improved. For us to know more about which aspects have increased, the measurement of the effectiveness of the improvement can be done for each aspect of the competency domain. The results of measuring improvements in each aspect of the competency domain are shown in **Table 4**.

Table 4 shows that the explaining aspect of scientific phenomena (K1) has increased in the high category (**Table 2**). This means that learning with a scientific approach has provided ways that are seen as effective to improve this competence. Meanwhile, the increase in the aspect of interpreting and scientific evidence (K3) is in a low category, which means that the learning methods used have not been effective in improving the competence of the largest. This can be explained by the acquisition of pre-test and post-test values as shown in **Figure 1**.

Table 4. LS improvements in every aspect of the competency domain.

Competency Domain	<g>
Explaining scientific phenomena (K1)	0.75
Evaluating and designing scientific research (K2)	0.46
Interpreting data and scientific evidence (K3)	0.15

Aspect K1 is competence to explain scientific phenomena. In **Figure 1**, the average percentage of pre-test scores in the K1 aspect is 58% which shows that students are quite able to explain and predict a phenomenon presented. After students are trained with a scientific approach, the average percentage of post-test scores becomes 89%, which means that students are very good at mastering this aspect. The improvement of the K1 aspect obtained a score of 0.75 which belongs to the high category. The increase in the K1 aspect is the highest improvement compared to the other two aspects. This shows that learning activities with the application of a scientific approach are seen as effective in training LS on the K1 aspect.

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The picture is reinforced by the characteristics of the scientific approach to the observing step. In this step, students are asked to explain the phenomenon using other representations such as images and make a prediction. For example, on the topic of hydrostatic pressure, students are asked to explain the range of liquid radiance from holes in the glass of different heights and holes in the glass containing different liquid substances. In addition, students are asked to predict what variables affect hydrostatic pressure. Students' answers to LKS in explaining phenomena and giving predictions, as expected. It turns out that this method provides an effective measure to improve the domain of competence in the aspect of explaining scientific phenomena.

The K2 aspect is the competence to evaluate and design research. In **Figure 1**, the average percentage of pre-test values in the K2 aspect is 27%, which shows that there is still a lack of familiarity with variables, controlling variables, designing procedures, and evaluating results. After students are trained with a scientific approach, the average percentage of post-test scores becomes 60%, which means that most students can master this aspect. The improvement in the K2 aspect obtained a score of 0.46 which belongs to the moderate category. This shows that learning activities with the application of a scientific approach are quite effective in training LS on the K2 aspect.

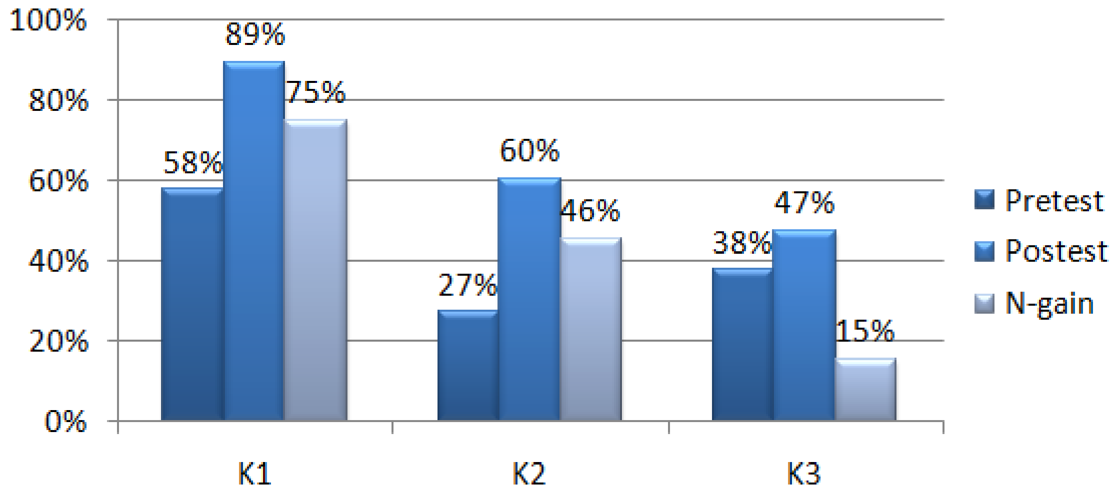

Figure 1. LS percentage on every aspect of the competency domain.

The picture is reinforced by the characteristics of the scientific approach to the step of planning an investigation. This step can facilitate students with teachers to plan experiments based on inquiry questions. The teacher demonstrates real phenomena related to the tendency of relationships between variables, introduces free and bound variables, and together with students designs experiments. For example, by demonstrating using a hart tool, students draw up experimental steps to understand the influence of the depth and type of liquid substance on hydrostatic pressure. Some students answered LKS correctly regarding the determination of the steps of the experimental activities to be carried out. It turns out that this method provides a fairly effective step to improve the domain aspect of evaluating and designing scientific research.

The K3 aspect is the competence to interpret data and scientific evidence. In **Figure 1**, the average percentage of pre-test scores in the K1 aspect is 38% which shows that students are still unable to take information and conclusions from the data obtained. After being trained with a scientific approach, the average percentage of post-test scores becomes 47%, which

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means that most students are still unable to master this aspect. This is because the K3 aspect requires more difficult competencies compared to the K1 and K2 aspects. The improvement in the K3 aspect obtained a score of 0.15 which belongs to the low category. The increase in the K3 aspect is the lowest improvement compared to the other two aspects. This shows that learning activities with the application of a scientific approach still do not train LS in the K3 aspect.

In learning activities, aspects of K3 are trained at the stage of associating and communicating. At the associating stage, in groups students analyze the data obtained from the experiment and discuss the conclusions. For example, in the hydrostatic pressure experiment, students made a graph of the liquid height data on the U hose against the type of liquid substance and the depth of the funnel. Then at the stage of communicating the group representative presents the results of his experiment and evaluates the experiment that has been carried out. However, in this activity students still have difficulty making graphs from the data obtained and making their conclusions. In addition, in the activity of communicating, students are less focused on paying attention to other groups that are being discussed and less critical in responding to arguments submitted by their friends. Students' answers to LKS regarding data analysis and conclusions regarding the stages of the activity show that only some of them master this aspect. Therefore, overcoming it can be done by giving examples by the teacher to interpret the data at the associating stage. For example, in changing data in the form of a table into a Table form. In addition, students are guided by the teacher in analyzing the data through questions that lead to conclusions.

In general, based on table 4, the most significant increase occurred in the K1 domain, then K2 and followed by K3. This is in accordance with the difficulty level of each of these competencies, starting with explaining based on their observations' results, then designing and evaluating research, to producing interpreted data and scientific evidence. Based on research results, the scientific approach can improve the scientific literacy of junior high school students, which is an essential competency to be nurtured from an early age to create a scientifically literate community (Al Sultan, 2018) as a necessity in a world that is changing rapidly in order to work successfully and responsibly within a society (Cavas, 2013).

4. CONCLUSION

Based on the research findings that have been presented, it can be concluded that after the application of learning using a scientific approach on the topic of pressure, LS students in the competency domain, experienced an increase in the moderate category. With an increase in the K1 aspect (explaining scientific phenomena) in the high category, an increase in the K2 aspect (evaluating and designing scientific research) in the medium category, and an improvement in the K3 aspect (interpreting data and evidence) in the low category. Thus, learning design using a scientific approach still needs to be optimized, especially in steps related to the competence of designing scientific research (K2) and interpreting scientific evidence (K3).

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6. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. The authors confirmed that the paper was free of plagiarism.

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