Enhancing science literacy capabilities of prospective primary school teachers through the STEM Project Learning Model

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Abstract. The STEM Project is a learning model that can be used by lecturers in the learning process so that students can get used to analyzing and synthesizing, to come up with an idea that can develop the competence and science literacy abilities of elementary school teacher candidates in the framework of learning in the 21st century. The study aims to improve the ability of the science literacy of Pre-service elementary school teachers by using the STEM Project Learning Model. This study was conducted on Pre-service elementary school teachers as elementary school teacher education students at the University of Halu Oleo Kendari. The results obtained indicate that the science literacy ability of Pre-service elementary school teachers has increased significantly. The increase is based on the results of statistical analysis which shows a significant increase in the ability of the science literacy of Pre-service elementary school teachers, after participating in learning using the STEM Project model. For this reason, the use of the STEM Project model in learning science enables prospective teachers to become accustomed to conducting comprehensive analyzes of problems and their solutions.

1. Introduction
The development of science and technology is a sign of the progress of civilization in the current era of globalization, which causes the need for the development of science literacy in education is very urgent. This is because science literacy is very necessary for the context of reforming science education [1]. Science literacy has an impact not only on learning but also on the ability of college students to apply knowledge related to the problems of everyday life [2]. Because the emphasis of science learning is currently directed at the importance of the ability of science literacy to college students in preparation for entering into society after completing studies, and science literacy are believed to help each college student as an individual to solve problems faced scientifically so that every action can be accounted for [3].

The ability of science literacy is needed by every college students, especially for pre-service elementary school teachers’ students, because they are resources that are highly expected to become professional teachers who have reliable science literacy skills and the frontline in improving and increasing the inability of students in Indonesia in terms of science literacy [4]. As the results of four assessments namely Human Development Index (HDI), TIMSS, PIRLS, and PISA show the low quality of education in Indonesia [5,6].

The low rank of PISA and TIMSS scores indicates the low mathematics literacy, literacy reading and science literacy of Indonesian students [4]. The low ability of science literacy for students is caused by various factors, one of which is the way teachers carry out learning in the class [7], which has never
trained students to analyze a problem, also because of the learning model used by teachers has not been student-centered. For this reason, teachers need to use a learning model that can train students’ science literacy skills [8]. One learning model that can be used to practice science literacy skills is the STEM Project learning model [9].

The STEM Project learning model provides new hope for education, especially in the learning process. Various research results have proven that the application of the STEM Project learning model in learning can encourage students to design, develop and utilize technology, sharpen cognitive, manipulative and affective, and apply knowledge [10]. And then the STEM Project learning model can train students in increasing knowledge, applying knowledge to solve problems and encouraging students to produce something new [11].

The results of research conducted by Chittum et al, [12] found that students who took part in learning using the STEM Project learning model were more motivated in learning thereby increasing their learning outcomes. Students can think more broadly [13]. And also can increase the ability of students to think critically [14].

In line with the thinking outlined above, efforts to improve the science literacy skills of pre-service elementary school teachers’ as the spearhead in producing professional teachers, are the right choice to improve the quality of teachers towards improving the quality of education in Indonesia. Therefore, application of the STEM Project learning model on the learning of pre-service elementary school teachers’ students is a new step in improving various applications of existing learning models, which are believed to improve the way to prepare prospective teachers so that later they can become professional teachers and have reliable science literacy abilities. Thus the purpose of this research is to improve the ability of the science literacy of pre-service elementary school teachers by using the STEM Project learning model.

2. Methods
This method of this study was used a quasi-experimental design in the form of a non-equivalent pre-post control group design. This design is used to compare the improvement of science literacy skills of pre-service elementary school teachers’ students after learning by using the STEM Project learning model which is conducted between the experimental class and the control class. The sample in this study were 61 pre-service elementary school teachers’ students at the University of Halu Oleo, Kendari City, which were divided into two groups: 30 for the experimental group and 31 for the control class.

Learning in the experimental class is carried out by applying the STEM Project learning model which is guided by the five learning steps proposed by Laboy-Rush [15], whereas in the control class is done by learning using the PjBL model, each learning is carried out as many as six meetings in the course basic concepts of science. The data of this study were obtained from the results of tests in the form of multiple-choice questions as many as 35 questions and five essay questions given to college students, both in the experimental class and the control class, which can measure the science literacy skills of pre-service elementary school teachers’. Measurement of scientific literacy ability on nine indicators based on TOSLS developed by Gormally et al [16].

Data analysis was performed using descriptive and quantitative statistical analysis. Data analysis was performed using:

2.1. Normalized gain test (N-Gain)
Used to find an increase between pre-test and post-test or N-gain. The magnitude of the increase is calculated by the normalized N-Gain formula [17]. The N-Gain calculation results are then interpreted using the adapted categories as follows: high category if $(<g>) > 0.70$; medium category if $0.70 > (<g>) > 0.30$; low category if $(<g>) < 0.30 $ [18].

2.2. Statistic test
The statistic test is used to determine the gain between pre-test and post-test using paired sample t-test statistical tests, while to find out the difference in average scores between experimental classes using
the STEM Project learning model and control classes using the PjBL model the statistical tests are used Independent Sample t-Test. The basis of decision making is based on probability values, where if sig > 0.05, then it is accepted, but if sig < 0.05 then it is rejected.

3. Results and discussion
Research on improving the ability of scientific literacy in prospective elementary school teachers through learning using the STEM Project model can be described in both experimental and control groups. The use of the STEM Project model is carried out based on five stages of learning developed by Laboy-Rush, namely Reflection, Research, Discovery, Application, and Communication [15].

The steps at each stage of the Project STEM model are carried out as follows, at the first stage of Reflection, in the first stage of Reflection, in groups, college students conduct experiments and complete projects according to the assigned material. In the second stage of Research, in groups, college students look for information about the material assigned, from a variety of literature, including from reference books carried and from the internet. Lecturers guide groups of college students to determine and design experiments related to the assigned material. In the third stage of Discovery, as a group, college students conduct experiments related to the assigned material, as well as finding a suitable model for implementing a project in designing experiments related to the assignment. The lecturer guides the college student group to start the project. In the fourth stage of Application, in groups, college students conduct experiments and complete projects according to the assigned material. In the fifth stage of Communication, in groups, college students deliver presentations about the results of their experiments in the form of projects related to the assigned material, this at the same time receives useful feedback for the improvement of a better project.

Research using the STEM Project model has been carried out by Tati et al. [19], but the research sample is junior high school students. Likewise with learning conducted by Meita et al. [20], with the research sample vocational high school students. Thus the use of the STEM Project model in conducting learning has been carried out by several previous researchers, but the research sample is different because the sample used in this study is students of elementary school teacher candidates.

The average value of the N-gain test results in the experimental class and the control class can be seen in Table 1 below:

Table 1. Average N-gain for each group.

| Experimentation Class | Control class |
|-----------------------|--------------|
| Pre-test | Post-test | N-gain | Pre-test | Post-test | N-gain |
| 44.33 | 85.50 | 0.74 | 44.68 | 72.74 | 0.51 |

Based on the average N-gain value in table 1 above, the results show that the N-gain in the experimental class (0.74) is higher than the N-gain in the control class (0.51), and based on these data, the average N-gain the experimental group was in the high category, while the average N-gain control group was in the medium category.

While the results of statistical calculations to test hypotheses can be described as in table 2 below.

Table 2. Summary of statistical test results of science literacy skills.

|               | Test for Normality | Homogeneity Test | t-test |
|---------------|--------------------|------------------|-------|
| Experimentation Class | p = 0.200          | p = 0.006        | p = 0.000 |
| Control class   | p = 0.782          | p = 0.006        | t' = 7.413 |

Based on the statistical test results in table 2 above shows that the sig value of 0.000 <0.05, it can be determined that learning is done using the STEM Project learning model there is a significant difference from learning using the PjBL model. And the average N-gain of the experimental group is 0.74 in the high category and higher than the average N-gain of the control group that is 0.51 in the medium category.
This difference is caused by the effect of the treatment given to the experimental class that is learning using the STEM Project learning model compared to the control group provided with learning using the PjBL model. That learning using the STEM Project learning model can improve the ability of pre-service elementary school teachers’ students in science literacy skills compared to learning using the PjBL model.

In addition to the results of the study as in table 1 and table 2 above, this study also resulted in an increase calculation for each indicator of science literacy as described in Figure 1.

![Figure 1. N-Gain graph for each indicator of science literacy.](image)

Based on Figure 1 above, then from the nine indicators of science literacy in the experimental group doing learning using the STEM Project learning model, the indicators that reach the high category are the indicator (g) understand and interpret basic statistics (0.83) experienced a higher increase, followed by the indicator (d) understand elements of research design and how they impact scientific findings/conclusions (0.78), then indicators (h) justify inferences, predictions, and conclusions based on quantitative data (0.77), then indicators (e) read and interpret graphical representations of data (0.74), indicators (a) identifying a valid scientific argument (0.73), indicators (i) create graphical representations of data (0.60), and only three indicators which reach the medium category, namely indicator (f) solve problems using quantitative skills, including probability and statistics (0.69), then indicator (c) evaluate the use and misuse of scientific information (0.68), and the smallest increase is the indicator (b) evaluate the validity of source (0.67).

Furthermore, out of the nine indicators of science literacy in the control group doing learning using the PjBL model, none reached the high category and only in the medium category, but the indicator that experienced a higher increase based on Figure 1 above is the indicator (i) create graphical representations of data (0.60), followed by indicators (g) understand and interpret basic statistics (0.56), (h) justify inferences, predictions, and conclusions based on quantitative data (0.53), indicators (d) understand elements of research design and how they impact scientific findings/conclusions (0.47), indicator (f) solve problems using quantitative skills, including probability and statistics (0.47), indicator (b) evaluate the validity of source (0.45), indicator (c) evaluate the use and misuse of scientific information (0.43), indicator (e) read and interpret graphical representations of data (0.42), and which have increased more reliably is an indicator (a) identifying a valid scientific argument (0.39).

Data from this study also show that before learning using the STEM Project learning model, the average initial science literacy ability of college students was classified as low. The low ability of college student science literacy is caused by each student not accustomed to generating many ideas for various questions and not yet accustomed to taking detailed steps and not being able to graph-based on existing data. But after learning using the STEM Project learning model, the science literacy ability of college students has increased to a high category.
The results of the calculation of the increase in each indicator of science literacy in Figure 1 shows that on average of the nine indicators, the average N-gain of each indicator of the experimental group is greater than the N-gain of each indicator in the control group. The average N-gain of each indicator of science literacy in the experimental group showed a high category, while the average N-gain of each indicator of science literacy in the control group showed a moderate category.

On average, students' ability to understand and interpret basic statistics is higher than other indicators. This reflects that the students' ability to understand and interpret basic statistics, explain in detail, coherently, and coherently to certain procedures, answers, or situations as a correct problem solving given by respondents.

Refer to Munandar [17]. The ability to understand and interpret basic statistics is the ability to understand and interpret basic statistics, as well as the ability to develop, add, enrich ideas, or detail details, and expand an idea. The instrument that explores the ability to understand and interpret basic statistics in students is in question number 26 to problem number 30 that is presenting data and then students are asked to interpret the data. Based on the analysis of student answers shows that in item 26 to item number 30 which illustrates the indicators of the ability to understand and interpret basic statistics reached a high category and experienced the highest increase (0.83).

Furthermore, the ability to understand elements of research design and how they impact scientific findings/conclusions which is the ability to understand the conclusions of a study and provide unusual answers, others from others, which are rarely given by most people [21]. It's just that in this problem some students answer with one answer that is already commonly answered by other students and don't give varied answers. The ability to understand elements of research design and how they impact scientific findings/conclusions is strongly influenced by the extent of one's knowledge and the greater the possibility of generating new ideas that are different or not commonly used by most people [22]. So it can be concluded that the ability of students to understand the conclusions of a study is quite good.

The similar results obtained by Lewis [19], the ability to justify inferences, predictions, and conclusions based on quantitative data is to make predictions based on data, as well as the ability to change forms, develop information, or change views. Student behavior that shows the ability to justify inferences, predictions, and conclusions based on quantitative data, that is, students can provide predictions by providing various interpretations of data, images, stories or problems, applying a concept or principle in different ways, giving consideration to different situations than those given by others, think of various ways to solve problems, classify things according to division (different categories), and be able to change the direction of thinking [23]. In the results of this study, it was found that the ability to justify inferences, predictions and conclusions based on quantitative data of students reached a high category (0.77). It was found that some (65%) students were able to see the problem from different points of view and were able to change the way of approach or thinking when solving a problem. Also, they have been able to dig up information from the problems presented, although sometimes they have difficulty understanding the purpose of the questions given.

The ability to read and interpret graphical representations of data is the ability of students to analyze and interpret data and has a positive impact on the development of students’ conceptions in the practice of science literacy [24]. Based on the results of tests on the ability to read and interpret graphical representations of data for prospective elementary school teacher students, the figures are already in the high category. It can be seen that the ideas issued by students are quite a lot like ideas for finding various forms of alternative energy, ideas for solving problems related to energy use. To find various forms of energy, students use the media that has been provided, namely books, newspapers, pictures, and videos. Students are also able to solve problems in various ways or find different answers.

The same thing from the calculation of the average N-gain increase of each indicator on the science literacy ability of students, seen in Figure 1 above shows that the nine science literacy indicators show a greater N-gain in the group given learning using the STEM Project learning model than with groups that only do learning using the PjBL model.

Furthermore, in Figure 1, it also shows that in groups that are given learning by using the STEM Project learning model, the science literacy capacity of students from the nine indicators is equally
increasing with a high category. On the other hand, in groups that are given regular learning, it is still in the medium category. Because according to Vale and Barbosa, that if a student is not able to think of a solution in learning and even does not understand the problem given, then the student will not be able to create a solution to the problem, and even have to be guided by how to solve the problem. Even to get creative thinking, high curiosity is needed, accompanied by a process of exploration and observation, as well as imagination and originality of high thought [25].

This is in line with the results of the Pertiwi research, that the learning activities presented in STEM are initiated by giving a problem or phenomenon to be able to practice students' creative thinking skills and the results can enhance students' creative thinking skills [8]. This is similar to the study of Subramaniam et al (2012) which states that STEM learning can develop when it is associated with the environment so that learning experience is experienced by students in daily life [26].

The same thing done by Parwati in the environmental context shows that STEM learning can build creativity and environmental literacy, which is very necessary to face the 21st century [27]. Because in general, the application of STEM in learning can encourage students to design, develop and utilize technology, sharpen cognitive, manipulative and affective, and apply knowledge [28]. Therefore, the application of STEM is suitable for use in science learning, because STEM-based learning can train students in applying their knowledge to create designs as a form of problem-solving related to the environment by utilizing technology [11].

STEM has been widely applied in learning [11]. This situation is shown from the results of research that revealed that the application of STEM can improve the academic and non-academic achievement of students [29,30].

Clegg and Brich stated that the ability to think creatively for individuals is no longer a compliment but has become a major factor that must be possessed by every individual to survive amid increasingly fierce global competition [31]. Likewise, Permanasari stated that STEM (Science, technology, engineering, and mathematics) education is now an alternative science learning that can build a generation that can face the challenging 21st century [11].

4. Conclusion

Based on the result and discussion, it is concluded The application of the STEM Project learning model in the learning process can improve the ability of science literacy in pre-service elementary school teachers’ students, this is based on the results of research data analysis which shows that there is a significant difference between the experimental class using the STEM Project learning model and the control class using the PjBL model. The mean N-gain value of the experimental class (0.74) > control class (0.51). The ability of science literacy can develop after participating in guided class learning using the STEM Project learning model. Thus the STEM Project learning model can be a good choice for lecturers in learning to improve the ability of science literacy in pre-service elementary school teachers’ students, to prepare professional teacher candidates for learning in the 21st century. For this reason, it is hoped that the STEM Project learning model can be continually diffused to lecturers in the LPTK through training, seminars, and conferences.

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