JURNAL PENDIDIKAN DAN PENGAJARAN
Volume 55 Nomor 1 2022, 173-181
E-ISSN: 2549-2608; P-ISSN: 2301-7821
DOI: http://dx.doi.org/10.23887/jpp.v55i1.37155

The Effectiveness of the Inquiry Learning Model on Basic Science Learning Materials on Problem Solving and Critical Thinking Skills

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Abstrak

Pelajaran ilmu pengetahuan alam memiliki peranan yang sangat penting, karena melalui ilmu pengetahuan alam (IPA) siswa dapat mengenal lingkungan sekitar dan segala isinya. Oleh karena itu pembelajaran IPA perlu disajikan dengan model pembelajaran yang baik dan relevan yang mampu mendukung perkembangan ilmu pengetahuan dan teknologi (IPTEK). Salah satu model pembelajaran yang cocok adalah pembelajaran IPA adalah bembelajaran berbasis inkuiri. Pembelajaran inkuiri dapat memberikan pembelajaran berbasis masalah yang melatih siswa dalam pembelajaran melalui pemecahan masalah. Penelitian ini bertujuan untuk meningkatkan kemampuan pemecahan masalah dan berpikir kritis calon guru ilmu pengetahuan alam. Penelitian dilakukan dengan menerapkan perangkat pembelajaran ilmu pengetahuan alam berbasis model inkuiri pada mahasiswa semester satu Jurusan Pendidikan ilmu pengetahuan alam Universitas Pendidikan Ganesha. Penelitian ini menggunakan desain one group pretest posttest design. Hasil penelitian menunjukkan bahwa model pembelajaran inkuiri efektif untuk meningkatkan kualitas keterampilan pemecahan masalah dan efektif untuk meningkatkan kualitas keterampilan berpikir kritis calon guru ilmu pengetahuan alam.

Kata kunci: *IPA Dasar, Inkuiri, Pemecahan Masalah, Berpikir Kritis*

Abstract

Science has an important role because students can get to know the surrounding environment and all its contents. Therefore science learning needs to be presented with a good and relevant learning model that can support the development of science and technology. One suitable learning model is inquiry-based science learning, it can provide problem-based learning that can train students to solve problems. This research study was aimed to improve problem-solving and critical thinking skills for science prospective teachers. The study was carried out by implementing a Basic Science learning tools based on an inquiry model for the first semester students of the Department of Science Education Universitas Pendidikan Ganesha. The research employed a one-group pretest-posttest design. The results of the study showed that the inquiry learning model is effective for improving the quality of problem-solving skills and effective for improving the quality of critical thinking skills for science prospective teachers.

Keywords: Basic Science, Inquiry, Problem Solving, Critical Thinking

History:
Received : February 16, 2022
Revised : February 26, 2022
Accepted : April 08, 2022
Published : April 25, 2022

Publisher: Undiksha Press

1. INTRODUCTION

The 21st century makes all civilizations develop very rapidly. This development is a challenge for a better future (Chowdhury, 2016). Judging from the statements about the progress of civilization, such as the rapid changes in science and technology, the increasing use of information technology, and the continuing movement related to the advancement of knowledge, everything focuses on education as an influential role. In line with this, the rapid development of science and technology makes the social and cultural lifestyle of the community very influential, so it is necessary to develop human resources of good quality (Nova., 2017). The right solution is to adjust the socio-cultural life of the community with the

development of education through a better learning process (Mardhiyah et al., 2021). Such as the ability of teachers to apply integrated and sustainable learning models, students' ability to train critical thinking through the teacher as a mentor, and learning that emphasizes student learning activities and others (Hartati & Hariyono, 2020; Kelana et al., 2021; Pérez-Sánchez et al., 2020).

Effective learning is applied in developing rapid changes in science and technology, namely science including science (physics, chemistry, biology, and environmental science) in the development of science and technology (Taştan et al., 2018). IPA (Natural Science) is the study of nature, which is related to natural events and phenomena (Kusumaningrum, 2018). In learning, science has an important role, because students can get to know the surrounding environment and all its contents. Science learning is a way of knowing nature systematically and not only through skills and knowledge but also through the process of discovery by experiment (Lusidawaty et al., 2020). In essence, science learning can be interpreted as a scientific process in the form of definite steps in investigating a problem, as a scientific product in the form of facts, principles, laws, and theories that have been accepted as true, and as a scientific attitude in the form of values and morals (Narut & Supardi, 2019).

Therefore, science learning needs to be presented with a good and relevant learning model that can support the development of science and technology that develops in the community, especially in schools (Ntemngwa & Oliver, 2018). Several types of learning models are suitable for these problems according to the needs, the character of students and schools as well as other supporting factors. One of the learning models that suit these problems is the inquiry learning model. Inquiry-based science learning can provide problem-based learning and train students to solve problems through problem-solving (Ong et al., 2020). Inquiry-based learning is learning through a student-centered approach that makes learning active, especially in environment-based learning or science (Duran & Dökme, 2016). Inquiry-based learning can affect students' critical thinking skills. This is because students have direct experience in learning and learning activities. Inquiry trains students to investigate issues related to science material because basically, an inquiry is a learning model through a process of investigation, discovery, collaborative learning to create new knowledge, how to think critically and creatively, and how to make discoveries through investigation, reflection, exploration, experimentation, and experiment (Prayogi et al., 2018). These investigating activities can help students to develop critical thinking skills, knowledge, and scientific reasoning (Maknun, 2020).

Based on previous research that has applied the inquiry learning model, it has been revealed that learning in the classroom that applies inquiry-based learning has a good effect and students' thinking abilities are higher than those applying conventional-based learning (Wartono, Hudha & Batlolona, 2018). Moreover, the other previous study also found that inquiry learning is the application of an effective learning model in training students' critical thinking skills through evaluation, explanation, interpretation, and inference based on the results of data analysis (Suryanti, Arifin & Baginda, 2018). The research that has been applied, also shows that inquiry learning has a positive effect on student learning outcomes and students' critical thinking skills significantly (Amijaya et al., 2018).

Reflecting on the challenge of developing students' problem solving and critical thinking, the government of Indonesia made adjustments from Curriculum 2006 to Curriculum 2013 (Çubukçu, 2012). In Curriculum 2013, the lesson is designed to be students centered with a scientific approach (Adeyemi et al., 2009). To develop the thinking skills, some innovative models are recommended, one of them is the inquiry model. The inquiry learning model is used to support the students to become critical, intelligent, and open-minded (Widowati et al., 2017). By using this model, the students are expected to learn about doing research, explaining the phenomenon, finding the core of a problem, and independently

solving it using scientific procedures (Tarnip et al., 2016). The inquiry learning model also encourages the students to develop higher-order thinking skills by asking open questions, using curiosity to find the solution to a problem and being able to give meaningful conclusions from their findings (Sadia, 2008). Based on the aforementioned characteristics of inquiry learning, it can be predicted that if this model is properly designed and implemented, it will facilitate the students to enhance their higher-order thinking skills (Hidayat et al., 2019). Problem-solving and critical thinking are some examples of higher-order thinking skills. Hence, the implementation of the inquiry model as a learning setting of Basic Science is expected to be able to improve the prospective science teachers' problem solving and critical thinking.

Besides curriculum, model, and learning strategy, the poor quality of education in Indonesia is also influenced by the lack of facilities in learning, such as the limitation of learning materials (Pike et al., 2020). The learning materials consist of a syllabus, lesson plan, worksheets, modules, assessment and evaluation instruments, students' and teacher's books and etcetera (Suryanti, Arifin & Baginda, 2018). Currently, those set of learning materials is partially developed means that each of those was hardly connected to another. Also, the science skills as laboratory practices had a limited allocation. In this condition, the students (who also is a prospective science teacher) are likely to wait for the transfer of information from the lecturer instead of constructing their knowledge (Smetana & Bell, 2012).

Hence, the learning process is more to be teacher-centered. Besides that, the assessment and evaluation instruments are written in worksheets or students' books usually do not exactly measure the learning indicators. Considering the aforementioned problem, we must develop a set of learning materials for Basic Science lessons using an inquiry model to enhance students' problem solving and critical thinking skills. The inquiry model is theoretically relevant to developing those skills, however, we need to examine the empirical value of its effectiveness. Hence, the research questions for this study are: how does the effectiveness of inquiry-based learning materials for Basic Science to improve the prospective science teachers' problem solving and critical thinking skills?

2. METHODS

This is an Educational Research and Development which was aimed to develop and test the validation of educational learning materials. In general, there are three steps in this research namely (1) preliminary study, (2) prototype design, and (3) product development. The designed product was tested to measure its validity and effectiveness to improve problem-solving and critical thinking skills by implementing it in the real classroom. The population of the study was 34 students in the first semester of the Science Education Department at a teacher training institution in Bali. All of the populations were used as a sample. This study employed a quasi-experiment with the One Group Pretest Posttest Design model (Creswell, 2008). The data on students' problem-solving ability were collected using a content-based problem-solving test (in topics temperature, heat, force, and energy) and a content-free critical thinking test. Those tests were given to the students before and after the treatment was implemented. To determine the quality of the students' ability in problem-solving and critical thinking, the scores were tested using normalized gain scores (N-gain) (Cheng et al., 2004). Afterward, the hypothesis of the study was tested using right-tailed t-test.

3. RESULTS AND DISCUSSION

Result

The scores of pre-tests and post-test of students' problem-solving ability can be observed in the following Table 1.

Table 1. Frequency and Percentage of Scores in Pre-& Post Test of Problem-Solving Ability (PSA)

No	Interval	Category	Problem Solving Ability			
			Pre –test		Post-test	
			F	%	F	%
1	85.0 – 100.0	Very Good	0	0	8	23.5
2	70.0 – 84.9	Good	0	0	12	35.3
3	55.0 – 69.9	Sufficient	0	0	6	17.7
4	40.0 – 54.9	Poor	0	0	5	14.7
5	0 – 39.9	Very Poor	34	100	3	8.8
Total			**34**	**100**	**34**	**100**

Based on Table 1, all of the students got very poor pre-test result. It was developed in the post-test where 8 students got very good, 12 students got good, 6 in sufficient and 8 more in poor and very poor. The comparison of those scores can be seen in Figure 1.

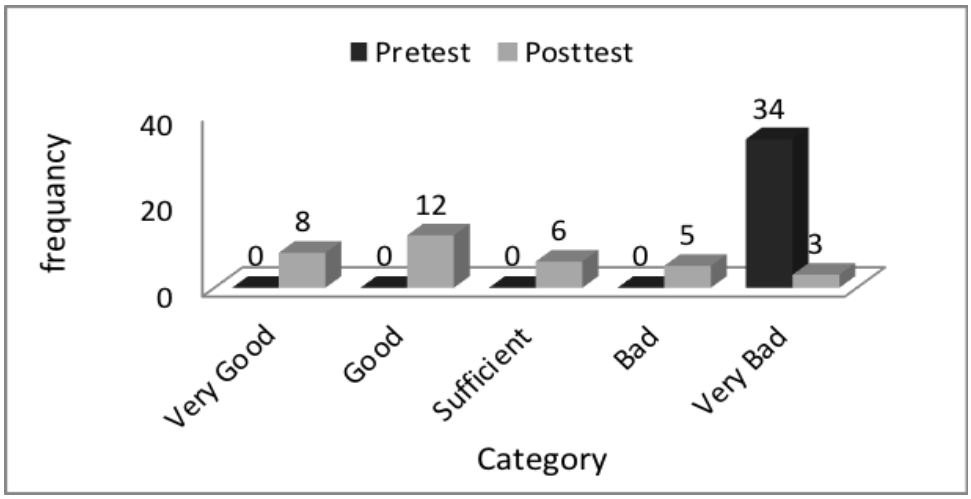

Figure 1. Comparison Graph of Pre- & Post-test Result of Problem Solving Test

The scores of critical thinking pre-&post-test, can seen in the following Table 2. The minimum score of the test is 0 and the maximum is 100. From that, it is found that the mean of pre-test score is 34.8 which is in very poor category. Also, it can be seen that there is an improvement, since themean of pre-test score is 45.8 which is in poor category. The comparison between critical thingking pre-&post-test can be illustrated in the following Figure 2.

Table 2. Frequence and Percentage of Scores in Pre-& Post Test of Critical Thinking Ability

No	Interval	Category	Critical ThingkingAbbility			
			Pre-test		Post-test	
			f	%	f	%
1	85.0 – 100.0	Very Good	0	0	0	0.0
2	70.0 – 84.9	Good	0	0	1	2.9

No	Interval	Category	Critical ThingkingAbbility			
			Pre-test		Post-test	
			f	%	f	%
3	55.0 – 69.9	Sufficient	2	5.9	8	23.5
4	40.0 – 54.9	Poor	6	17.6	14	41.2
5	0 – 39.9	Very Poor	26	76.5	11	32.4
Total			**34**	**100**	**34**	**100**

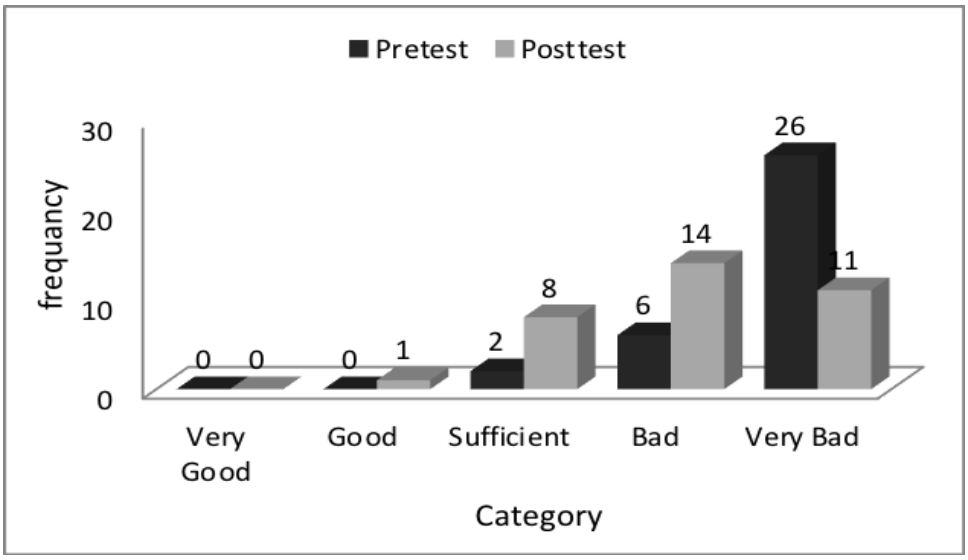

Figure 2. Comparison Graph of Pre- & Post-test Result of Critical Thinking Test

The hypothesis test to evaluate the effectivity of Basic Science learning materials to improve the prospective science teachers' problem solving abilitiesand critical thinking skills was using right tailed t-test. The result of analysis can see in Table 3.

Table 3. The Result of Hypothesis Test of Problem Solving Abilities (PSA) and Critical Thinking Skills (CTS)

Variable	t-count	t-table (0.05)	Description	Conclusion
Problem Solving Abilities (PSA)	15.96	2.029	(H_0) rejected	Improved of PSA
Critical Thinking Skills (CST)	4.004	2.029	(H_0) rejected	Improved of CST

Discussion

Based on the results of the data (table 1) obtained on the Frequency and Percentage of Scores Pre & Post Problem Solving Ability Test (PSA) showed that in the initial observation, students had difficulties in the problem-solving ability test, with an interval 0-39.9. This happened because, before the pre-test, the teacher had not yet trained students' problem-solving skills (Hendikawati et al., 2019; Prastiwi & Nurita, 2018). However, after the teacher trained the students' problem-solving skills, the post-test results showed good results, including the interval of values from 85.0-100.0 of 23.5%, the interval of values from 70.0 to 84.9 being 35.3%, the interval of values from 55.0 to 69.9 is 17.7%, the interval of values from 40.0 to 54.9 is 14.7% and the interval of values from 0 to 39.9 is 8.8%.

Based on the data (Table 2) obtained on the Frequency and Percentage of Pre & Post Critical Thinking Skills Scores, it showed that in the initial observation, students had quite a difficulty in doing the critical thinking ability test, with an interval of values 0-39.9, 40.0-54.9 and 55.0-69.9. This happened because, before the pre-test, the teacher had not yet trained students' critical thinking skills (Lieung, 2019; Retnowati et al., 2017). However, after the teacher trains students' critical thinking skills, the post-test results show developments and improvements from before, including in the interval of values 70.0-84.9 of 2.9%, the interval of values from 55.0-69.9 of 23 .5%, the interval of values from 40.0 to 54.9 is 41.2% and the interval of values from 0 to 39.9 is 32.4%.

From the analysis of the normalized gain score, it is known that the N-gain for problem-solving ability is 60.9 (medium category). By obtaining this value, it shows that there is an increase between pre-test and post-test in the moderate category. This is because students experience a series of processes in the form of observing, asking questions, gathering information, and communicating, the knowledge that students build with previous experience and knowledge (Mutlu, 2020). N-gain for critical thinking ability is 14.1 (low category). Obtaining this value indicates that there is an increase between pre-test and post-test with low category (Sumarli Nugroho & Yulianti, 2018). This is due to the lack of understanding of students in understanding the material based on the concepts that need to be reviewed in the application of learning (Rajendra & Sudana, 2017).

Table 3 showed that t-count>ttable, the Null Hypothesis was rejected. It means that basic science learning material based on inquiry was effective in increasing prospective teacher problem solving and critical thinking skill abilities. This is because there is a significant difference in the application of science learning before and before the implementation of the test on critical problem-solving problems (Nugrahini, 2021). We can also observe the difference between the score results of problem-solving and critical thinking tests. It is predicted that the noticeable difference in score results is caused by the difference in test type. The type of problem in problem-solving and critical thinking tests are harder since it requires higher-order thinking. But, it can be seen that the score for problem-solving ability was higher rather than for critical thinking ability. The problem-solving skills required concept mastery or comprehensive knowledge from facts to a foundation for developing problem-solving skills (Batlolona et al., 2018). Besides that, Inquiry-based science education enables the individual to form positive attitudes toward learning while developing the learning skills of an individual (Karamustafaoğlu & Havuz, 2016).

The item used in the problem-solving test was in-content essay form. Hence, after following the lesson there will be an improvement in the score result, even though not in all learning indicators. It is in line with previous research that studies about critical thinking skills of the students taught by using inquiry-discovery (Wartono, Hudha & Batlolona, 2018). The result of the critical thinking skills of the students in the inquiry-discovery class was higher than that of the conventional learning class. The research recommends that teachers empower the HOTS ability of the students in the inquiry-discovery class so that meaningful learning and student-centered learning can be created. On the other hand, the critical thinking test was multiple-choice with free content. Hence, if the critical thinking of the prospective science teacher is not well-developed yet, they will find it is difficult to answer the test. Moreover, the students stated that they were not interested to answer the problem in the critical thinking test. In line with a previous study that stated the improvement of the students' problem-solving skills was in a low category because the student found it difficult in solving the physics problems (Pol et al., 2008).

4. CONCLUSION

Based on the discussion above, it can be concluded that the inquiry learning model is effective for improving the quality of problem-solving skills and effective for improving the quality of critical thinking skills. Based on the t-count analysis with the t-table shows that the inquiry model is effective for improving problem-solving abilities and thinking skills in science learning. The inquiry-based learning materials for Basic Science is necessary for the science department, especially for the teacher training program. Hence, the upcoming research related to the development of other learning sources and tools related to the topic is needed to improve the quality of science education.

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