

GUIDED INQUIRY: HOW TO IMPROVE SCIENTIFIC LITERACY STUDENT SENIOR HIGH SCHOOL

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Article History: Received on 12th March 2020, Revised on 15th July 2020, Published on 31st August 2020

Abstract

Purpose of the study: Students' scientific literacy skills are very much needed in 21st-century learning, but the fact is that field gains in scientific literacy are still low. Research with a focus on improving the ability of students' scientific literacy to use an inquiry-based approach is also limited. Therefore, this quantitative quasi-experimental study aims to improve students' scientific literacy skills by using the inquiry model.

Methodology: Using quantitative designs in quasi-experimental designs. By using 42 secondary students obtained based on purposive sampling. The experimental group used the guided inquiry model, while the control group used the traditional learning model. Then the data are analyzed to get descriptive and inferential results.

Main Findings: There is a significant difference in terms of students' scientific literacy skills between the control class and the experimental class. It was found that using the guided inquiry model found differences with the t-test value of 19,373 on students' scientific literacy abilities. It can be underlined that the guided inquiry model has a significant effect on students' scientific literacy skills compared to traditional learning models.

Applications of this study: In this research can be a consideration for teachers to apply guided inquiry to improve students' scientific literacy skills.

Novelty/Originality of this study: In this study, the renewal of learning that uses the guided inquiry learning model can improve the scientific literacy abilities of students.

Keywords: Chemistry, Guided Inquiry, Improve, Science Literacy, Senior High School, Students.

INTRODUCTION

Based on Law No. 20 of 2003, concerning the national education system, education is a conscious and planned effort that has the aim of actively making students able to develop their potential. One of the ways the government implemented the 2013 curriculum, which involved five main learning experiences—one of them in science subjects. Science is one of the keys to the success of increasing the ability to adapt to changing times and enter the world of technology, including information technology ([Asrial et al., 2019](#); [Astalini et al., 2019](#); [Maison et al., 2019](#); [Syahrial et al., 2020](#)). Education in the present time should be able to equip the young generation to discover scientific concepts well so that problems that will arise in the future can be anticipated. Science is a systematic way to find out about the natural surroundings. Learning Science is not enough just to memorize the material, but also must be able to understand the concepts in it. This can be achieved if the learning is meaningful. According to [Budiarti, Harlis, & Natalia \(2020\)](#), meaningful learning is a process of linking new information to relevant concepts in a person's cognitive structure. Psychological aspects contained in the inquiry method provide many advantages because it allows students to use all their potentials, especially their mental processes to discover their own concepts and principles of science plus other mental processes that characterize adults or the characteristics of a scientist, so students can find their ideas in scientific literacy ([Kurniawan et al., 2019](#); [Maison et al., 2019](#); [Maison et al., 2020](#)).

Learning based on scientific literacy can be applied in chemical concepts in accordance with opinions ([El Islami, Nahadi, & Anna, 2016](#)). One of the chemicals studied at school is acid and base solutions. Acid and base solutions are chemicals studied at the beginning of the even semester of class XI, which explain the concepts of acids and bases, indicators of acid-base, pH of acidic solutions, and basic solutions and acid-base reactions. This material contains concepts and calculations ([Ernavita & Tine, 2016](#)). The use of the term "scientific literacy" underscores the purpose of Programme for International Student Assessment not only to assess what students know in science, but also what they can do with what they know, and how they can creatively apply scientific knowledge to real-life situations. The results of the 2015 Programme for International Students Assessment survey, Indonesia's score was only 403 as a ranking of 62 out of 70 participants ([OECD, 2016](#)).

One of the causes of underachievement in science is that the learning system of science (including chemistry) is more oriented to the content of science material rather than oriented to the scientific process. Learning chemistry in Indonesia should be able to train students' literacy skills. The ability of scientific literacy is the ability to engage issues and ideas related to science as reflective citizens. Scientific literacy assessment is basically developed based on four aspects of scientific literacy. The four aspects of scientific iteration include the context, competence, knowledge, and attitude of Science (Abidi, Tita, & Hana, 2017). The low ability of student literacy can be caused by the strategies applied by the teacher in learning not yet oriented to the empowerment of high-level thinking and only emphasizes understanding of

concepts. The results showed that students' mastery of concept improved significantly after they were trained with certain thinking skills (Kjaersli & Lie, 2004). To overcome the problems that exist in the field of chemistry, variations in learning models are a must for (Techakosit & Wannapiroon, 2015). One of the learning models that can be expected to improve students' mastery of concepts and scientific literacy skills is an inquiry. Learning with science inquiry can improve work skills (formulate problems, make hypotheses, design experiments, take data, control variables) and improve concept understanding (Aktekin, 2019). Inquiry as the main approach in learning chemistry has proven successful in arousing students' interests and abilities (Cindy & Clark, 2006). In the high school curriculum, it is stated that the objectives of Chemistry subjects can be achieved by students through various approaches, including inductive approaches in the form of scientific inquiry processes at the level of open inquiry. The scientific inquiry process aims to foster students' scientific literacy skills and be scientific and communicate as one of the important aspects of life skills. Inquiry can simply be seen as a process of solving problems based on facts and observations (Xu & Talanque, 2013; Ural, 2016; Tornee et al., 2019). Thus it is important to apply guided inquiry as a model for conducting chemistry learning in schools. The implementation of this learning model is expected to improve students' cognitive, affective, and psychomotor abilities.

Therefore, the purpose of this study is to see whether there is an influence in using the guided models of learning in improving the scientific literacy of students.

LITERATURE REVIEW

Inquiry-based learning is a method of teaching and educational philosophy in which problem-solving in learning by participating or engaging in learning. This inquiry learning model aims to provide a way for students to build intellectual skills related to thought processes. Students work independently and in small groups to gain knowledge through their involvement. Problem-solving skills refer to the ability of students to investigate solutions to a given problem or find a way to realize a given goal (Tornee et al., 2019). Creative thinking is needed to generate ideas to solve problems and find new approaches. Meanwhile, teamwork is often a key component of problem-solving (Ural, 2016). Therefore the inquiry learning model has a good impact on learning. Based on understanding inquiry itself, especially inquiry-based learning, also has a very close relationship with the way students learn and behave. Learning with scientific inquiry can improve work skills (formulate problems, make hypotheses, design experiments, take data, control variables) and improve conceptual understanding (Aktekin, 2019). Inquiry as the main approach in learning chemistry has proven successful in arousing the students' interests and abilities (Cindy & Clark, 2006). In the high school curriculum, it is stated that the objectives of Chemistry subjects can be achieved by students through various approaches, including inductive approaches in the form of scientific inquiry processes at the level of open inquiry. The scientific inquiry process aims to foster students' scientific literacy skills and be scientific and communicate as one of the important aspects of life skills. Inquiry can simply be seen as a process of solving problems based on facts and observations (Xu & Talanque, 2013; Astalini et al., 2020). Thus, it is important to apply guided inquiry as a model for conducting chemistry learning in schools.

Scientific literacy has become an internationally recognized educational slogan, keywords, catchphrases, and contemporary educational goals. Scientific literature "represents what the general public should know about science" (Durant, 1993), and "generally implies an appreciation of the nature, purpose and general limitations of science, coupled with an understanding of most important scientific ideas" (Jenkins, 1994). This term is usually regarded as synonymous with "public understanding of science, "and while" scientific literacy "is used in the United States, the phrase previously was more commonly used in Britain, with" la culture Scientifique" used in France (Durant, 1993). However, it is generally accepted that a simple conceptualization of scientific literacy only illustrates the mask of different meanings and interpretations related to the concept of scientific literacy because, for example, different views about what people should know about science and who is the public. This interpretation results in scientific literacy that appears as a concept needed by the junior high student.

METHODOLOGY

The research design used by researchers is a quantitative research type of quasi-experimental design using pretest and posttest non-equivalent control group design. That was done to investigate the causal hypothesis about causes that could be manipulated by comparing one or more experimental groups that were treated with one comparison group that was not treated (Cramer, 2003; Cohen, Manion, & Morrison, 2007; Creswell, 2012). The design of this study was applied because it was in accordance with the objectives of the study, where the aim was to see whether inquiry learning models could affect students' scientific literacy skills on acid-base material. This study uses descriptive statistics in the form of mean, min, and max and uses inferential statistics. The inferential statistics used are independent sample t-tests.

Table 1: Pretest-Posttest Non-equivalent Control Group Design

Group	Pretest	Treatment	Posttest
Experimental	O ₁	Using the Guided Inquiry Model	O ₁
Control	O ₂	Traditional Model	O ₂

This research is located in the Titan Teras High School, with a total of 42 students. In the experimental class, there were 21 students, and in the control class, there were also 21 students. In the experimental class, they are using the guided inquiry learning model and the traditional learning control model. The sample collection technique uses a purposive sampling method. Purposive sampling is a sampling technique based on researchers' criteria (Kerlinger, 2014). Data collection procedures for referring (Creswell, 2012), are explained in the figure below:

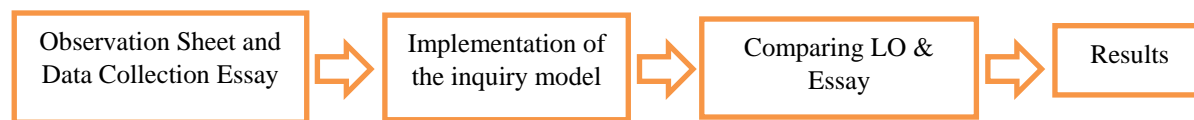


Figure 1: Research Procedure

Based on the picture above, it can be seen that the first activity that must be carried out in the process of collecting data, which is sampled in research that aims to see the initial value. Then provide action only to the experimental class using the guided inquiry learning model, while for the control class given the traditional learning model after that see the results of student essays in the scientific literacy abilities possessed by students after being given a guided inquiry model with those not using the guided inquiry model. The instrument used was a test in the form of essays aimed at seeing students' scientific literacy abilities and observation sheets that were used to see the implementation of guided inquiry learning models in improving students' scientific literacy abilities.

Below this is the category of the implementation of guided inquiry learning models.

Table 2: Implementation category of Guided Inquiry Model by Students

Score	Percentage of Implementation	Category
91.1 – 112.0	81.25 – 100.0	Very Good
70.1 – 91.0	63.37 – 81.24	Good
49.1 – 70.0	44.63 – 63.38	Enough
28.0 – 49.0	25.0 – 44.62	Not Good

While the categories for abilities in scientific literacy can be seen in table 3.

Table 3: Categories of Students' Literacy Literacy Abilities

Score	Percentage of Capabilities	Category
29.3 – 36.0	81.4 – 100.0	Very Good
22.6 – 29.2	62.8 – 81.1	Good
15.8 – 22.5	43.9 – 62.5	Enough
9.0 – 15.7	25.0 – 43.6	Not Good

All data obtained from observation sheets and essay tests about students' scientific literacy in the control class and experimental class were collected and then calculated and assisted with the SPSS 21 application to search for descriptive statistics. Descriptive statistics are given to calculate frequency, percentage, average, minimum, and maximum sample of 42. In the control and experimental groups. In this study, quantitative data were analyzed using parametric statistics from independent sample t-tests. An independent t-test sample was conducted to test the effect of the inquiry learning model on students' scientific literacy abilities. This study uses SPSS 21 at a significance level of 0.025. N-gain is used to determine the increase in achievement scores between pretest and posttest using the formula (Hake, 1999) $n\text{-gain} = (\text{posttest score} - \text{pretest score}) / (\text{maximum} - \text{pretest score})$, with low ($n\text{-gain} < .30$), medium ($.30 < n\text{-gain} < .70$), and high criteria ($n\text{-gain} > .70$).

RESULTS/FINDINGS

Research findings are explained in this section. The Category, Mean, Min, Max, and Percentage results, both pretest and posttest, to show the impact of the inquiry model on the scientific literacy abilities of students are presented as follows (see Table 4-5).

Table 4: Gaps in the score of the implementation of the inquiry model and the ability of students' scientific literacy to pretest between the Experiment Class and the Control Class

Variable	Groups	Category	Mean	Min	Max	N	%
Implementation	Experiment	Enough	60.7	31	68	21	53.6
	Control	Enough	58.3	30	66	21	48.7
Scientific Literacy Ability	Experiment	Enough	19.4	10	18	21	55.8
	Control	Enough	17.6	11	16	21	47.5

Based on the average rank and category shown in Table 4, the pretest scores of the experimental group students were slightly higher in students' scientific literacy ability, which was 55.8% (M = 19.4) and the lowest feasibility of the guided inquiry model was 53.6% (M = 60.7). The control group students were slightly higher in terms of scientific literacy ability at 47.5% (M = 17.6) and lowest in the inquiry model 48.7% (M = 58.3). This shows that before treatment, all students had the same incubation model and scientific literacy skills.

Table 5: Gaps in the score of the implementation of the inquiry model and the ability of scientific literacy posttest between the Experiment Class and the Control Class

Variable	Groups	Category	Mean	Min	Max	N	%
Implementation	Experiment	Good	88.5	36	93	21	79.3
	Control	Enough	52.8	32	85	21	52.6
Scientific Literacy Ability	Experiment	Good	26.5	14	32	21	77.6
	Control	Enough	17.2	12	26	21	49.3

According to the average rank and category presented in Table 5, it shows that the experimental group students were more dominant in all variables compared to the control group students. This confirms that the implementation of the guided inquiry learning model has a significant impact on students' scientific literacy abilities. In addition, the experimental group students received the highest average rating in 79.3% (M = 88.5) and the lowest in 77.6% scientific literacy ability (M = 26.5). Meanwhile, control group students got the highest average rating in the implementation of the inquiry model of 52.6% (M = 52.8) and the lowest in the scientific literacy ability of 49.3% (M = 17.2).

Table 6: Differences in n-gain values for experiments and control groups

Groups	The implementation of the Guided Inquiry Model		Scientific Literacy Ability	
	Control	Experiment	Control	Experiment
Pretest	66	68	16	18
Posttest	85	93	23	32
N - gain	0.41	0.56	0.50	0.78
Category	Medium	Medium	Medium	High

Based on the n-gain presented in Table 6, it showed that the experimental group students had an increase in scores in the high category, while the control group students had an increase in scores in the moderate category. It can be concluded that there was an increase in pretest to posttest in both groups, even though the experimental group students who were taught using the guided inquiry model showed better performance than the control group students who were taught using the traditional model.

Table 7: Independent sample t-test for scientific literacy skills

		T	df	Mean	Std.Deviation	95% confidence interval	
						Lower	Upper
Scientific Literacy Ability		19.373	42	4.0906	.24321	18.246	.6130
		19.373	68.067	3.2033	.30015	17.945	.8625

In table 7 it can be seen that the value obtained for $t_{\text{arithmetic}}$ is smaller than the value of t table. The t-table value is seen based on the significant value of 0.025 (two-tailed test) at a degree of freedom (df) 42. In this study, the t table is 2.01808, while for $t_{\text{arithmetic}}$ is 19.373. If t arithmetic is smaller than t table, then there is no difference (Cramer, 2003). So, it can be concluded that there is a significant difference in students' scientific literacy skills between control classes taught using traditional learning models and experimental classes using guided inquiry learning models. It can be seen from Table 7 that the average value of student interest is 4.0906, which means it can improve students' scientific literacy skills in acid-base material.

DISCUSSION/ANALYSIS

We have entered the 21st century marked by the increasingly rapid and complex development of the world. Various changes occur in the field of knowledge, technology, and information globally, and these changes are basically intended to improve the quality of life of modern society, such as its benefits in the fields of medicine, communication, and nanotechnology. But along with the benefits felt by the community, negative impacts also arise, such as global warming, energy crisis, or environmental damage (Bybee & McCree, 2011). Therefore, it is inevitable that society needs an understanding of scientific facts and the relationship between science, technology, and society. People who have that knowledge and are able to apply their knowledge to solve real-life problems are called science-literate societies (Kremer et al, 2014). Therefore, the achievement of a society that is encircled by science has become a demand of the times. Science literacy is one of the skills/capabilities needed in the 21st century among the 16 skills identified by the World

Economic Forum ([World Economic Forum, 2015](#)). Given the importance of scientific literacy, educating people to have scientific literacy is a major goal in any reform of science education ([DeBoer, 2000](#)). Many educational organizations today accept and issue standards and guidelines relating to content, pedagogy, and assessments related to scientific literacy ([AAAS, 1993](#); [NRC, 1996](#); [Millar & Osborne, 1998](#)). In addition, several attempts have been made to theoretically define biological literacy and chemical literacy ([Holman, 2002](#); [Atkins, 2005](#); [Shwartz, Ben-Zvi, & Hofstein, 2005](#)). The choice of strategy in applying the learning model is a very important factor for the achievement of good scientific literacy skills. [Soltis et al. \(2015\)](#), described inquiry as a student-centered approach. This approach has a positive influence on students' academic success and develops students' scientific literacy abilities. What we can see in the results that have been obtained is that the implementation of the inquiry learning model and the scientific literacy ability of students in the category are quite good in the experimental class and the control class, but are still dominant in the experimental class. Although it shows that the experimental class is more dominant, we can say that students have the ability of scientific literacy.

After applying the inquiry model in learning that is only applied to the experimental class and to the control class using the traditional learning model. This results in there is a significant increase in the ability of the scientific literacy of students, which from the beginning has enough categories (55.8%) after the action is good (77.6%). This is supported by the n-gain value in table 4, which shows that there is an increase in the ability of scientific literacy from moderate to good. That indicates that the inquiry learning model can improve students' scientific literacy abilities. Learning that involves the use of varied learning resources, inquiry processes, and decision making related to daily life is a concept of learning based on scientific literacy ([Millar, 2006](#); [Demirel & Caymaz, 2015](#); [Gurses et al. 2015](#)). Learning that begins with a scientific problem, continues with the formulation of temporary answers and the process of inquiry to solve problems through literature and laboratory activities, then, the understanding gained from the process of solving these problems is used to make decisions in everyday life. The Guided Inquiry learning model is a series of learning activities that emphasize the process of thinking critically and analyzing to find and find answers for themselves of a problem in question ([Kuhlthau, 2010](#); [Biggs, 2011](#); [Gonzales & Diaz, 2015](#); [Treagust et al. 2018](#)). Students are actively involved in the acquisition of knowledge through a series of stages based on scientific methods such as: investigating problems and formulating hypotheses, designing experiments, collecting data, and describing problem-solving. In guided inquiry learning, the teacher raises a problem, students determine the process and the solution with the help of teacher guidance ([Hackling, Goodrum, & Rennie, 2001](#); [Rambuda & Fraser, 2004](#); [Yalcin, Acisli, & Turgut, 2011](#)).

Based on data obtained from the inquiry learning model implementation, it can be seen that the use of inquiry learning models is effective in improving students' scientific literacy abilities where there is a significant influence shown in table 6. Where learning is a cognitive, affective and psychomotor characteristic, as an indicator that acts relatively stable for learning that is interconnected and reacts to the learning environment ([Asrial et al., 2019](#); [Astalini et al., 2019](#); [Mundy & Potgieter, 2019](#); [Maison et al., 2019](#)). Through learning to use products from information and communication technology, various multimedia services can be easily transferred, such as audio, video, high-resolution graphics, so that the process of scientific literacy is better. It has developed a personalized mobile learning system to support guided inquiry learning activities for secondary school students ([Wongwangkit, Panjaburee & Srisawasdi, 2017](#); [Zheng et al., 2018](#)).

CONCLUSION

It can be seen that the results of the literacy and scientific literacy skills of cultural students show good categories after being given an inquiry-based learning model. On the results of the performance and ability of students' scientific literacy for the control class that uses traditional learning models, there is a significant difference with the experimental class that uses inquiry learning models that are in the superior experimental class because it uses inquiry learning models with a test score of 19.373 on the scientific literacy ability of students. According to the results, it is recommended that students need to be given the opportunity to develop direct experience and thinking in science activities. Teachers must utilize the inquiry learning model to develop a variety of lifelong student learning abilities.

LIMITATION AND STUDY FORWARD

This study only investigates whether a guided inquiry is able to improve the scientific literacy skills of secondary school students. Not yet investigated how guided inquiry is able to improve students' Attitudes, or Students' Higher Order Thinking Skills.

ACKNOWLEDGEMENT

The researcher thanked the principal of the senior high school Titian Teras in Jambi which was the place of the study and became a sample of this research, I thank you, and all parties involved I thank you for that.

AUTHORS CONTRIBUTION

Haryanto is a lecturer in the teaching and education faculties, and the role of this article is to make articles.

Abu Bakar is a lecturer in the faculty of education and education; the role of this research is as a coordinator and data collector of students' scientific literacy.

Aulia Sanova is a lecturer in the faculty of education and education; the role of this research is to input and manage data for students' scientific literacy.

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