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Inquiry Model: How to Improve the Ability of the Nature of Science and Its Aspects in Elementary School?

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ABSTRAK

Hakikat sains dan merupakan sesuatu yang sangat penting untuk diajarkan di sekolah dasar. Dilapangan belum banyak penelitian yang melibatkan model pembelajaran dalam upaya pengembangan hakikat sains, baik dari dimensi sains maupun sifat-sifat sains itu sendiri. Tujuan dari penelitian ini adalah untuk mengungkap bagaimana model inkuiri berpengaruh terhadap kemampuan hakikat sains dan sifat pada siswa di sekolah dasar. Metode yang digunakan adalah kuantitatif dengan desain pre eksperimental jenis pre-test dan post-test one group design. Subjek dari penelitian ini adalah siswa kelas V sekolah dasar dengan sampel penelitian sebanyak 36 siswa. Instrumen dalam penelitian ini menggunakan soal tes (produk), lembar observasi siswa (proses) dan angket (sikap). Hasil penelitian menunjukan data bahwa P-value = 0,000 < 0,05. Jadi H_1 diterima. Dengan demikian, pembelajaran dengan model inquiry meningkatkan secara signifikan dimensi produk (kognitif) siswa di sekolah dasar. Pengukuran dimensi proses melalui observasi nilai rata-rata mencapai 58,2% dan ada dikategori cukup. Untuk mengukur dimensi sikap menggunakan angket dalam mengukur 10 sifat dasar sains, penganalisisan data ada pada kriteria baik. Secara umum model inquiry dapat memberikan pengaruh terhadap kemampuan hakikat sains dan sifat pada siswa di sekolah dasar. Untuk penelitian selanjutnya dapat dikembangkan menggunakan model/pendekatan/ stategi/metode lain, guna meningkatkan kemampuan siswa terhadap hakikat sains dan sifat-sifatnya.

ABSTRACT

The nature of science and is something that is very important to be taught in elementary schools. In the field there are not many studies that involve learning models in an effort to develop the nature of science, both from the dimension its aspects and the nature of science itself. The purpose of this research is to reveal how the inquiry model affects the ability of the nature of science and its aspects of students in elementary school. The method used is quantitative with a pre-experimental pre-test and post-test one group design. The subjects of this study were fifth grade elementary school students with a sample of 36 students. The instruments in this study used test questions (products), student observation sheets (process) and questionnaires (attitudes). The results showed that the P-value = 0,000 < 0,05. So H_1 is accepted. Thus, learning with the inquiry model significantly increases the product dimensions (cognitive) of students in elementary schools. The measurement of process dimensions through observation has an average value of 58.2% and is in the sufficient category. To measure the dimensions of attitude using a questionnaire in measuring the 10 basic properties its aspects, data analysis is on good criteria. In general, the inquiry model can have an influence on the ability of the nature of science and its aspects of students in elementary schools. For further research, it can be developed using other models/approaches/strategies/methods, in order to improve students' ability to the nature of science and its aspects.

1. INTRODUCTION

The 2018 PISA survey related to the acquisition of scientific literacy skills, again showed unsatisfactory results. Indonesia was ranked 72 out of 80 participating countries with a score of 396 (J. B. Kelana et al., 2021; Nurhanurawati, N. et al., 2019). This is something that is worrying in the midst of the government's efforts to improve literacy and numeracy skills. Many studies have discussed the weakness of scientific literacy skills. The average research leads to students' understanding of the nature of science (Khishfe, 2017; William F. McComas, 2015; Putri et al., 2021). The nature of science is one of the important elements in scientific literacy, because it is the main goal of learning IPA (Yanuar & Widodo, 2021). If you look at several reference sources related to the nature of science, there is no specific agreement on the definition. But in general it can be concluded that the nature of science is an aspect related to products, processes and attitudes and their characteristics (Glynn & Winter, 2004; Lorsbach et al., 2019) The nature of science is an aspect that cannot be separated from science. To understand the nature of science we need

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to understand the concept of knowledge which includes philosophical, sociological, and historical (Kampourakis, 2016). The nature of science refers to the epistemology of knowledge and sociology, namely knowledge as a form of knowledge or evaluation and belief which is the essence of scientific knowledge (Mudavanhu & Zezekwa, 2017). Science is basically based on the assumption that the natural world can be derived from human understanding of ontology, epistemology, and value theory (Jiang & McComas, 2014).

Previous literature explained that the nature of science includes products, processes and attitudes (Hacieminoglu, 2014). Science as a product includes principles, laws and theories related to nature and the various phenomena that occur in it. Science as a process is better known as science process skills, which are a number of skills to study all natural phenomena in a certain way and to acquire and develop that knowledge. Science as an attitude is an attitude that scientists have in seeking and developing their knowledge, for example: being responsible, objective, careful, etc. Meanwhile, in the latest literature related to the nature of science, more emphasis is placed on the properties of science (Widodo, 2021). The nature of science is concerned with (1) scientific knowledge is not completely objective; (2) scientists use creativity; (3) scientific knowledge is tentative; 4) scientific knowledge is socially and culturally embedded; (5) law and theory are different types of knowledge; (6) scientific knowledge is based on empirical; (7) there is no fixed scientific method; (8) there is a difference between observation and conclusion; (9) science is limited; (10) cooperation and collaboration are needed to develop knowledge; (11) there is a difference between science and technology; (12) experiments have an important role in science (William F. McComas, 2015). There are seven properties of the nature of science including: (1) tentative, (2) subjective, (3) empirical, (4) scientific method, (5) socio-cultural, (6) theory and law and (7) creative (Ari Widodo et al., 2019). If examined in more depth there is no difference from these opinions, the only difference is from the point of view that certain aspects are important to be raised separately.

The application of the nature of science, especially in elementary schools is still low (Nugraheny, D. C., & Widodo, 2021; Sutinah & Widodo, 2020). Based on the findings in the field, teachers still feel unfamiliar with this term (Jumanto & Widodo, 2018). The reasons why the nature of science is very important to be developed, including: (1) Utilitarian, the nature of science is needed to understand science and its use in everyday life, (2) Democratic, the nature of science is needed for making a decision related to socioscientific, (3) Cultural, the use of knowledge related to scientific values as part of contemporary culture, (4) Moral, the nature of science helps develop an understanding of useful norms about general values in society, (5) Science learning, the nature of science bridging material related to science learning (W. F. McComas, 2017). Another factor is that there are still many learning designs made by teachers in the classroom that seem monotonous. This can lead to boredom or burnout. Such learning makes students unmotivated to learn (Andrini, 2016; D. S. Wardani et al., 2021). Previous research has shown that the nature of science is very important to be taught, especially at the elementary school level. Efforts that can be made to develop the nature of science are to use learning models that can stimulate elementary school students to be active and find their own knowledge through investigation so that they can improve their skills and knowledge independently. One of them is by using the inquiry model.

The inquiry model is a learning activity that prepares students to do something, use the symbols they find, make questions and find answers to their own questions (Maaß & Doorman, 2013; Schallert et al., 2020). The steps of the inquiry model include: (1) formulating questions, (2) planning an investigation, (3) carrying out an investigation, (4) analyzing data, (5) drawing conclusions and (6) communicating (Eggen & Kauchak, 2012). Through this learning step, it encourages students to be active, think critically, discover and explore their knowledge so that they can confidently formulate their findings (Jajang Bayu Kelana & Wardani, 2021). In addition, inquiry in science learning focuses on the involvement of students in developing their real knowledge, both related to concepts or scientific reasoning skills. Learning science is not only memorizing scientific facts and information, but also about how to understand, apply scientific concepts and methods in everyday life (Jocz et al., 2014; Lazonder, 2013). The explanation above proves that the inquiry model can be used in science learning. Previous research has not involved many learning models in an effort to develop the nature of science in the form of product dimensions, processes and attitudes and characteristics. For this reason, the purpose of this researcher is to reveal how the inquiry model affects the ability of the nature of science and its nature in elementary school students.

2. METHOD

This study uses a quantitative method with a pre-experimental design type of pre-test and post-test one group design (Creswell, 2014). This method was chosen because the data selected was only one group and without a comparison group. The research design is presented in Table 1.

Table 1. Research Design

	Pretest	Treatment	Postest
Grup	O_1	X	O_2

To streamline time, cost and effort, the research subjects were chosen as representatives of the population. The subjects of this study were fifth grade elementary school students with a research sample of 36 students and assumed to have the same characteristics. The instrument was prepared based on a planned learning design and was validated in the field and then validated to experts and colleagues who also conducted similar research with other learning designs. The components in the nature of science include products, processes and attitudes, for that the instruments in this study used test questions (products), student observation sheets (process) and questionnaires (attitudes). The test instrument used to measure the product (related to cognitive) is 10 questions. The description of the cognitive dimensions in this test is as shown in Table 2.

Table 2. Product Dimensions (Cognitive)

Cognitive	Aspect	Total
C1	Recognize	2 items
C2	Give an example	4 items
	Classification	1 item
C3	Implementation	2 items
C5	Evaluation	1 item

The process dimension uses student observation instruments consisting of observing, experimenting, processing data and communicating. While measuring the dimensions of attitude using a questionnaire. This instrument uses a Likert scale (4,3,2,1) which consists of 20 statements. The statements contained in the questionnaire are also related to the properties that exist in science. There are 10 properties developed, for more details can be seen in Table 3.

Table 3. The Nature of Science

Aspects	No item	Total
Tentative	1, 2, 3	3
Subjective	4,5	2
Empirical	6,7,8,9	4
Socio-cultural	10,11	2
Limitations	12,13	2
Scientific method (process)	14	1
Scientific method (attitude)	15,16	2
Law and theory	17	1
Science and technology	18	1
Creative	19,20	2
Total		**20**

The procedure in this research can be described as follows: 1) the preparation stage includes the licensing process to the school, determining research samples, studying literature, making instruments and testing instruments. the instrument was compiled, consulted with experts and then validated and analyzed using the help of Ms. Excel and SPPS 23; 2) the implementation stage, including giving pretest-posttest, giving treatment using the inquiry model and observing students during the learning process. 3) the evaluation stage includes collecting, processing and analyzing data from research that has been carried out previously. The design for the use of the inquiry model in the development of the nature of science and its nature is as shown in Table 4.

Table 4. Stages of the Inquiry Model in Learning

Structure in Students	Stages Structure	Model in Teachers
Thinking and asking questions about a phenomenon then determining the questions to find out the answer to	Formulating research questions	Formulating research questions Raising conditions that arouse students' curiosity

Structure in Students	Stages Structure	Model in Teachers
Plan the steps to answer the question you want to know the answer to	Planning an investigation	Directing the research design will be carried out by students
Gather the evidence needed to answer the question	Carry out research	Guiding students to carry out investigations and data collection
Analyze the suitability of the evidence obtained with the questions	Analyze data	Directing how to interpret the evidence obtained by students
Making conclusions based on the evidence obtained	Conclusion	Help find patterns and relationships of data owned by students
Communicating the results obtained	Communicating	Communicating the results obtained
Communicating the results obtained	inquiry	Generate new problems to strengthen the inquiry skills that have been learned

The data obtained from the results of this study are divided into quantitative and qualitative data. Quantitative data were obtained from test questions, both pretest and posttest. Pretest and posttest result data is needed to see the extent to which students' mastery of product (cognitive) dimensions before and after learning is given. Data analysis regarding this initial ability was obtained through a pretest. The questions used in the pretest are questions that have been tested first with specified validation and reliability. After being given treatment, students were given a posttest at the end. Qualitative data obtained from student observation data and questionnaires. For student observation data, it is adjusted based on the grid that has been made. Students were observed their learning activities using the instrument. Then see what the total percentage for each meeting is and interpreted using the criteria Table 5.

Table 5. Student Observation Criteria

%	Interpretation
81 % - 100%	Very well
61 - 80%	Good
41 - 60%	Enough
21 % - 40%	Not enough
0 % - 20 %	Less once

The questionnaires were analyzed based on the nature of the nature of science, then described, compared with one another and conclusions were drawn from the results of the research.

3. RESULT AND DISCUSSION

Result

The results of this study related to student mastery in the product dimension (cognitive) are as shown in Table 6.

Table 6. Result of product dimension analysis (cognitive)

Data Type		Pretest	Postest
N		36	36
Mean		5.81	7.25
Std. Deviation		2.471	1.592
Std. Error Mean		0.412	0.265
Normality test	Sig.	0.062	0.216
	Description	Normal	Normal
t-Test	Sig.2-*tailed*	0.000	
	Description	Significant	

From the data in Table 6, the average pretest data was 5.81. Meanwhile, the posttest average value is 7.25. The number of students used as the research sample was 36 students. Std value. Deviation in the pretest is 2.471 and the post-test is 1.592. For the value of Std. Mean error for pretest is 0.412 and for post-test is 0.265. Based on these data, the mean value of pretest was 5.81 < posttest was 7.25. So, it can be said

that there is a difference in the average cognitive ability of students. Based on the normality test, it is known that the results of the pretest and posttest data have P-values (Sig.) of 0.062 and 0.216, respectively. Thus, the pretest and posttest P-value (Sig.) data is greater than = 0.05, so H_0 which states that the data comes from a normally distributed population is accepted. That is, the posttest and pretest data are normally distributed.

Homogeneity testing between pretest and posttest was conducted to determine whether the variance of the two test classes was the same or different. It is known that the results of the homogeneity test have a P-value (Sig.) of 0.124 which is greater than = 0.05, such conditions indicate that H_0 is accepted. Thus, there is no difference in test variance or it can be said that the data is homogeneous. Furthermore, for further evidence, the paired sample t test will be used at a significance level of = 0.05. The P-value (Sig.2-tailed) is 0.000. Because P-value (Sig.1-tailed) is required, the P-value (Sig.2-tailed) 0.000/2 = 0.000 is smaller than 0.05. So H_0 is rejected and H_1 is accepted. Thus, learning with the inquiry model significantly increases the product dimensions (cognitive) of students in elementary schools. To measure the mastery of the process dimensions using student observation instruments. The aspects observed in the observation instrument include: observing, experimenting, processing data and communicating. The recapitulation of the results of student observations during the learning process is Based on the data above, there was an increase in student activity during learning. The first meeting the percentage reached 54.7% and the second meeting the percentage reached 62.3%. The average value reaches 58.2% and if it is interpreted there is a sufficient category.

The questionnaire was used to measure the mastery of the attitude dimension. This instrument is given to students after the learning is carried out. The questionnaire given contains 20 statements covering 10 traits in the nature of science. Each statement contains four responses, namely the words SS (strongly agree), S (agree), TS (disagree), and STS (strongly disagree). Table 7 present the results of the questionnaire that has been given to students.

Table 7. Recapitulation of Questionnaire Results with their Characteristics

No	Characteristic	%
1	tentative	83.33
2	Subjective	77.08
3	Empirical	82.12
4	Socio-cultural	79.86
5	Limitations	78.47
6	Scientific Method (Process)	85.42
7	Scientific Method (Attitude)	74.65
8	Law and Theory	84.72
9	Science and Technology	86.11
10	Creative	80.21
	Average	**81.20**

The result of the interpretation of the questionnaire in the table above shows that the one that gives the biggest contribution is the nature of science and technology at 86.11%. While the smallest trait is the nature of the scientific method (attitude) of 74.65%. The difference between the properties of one and the other does not contribute much difference. The average value of the nature of science is 81.20% or in good criteria.

Discussion

Increased ability in the science learning process is closely related to the mastery of the nature of science. For this reason, a good understanding of the teacher is needed to design learning that can develop mastery of the nature of science in students (Dogan & Abd-El-Khalick, 2008);(Kelana, dkk, 2021). The nature of science is not only limited to the dimensions of products, processes and attitudes, more broadly it must develop the properties that are in it as well. Science is seen as a product because it studies and examines phenomena that occur in nature scientifically and systematically. Research will produce a product in the form of theories, principles, laws and facts that are useful for human life. Science as a product contains principles, laws, and theories that can explain and understand nature and the various phenomena that occur in it (Bundu, 2006);(Wardani,, et al., 2021). The results of the study show that through the application of the inquiry model, it can be an alternative to develop product dimensions (cognitive) (Ong et al., 2021);(Hastuti et al., 2020). Students' ability to recognize, give examples, classify, implement and evaluate is honed by applying this model. The inquiry model provides the widest opportunity for students to find and investigate the concepts they are learning. Based on the view of constructivism which views that people

produce knowledge and form meaning based on their experiences (Serevina et al., 2018). In using the inquiry model, students get the necessary instructions or it can be in the form of directing questions. So that students can work independently in solving these problems (Sesunan et al., 2021). The product (cognitive) in the form of knowledge or understanding of science is obtained based on direct experience. These experiences will become specific patterns that exist in science.

The scientific process is a set of skills used in studying natural phenomena so as to generate knowledge and develop that knowledge. Through these science process skills, students will behave like experts or scientists when they study science. These process skills include observing, experimenting, processing data and communicating (Özgelen, 2012). Measurement of mastery of the process dimensions through student observation sheets showed sufficient results. There was an increase in student activity during the learning process with an average score of 58.2%. This is inseparable from the syntax contained in the inquiry model. Students are faced with problems, the solutions to these problems are investigated and found by themselves according to their abilities. The teacher stimulates and encourages students to be able to ask their own questions, then gives students the opportunity to conduct investigations based on the questions made and find the answers themselves. In this process, the teacher guides students to be able to go through the stages that are adjusted to the lesson plan. The inquiry model has an effect on students' science process skills Mardaleni et al., (2019). This model can create effective learning and encourage students to experiment actively, independently, and cooperatively. Saying that the results of learning science through the scientific process leave a deep impression and are not easily forgotten by students (Kelana et al., 2020);(Sari et al., 2020). Thus, learning will be more meaningful for students' lives. The skills or competencies that have been obtained can also be used as the basis for solving problems encountered in everyday life.

Scientific attitude is the attitude that scientists have in seeking and developing new knowledge, such as being objective, careful, responsible, open-minded, always wanting to learn, and so on (Wildayanto & N, 2020);(Supardi et al., 2019). In the latest reference sources, scientific attitudes also cover their characteristics, including tentative, subjective, empirical, socio-cultural, limitations, scientific method (process), scientific method (attitude), law and theory, science and technology, creative. Scientific attitudes can be developed by learning that takes place in schools (Fitriani et al., 2020);(Kadmayana et al., 2021). The development of scientific attitudes cannot be taught through certain units of study, scientific attitudes can be developed through positive examples that must be continuously supported, fostered and developed so that they can be owned by students. In this study, the measurement of the dimensions of scientific attitude used a questionnaire instrument containing 10 properties of the nature of science, data analysis showed the average value on good criteria. The development of the nature of science is expected to make a major contribution to the improvement of the learning process that aims to achieve the objectives of science learning (Sutinah & Widodo, 2020). The process of learning science so far is still dominated by teachers so that it only touches the cognitive abilities of students (Sulistriani et al., 2021). The lack of innovation has an impact on the scientific attitude of students. By participating in learning using the inquiry model, students are expected to further develop their scientific attitude (Pamuji et al., 2019).

4. CONCLUSION

The ability of the nature of science and is something that is very important to be taught in elementary schools. This is because the nature of science is an element in the development of scientific literacy. To develop this ability, support from various parties is needed, especially from the teacher himself as a practitioner in the field. The results of the study indicate that the inquiry model can improve the ability of the nature of science and its nature in students in elementary schools. The components in the nature of science which include products, processes and attitudes and ten properties, show average results on good criteria. Therefore, teachers can use the inquiry model as an alternative in developing components and traits related to the nature of science. In future studies, it is hoped that they can develop other models/approaches/strategies/methods, in order to improve students' abilities towards the nature of science and its characteristics.

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