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"HOPE" Learning Model to Improve Elementary School Students in Understanding of The Tentative Aspect Nature of Science (NOS)

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Abstract

The "HOPE" learning model is used to determine differences in understanding the nature of science (NOS) in tentative aspects of elementary school (SD) students before and after learning. The method used is pre-experimental with one group pre-test and post-test design. The respondents of this study consisted of 32 public elementary school students. Questionnaires for understanding the nature of science and interview sheets are the instruments of this study. The data obtained were analyzed by Wilcoxon test using SPSS ver. 23 at α (0.05). The results of the study showed that there were differences in understanding the nature of the tentative aspects of science in students before and after learning using the "HOPE" model. It can be concluded that the "HOPE" learning model has an effect on increasing understanding of the nature of science in the tentative aspect.
Keywords: Nature of Sience, Learning Model, Elementary Science

INTRODUCTION

The Nature of Science describes science as a way of knowing (Fouad et al., 2015). The main goal of learning science is to develop scientific literacy and understand key aspects of NOS. This is considered a key factor in developing scientific literacy (Abd-El-Khalick, 2001p.; Akerson et al., 2019; Khishfe, 2022). There is no universal agreement on the meaning or definition of NOS, but NOS is usually defined as the epistemology of science, science as a way of knowing, or the values and beliefs attached to scientific knowledge and its development (Lederman et al., 2007).

According to McComas (2017), Nature of Science (NOS) can be defined as the nature needed to connect science with technology and all processes in life, form decision-making skills in socio-science issues and respect the value of science as part of contemporary culture. The nature of science consists of (1) tools and products of science (empirical evidence, scientific methods, differences in theory/law); (2) science knowledge and its limits (science is different from technology, science is tentative but of duration, science cannot address all questions); and (3) human elements of science (creativity, subjectivity, social and culture).

NOS is a part of science that must be taught by teachers but is often neglected or receives little attention. NOS can provide students with important background on how science and scientists work and how scientific knowledge is created, validated, and influenced (W. F.

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McComas, 2015). NOS understanding nurtures students' interest and encourages appreciation for science (McComas, 2020). Discussions about NOS or the nature of natural science in Indonesia usually focus more on natural science components, namely natural science as a product, process and scientific attitude. In science learning, there are also three kinds of learning outcomes that you want to develop, namely knowledge, attitudes commonly known as scientific attitudes, and skills that are popular with process skills in learning science (Nur Kumala, 2016). The newer literature on the nature of science generally focuses more on the characteristics of science, for example that knowledge of science is tentative, subjective or that the scientific method is not the only method for gaining knowledge (Widodo et al., 2019).

Based on the results of several science learning researchers in elementary schools, they still do not teach science with the nature of science. (Lederman et al., n.d.) shows that elementary to high school students and their educators have not achieved the desired understanding of NOS. Bell, (2010) states that learning in schools about NOS has not reached the expected understanding, both the understanding of educators and their students. Textbook sources and learning processes used in teaching science still focus on scientific knowledge while scientific investigations, scientific thinking and social aspects of science are not optimal (Kampourakis, 2016). Research on NOS in Indonesia has been widely carried out which aims to see how students and educators understand NOS. The results of the study of Nurhayati & Widodo (2021), show that there are differences in the understanding of NOS by elementary school students before and after using the NOS learning model as a method. The NOS learning model has a significant effect on the level of understanding of NOS by fifth grade elementary school students (Lestari & Widodo, 2021). Understanding of NOS prospective educators and elementary school educators in the good category (Rahayu & Widodo, 2022). Both educators and students have an understanding of NOS in the moderate category range (Adi & Widodo, 2018). The results of the research of Putri et al., (2021) regarding the analysis of science in the elementary school science curriculum and its embodiment in student books, it can be concluded that in general the 2013 curriculum in science subjects and elementary school students' books has shown aspects of the nature of science (NOS). However, there are still several aspects of the nature of science that have not been explicitly addressed, such as attitudes, process, empirical, tentative, theory and law, social culture, and scientific method. An understanding of NOS is a very important understanding in science learning. This is reinforced by the opinion of (Lederman et al., n.d.) that NOS is part of an understanding of the nature of science as a

whole. This understanding includes the nature of empirical, creative and imaginative, embedded social and cultural as well as tentative nature.

Students' views on the nature of science are tentative, being the most studied aspect of NOS (Metin & Leblebicioglu, 2012). Some studies report that students' views about the tentative nature of science show a lack of understanding (Khishfe, 2008). The pre-research from this study also showed the same results. The pre-research was conducted on 432 respondents in two cities, namely Bandung and Lampung. There are three aspects of NOS that are still poorly understood by elementary school students, namely empirical, tentative, and culturally influenced. The results of Metin & Leblebicioglu (2012) research using the science camp method show that elementary school students accept that science changes or is tentative.

According to (Bromme & Goldman, 2014) findings in science should be viewed as tentative and provisional, possibly subject to falsification or reconceptualization when different interpretations lead to altered conclusions or when future research provides new evidence that may lead to different explanations. The discovery of new tools, techniques, and interpretations can change our initial view of science because science is constantly adjusting with occasional radical changes (McComas, 2020). Earth is no longer the center of the universe, species change, continents shift and so on. Lack of understanding of the tentative nature of science can lead to the false impression that scientific findings are unreliable (Fouad et al., 2015). Students need to be taught about the tentative aspects of NOS so they don't feel wrong if they find new evidence. Learning about the tentative aspects of NOS teaches students to have the courage to come up with new things and that different (new) things must be appreciated as an effort by researchers to reveal the truth.

NOS learning using various models or methods has been carried out by many educational researchers. The NOS learning model is a constructive learning model through an inquiry approach where students are placed as subjects in learning or student centered (Sudirgayasa et al., 2014). NOS learning develops towards the enrichment of the methodology for teaching aspects of NOS explicitly (Metin & Leblebicioglu, 2012). This study uses a learning model that begins by first determining the cognitive structure of students and educators. After that, determine the outer cognitive structure of students and educators so that a learning model is obtained to improve one of the aspects of NOS that is still low in elementary schools, namely the tentative nature of science. From the results of the previous study, which was conducted on 334 elementary school student respondents in the city of Bandung and Lampung city, the researchers obtained data that there were four aspects of NOS that were still

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low, namely, empirical, tentative, socio-cultural and subjective influences. The learning model designed by researchers is named the HOPE model to increase understanding of tentative aspects. The syntax of the HOPE learning model to improve understanding of tentative aspects begins first by determining the structure of students and educators. After that determine the outer structure of students and educators so that a learning model design is obtained that is in accordance with science learning. The syntax of the HOPE learning model can be seen in Table 1.

Tabel 1. Syntax of "HOPE" Learning Model

Syntax	Teacher's Activity	Students' Activity
History revealed (inner structure)	Attract students' attention through changing scientific phenomena	Students questioned changing scientific events/phenomena
(outer structure)	The teacher shows a picture or videos of the history of changes in a phenomenon	Students ask questions why there is a change
Observation	Helping Students analyze changes in science	Students analyze changes in scientific phenomena shown at the beginning by gathering evidence and by reading the worksheet, discussing and drawing mind map/diagrams in groups
	Educators provide student worksheets and circle around to ask and monitor the group works	Students conduct group discussions to analyze changes in science
Presentation	The teacher helps students to interpret changes in phenomena from the results of the analysis	Students interpret changes in phenomena from the results of the analysis
	Teacher could display the video again or listening and make notes to the group presentation	Students present their result of discussion in the observation stage
Evaluation	Forming students' understanding that science changes	Formed understanding that science is tentative
	Educators guide students to carry out self-evaluations.	Students understand that science is changing or tentative through questions asked by the teacher

The use of the HOPE learning model refers to Bruner's theory of learning science in elementary schools. Bruner put forward a learning model called the discovery learning model.

According to Bruner, the learning process is more important than learning outcomes. In line with Bruner's learning theory, the purpose of discovery learning is not only to gain knowledge, but to provide motivation, train thinking skills, and develop students' curiosity (Rokiyah, n.d.).

The HOPE learning model was carried out to measure the tentative aspects of NOS understanding of elementary school students. The question of this research is whether there are differences in students' understanding of NOS in primary schools before learning using the HOPE model and after learning using this model, and how to increase the tentative aspects of NOS from differences in gender and interest in science.

METHOD

This research was conducted on November 29, 2022, at one of the leading public elementary schools in Bandung. The purpose of this study is to introduce the history of science material, namely about electricity and one aspect of NOS (tentative) to students. This type of quantitative research uses pre-experimental, pretest and posttest one group design methods (Creswell, 2014). The method used aims to obtain information about the understanding of NOS of elementary school students before and after treatment. The treatment in this study uses the HOPE learning model. This model adopts a learning model that emphasizes how students learn and think.

1. Participant

The participants of this study were 32 class VI students of a public elementary school in Bandung City. The majority of respondents consisted of 21 female students and 11 male students. The age of the respondents is between 11 to 13 years. Respondents who are interested in science are 91% and non-science are 9%. Respondents who aspire to move in the field of science as many as 6 people. Figure 1 below shows the percentage of respondents by gender.

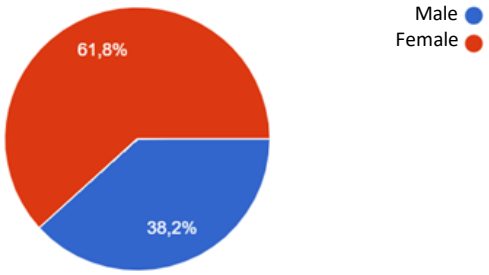

Figure 1. Percentage of Respondents by Gender

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2. Data collection

Data was collected through distributing instruments in the form of NOS understanding questionnaires and interview sheets. The NOS understanding questionnaire consists of 10 questions adapted from a questionnaire developed by Jumanto & Widodo, 2018. The ten statements were developed using a Likert scale with four possible answer choices of strongly agree, agree, disagree and strongly disagree. The NOS understanding questionnaire was developed in accordance with the NOS aspects taught in this lesson, namely the tentative aspect. Here are the ten statements in the instrument:

a. Existing knowledge can change if there is new knowledge that is more convincing.
b. IPA cannot be wrong because it was developed by scientists in a way that is often used.
c. If new research turns out to have different results from existing knowledge, it means that the new research is wrong.
d. Science, both past and present, may contain errors.
e. Knowledge from other fields may be wrong but that is not possible for science.
f. Science that has been written in a book cannot possibly contain errors.
g. Science can change if there are new scientific discoveries.
h. Natural science cannot be wrong because it has been developed through repeated experiments.
i. In the future, natural science may change.
j. Scientific knowledge can change through the interaction of scientists with other scientists.

3. Data analysis

The data that has been obtained was analyzed descriptively quantitatively by calculating the percentage of students' answers regarding the understanding of the tentative aspect of NOS. Next, the data were analyzed inferentially (paired-sample t-test) using SPSS ver. 23 at $\alpha=0.05$ in order to determine differences in understanding of the tentative aspects of NOS before and after being taught using the HOPE learning model. Differences in students' understanding of NOS can be seen from differences in gender and interest in science. The learning process is recorded in a learning video so that researchers can re-analyze the activities at each stage carried out by educators and students.

RESULTS AND DISCUSSION

Results

Students' views on the tentative aspect of NOS seen before and after learning using the HOPE model can be seen in Figure 2 below.

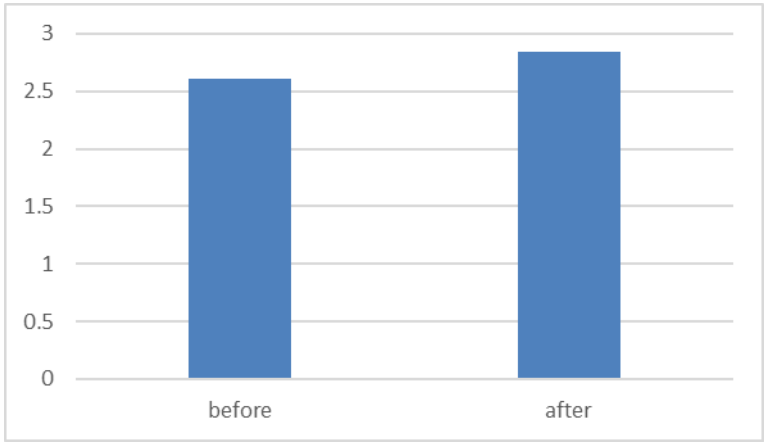

Figure 2. Average Score of Tentative Aspects of Elementary School Students' NOS Understanding

Figure 2 shows that there is an increase in students' understanding of the tentative aspects of NOS before and after learning using the HOPE model. Prior to learning using the HOPE model, the average NOS understanding of students in the tentative aspect was 2.61. After learning the HOPE model, the average NOS score is 2.84, an increase of about 0.2 points. It can be concluded that there are differences in the understanding of NOS among elementary students before and after being given the HOPE learning model, which means that there is an influence of the HOPE learning model on increasing the understanding that science is tentative. To see whether there is a significant difference in students' understanding of NOS before and after giving the HOPE model, the data was tested using a paired sample t-test using SPSS ver. 23 at α= (0.05), and the following output is obtained.

Table 2. The Average Value of Understanding the Tentative Aspects Of NOS Before and After Learning the HOPE Model

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Before	26,16	32	3,539	0,626
	After	28,4063	32	3,56379	0,63000

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Based on Table 2 above, it can be seen that there are differences in students' understanding of the tentative aspects of NOS before and after learning using the HOPE model. Prior to learning, the average understanding of NOS was 2.61 while after giving the HOPE learning model the average understanding of students' NOS in the tentative aspect was 2.84. It can be concluded that there are differences in understanding NOS of elementary school students before and after giving the HOPE learning model. To determine whether the difference is significant, the data was tested using a paired sample t-test using SPSS ver.23 software at α=0.05 and the following results were obtained.

Table 3. Paired-Sample T-test results

		Paired Differences							
					95% Confidence Interval of the Difference				Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	
Pair 1	before - after	-5,62500	5,57211	0,98502	-7,63396	-3,61604	-5,711	31	0,000

Based on Table 3 above, a sig value of 0.000 is obtained. The sig value of 0.000 is smaller than α = 0.05, then Ho is rejected and H1 is accepted, which means that there is a significant difference between the understanding of NOS in before the learning of HOPE model and after. There are significant differences in the use of the HOPE learning model before and after learning. The next analysis is based on differences in gender in general. The following is an overview of the number of respondents based on gender along with the results of their responses to the tentative aspect of understanding NOS. The results of the analysis based on gender differences in general can be seen as follows.

Based percentage of respondents by gender, it can be concluded that the number of respondents in this study was dominated by female, namely 61.5%, while male were 38.2%. Comparison of the mean scores of tentative aspects of NOS understanding by gender can be seen in Figure 3 below.

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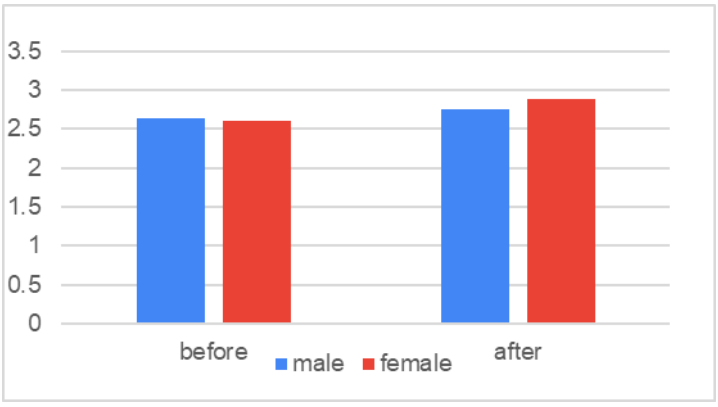

Figure 3. Average NOS Understanding of Students in Tentative Aspects by Gender

Based on Figure 3, it can be seen from the gender difference that it turns out that male and female respondents have an average percentage, the difference is not too distinct. Prior to learning, the average understanding of male and female students was not much different and that of female respondents was slightly lower. However, after learning, the average understanding of female respondents was higher than that of male respondents, namely 2.88 an increase of 0.28 points compared to the previous 2.6, while male students increased 0.12 from average score before 2.64 and after 2.76.

Questionnaire related to the tentative nature of NOS, consisting of 10 statements, positive and negative. The results of the average per item before and after learning can be seen in Figure 4.

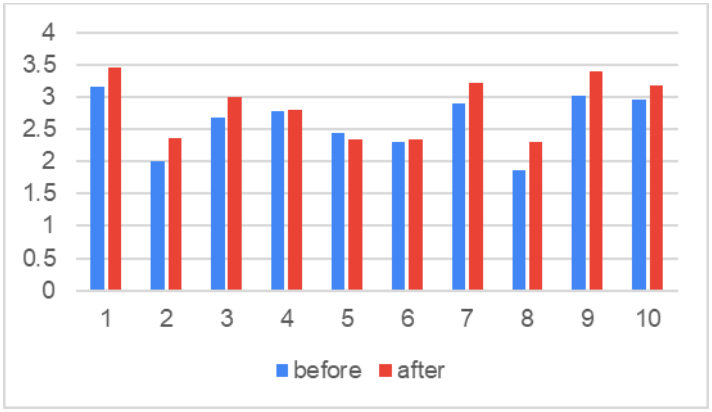

Figure 4. Average NOS Understanding of Students on Tentative Aspects per Statement

In Figure 4 it can be seen that the average understanding of students' NOS has increased after learning using the HOPE model, except for questions number 5 and 6.

Discussion

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The purpose of this research is to see the understanding of tentative aspects of NOS in elementary school students using the HOPE learning model. The stages of activity in this model begin with a presentation about the history of electricity and end with group presentations and strengthening through evaluation. The results show that the majority of students' views on the tentative aspects of NOS develop during learning. It can be seen in Figure 1, where the average score of understanding of the tentative aspect of NOS has increased. This is in line with the results of research (Lestari & Widodo, 2021) that the application of the NOS learning model explicitly helps students to understand the nature of science holistically. Likewise with research results (Rahayu & Widodo, 2022) that the responses of students and educators to understanding science in the digital era are in the good category with a percentage of 68.7%.

To see differences from gender, it can be seen in Figure 2 that before learning, the average score of male students was higher than the female group. However, after learning took place, the average score of the female group was higher than that of the male. This can be explained by the less balanced number of male and female respondents. 61.8% female students or 21 students and 11 male students. As we Viewed from the cognitive style or cognitive activity, women have a field-dependent cognitive style. According to (Griggs & Dunn, 1984), the field-dependent style is stronger in remembering social information such as conversations or interpersonal interactions. Women are more sensitive to social relations in terms of history, language literature and social studies (Widayanti, 2015). In the second stage of the learning model, namely the observation stage, the main activity of the students is reading the information in the LKPD (worksheet) and then discuss in groups. In a more in-depth interview, students were asked about their goals. Even though those who are interested in science are 90.9%, only 25% or 8 students aspire to work in science and all six are female students, while the rest aspire to sports, social studies, music, and become a youtuber.

Grade VI students do not come to class with null knowledge of science. They already know about natural science especially from books and lessons in previous classes. However, for the tentative aspect, not all students are convinced that knowledge contains errors and can change if new knowledge emerges, which can be seen from Figure 4 in questions number 5 and 6. (Widodo et al., 2019) states that although educators have a good understanding of NOS, but it is not always certain that it is in line with their students. It is assumed that educators who already understand NOS do not necessarily understand how to teach it. When analyzed from the learning video recordings, at the evaluation stage there is less re-emphasis on the tentative

aspect of the NOS concept. At this evaluation stage the teacher should ask students to conclude before working on evaluation questions.

In evaluating students' responses to the statements submitted in the questionnaire, we took into account their young age. Even though they are already in grade VI SD, not all students can articulate statements properly. There are one or two students who still have difficulty understanding sentences, especially statements that, according to their perception, are doubtful. Statement number 5 is "Science from other fields may be wrong but that is not possible in natural sciences" and statement number 6 is "Knowledge that has been written in a book cannot possibly contain errors". After being interviewed personally, they said that according to their perception the two statements were positive that knowledge had been written in the book could not possibly contain errors. Their opinions related to the material of electricity and solar system. According to them "electricity has not changed in the past". This should be anticipated at the evaluation stage, where the teacher asks students to conclude. However, due to time constraints, the teacher did not give enough reinforcement at the Evaluation stage.

The results of interviews with several students showed positive changes that occurred in students' views on the tentative aspect of understanding NOS. Several students were interviewed to ask for their opinion whether through the HOPE learning model made them understand better that science is tentative. Of the 4 students interviewed, all agreed that the HOPE learning model changed their views about science. The students stated that at the Observation stage they found answers to questions.

The first stage of the HOPE learning model is that students watch videos about the history of electricity and solar system (History revealed). From this broadcast, questions will arise from students: why does science change? Then in the second stage, namely the Observation stage, students are given the opportunity to read the information written in the worksheet. At the Observation stage, students discuss and observe the pictures in the worksheet. After that, students re-illustrate the history of changes through charts/sketches. The next stage is the Presentation stage. Preparation for entering the third stage, namely Presentation, students inevitably have to prepare better to present the results of their discussions in groups. The purpose of the presentation is to make it easier for them to better understand the intent of the material being taught. The HOPE learning model places students as active learning subjects. Learners are not learning objects that are flooded with information, but they are subjects who have potential. Therefore the learning process is directed to develop the students' potential. Attard et al., (2010) argues that the best learning process is involving students

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actively in learning the subject matter. In the learning process using the HOPE model, each stage involves students to actively use their thinking.

The results of interviews with several students showed positive changes that occurred in students' views on the tentative aspect of understanding NOS. The main method of the HOPE learning model is the interaction of students in group discussion which begins with giving a stimulus in the form of a phenomenon in the early stages so that questions arise in the minds of students so that they are expected to questioned the phenomenon. Scientific phenomena displayed by educators are accompanied by a strategy of asking, directing and exploring, can help the child's learning process interpret science concepts and processes properly (Fasha, 2020). Positive changes in students' understanding of NOS have been reported from the results of several studies showing that learning about science related to the nature of elementary science has proven effective (Widodo et al., 2019; Jumanto & Widodo, 2018; Lestari & Widodo, 2021; Nurhayati & Widodo, 2021; Rahayu & Widodo, 2022).

The most salient aspect of this study is the fact that tentative conceptions of science are not a separate group. On the other hand, the tentative nature of science is closely tied to other concepts about the nature of science that science is also empirical, subjective, has limitation, culturally influenced and science can not adress all questions. As with the knowledge of science, the knowledge of an individual learner must fit into a broader conceptual framework for the nature of science. The learner must see how all the pieces fit together. If the tentative nature of science is not given a rationale, then it is simply an isolated fact, devoid of context and meaning. In these cases, learners will produce their own explanations and justifications for the change of scientific knowledge, and these explanations may simply reinforce each learner’s misconception of what science truly is (Johnston & Southerland, 2001).

CONCLUSION

The results showed that the understanding of NOS of elementary school students in the tentative aspect was at a score of 2.61 with sufficient criteria. Understanding of the tentative aspects of NOS experienced significant differences between before learning and after learning using the HOPE model. Students learn about the nature of science (NOS) tentative aspects through historical exposure at the beginning until they can conclude that knowledge is tentative or subject to change. Explicit NOS activities make the tentative aspects of NOS even more explicit. Therefore the researcher suggests conducting further study in using the HOPE model to introduce the tentative nature of science, especially on other science topics and generally on

all subjects. If anyone is interested in conducting research using the HOPE model, the results of this research can be considered.

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