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Effect of the inquiry-based nature of science argumentation instructional model in scientific literacy skills

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ABSTRACT

The purpose of this study is to see how the inquiry-based nature of science (NOS) argumentation (IB-NOSA) instructional model affects scientific literacy skills. This research used a quasi-experimental method. The design of this research is a pretest-posttest control group design. This study describes the significance of the differences between participants who learn through IB-NOSA, guided inquiry, and discovery learning model. The subjects of this study were 288 students of grade VIII in the 2022/2023 academic year from three junior high schools in Sleman, Yogyakarta, Indonesia. Data analysis in this study used an analysis of variances (ANOVA) mixed design. The result showed that there was a difference between the pretest-posttest scores of scientific literacy skills in each group. There was a significant increase in the pretest-posttest scores of scientific literacy skills in each group. Effect size showed that the IB-NOSA in increased scientific literacy skills was 0.79; the guided inquiry was 0.76; and the discovery learning was 0.71. The IB-NOSA was the most effective in improving scientific literacy skills with a gain score of 0.49 (medium). So, it can be concluded that the IB-NOSA instructional model can be used as an alternative solution in improving scientific literacy skills.

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1. INTRODUCTION

The development of scientific literacy skills is one of the main future of science education. Therefore, students must be prepared for scientific literacy skills to be able to solve scientific problems [1], [2]. Scientific literacy skills are a person's skills to understand scientific laws, theories, and phenomena in everyday life [3]. Scientific literacy skills are important for a country to produce scientists who think scientifically so that students are cultured in the way of science [4], [5]. Scientific literacy skills are most noticed in students between the ages of 10-15 when they are transitioning from the concrete to the abstract stage [6].

Research on the scientific literacy skills profile of junior high school students in Indonesia shows that was still low [7]–[10]. According to the 2018 programme for international student assessment (PISA) data, Indonesian students' achievement in scientific literacy skills has not improved from 2000 to 2018. Indonesia was still rated 69th out of 77 countries. Despite being ranked ninth lowest in 2019, Indonesian students' achievement of scientific literacy skills has not improved [11]. In addition, the results of the

European Commission Research [12] show that between 4 and 32% of children aged 15 years in 41 countries are not sufficiently literate in science.

The factor that influences scientific literacy skills is the involvement of students in learning which is still low [13]. Additionally, it is created by a lack of connection between what pupils learn in class and what they encounter every day of their lives [14]. In simple experimental designs, students are unable to make the connections between everyday content and fundamental procedural knowledge to recognize scientific explanations, evaluate data, and come to reliable conclusions [15]. Schools need to improve the quality of learning to overcome students' low scientific literacy skills. An alternative to solving the problem of scientific literacy skills is by applying the correct instructional model.

The use of appropriate instructional models will support the achievement of learning objectives and educational goals. The inquiry-based instructional model is one model that can be used to improve scientific literacy skills. Inquiry is very prominent in science education because it can facilitate deeper learning and thus encourage active knowledge construction [16]. Many researchers have raised inquiry in natural sciences as a means to improve the various abilities of students [17]. The inquiry-based instructional model has several advantages including students can grow and have expertise through psychological means; students gain insight in solving problems; students can increase their thinking power, and students can construct their knowledge actively [18]. Through the inquiry-based instructional model, students can gain experience and knowledge of how scientific knowledge is built [19]. Recent international comparative studies, such as the PISA, have shown that the inquiry-based instructional model has a negative impact on scientific literacy skills [20].

The inquiry-based instructional model has the disadvantage of only being able to train students to design and carry out investigations. Meanwhile, the benchmark for the success of scientific literacy is that students must have a reason for carrying out an investigation and be able to make claims from the data obtained [21]. Additionally, studies based on the Italian longitudinal study of aging (ILSA) often show that inquiry is associated with lower science achievement [22]. The inquiry-based instructional model is positively related to outcomes when teacher guidance or scaffolding is applied, and negatively if it is not applied [16]. So, for the inquiry-based instructional model to be effective, teachers must add other components that can improve scientific literacy skills [23].

Teaching nature of science (NOS) in an explicit-reflective manner shows a positive impact on student learning outcomes [24]–[26]. The addition of explicit reflective training on the NOS and inquiry SI into traditional science coursework is designed to improve scientific literacy skills [21]. NOS is considered an important aspect of scientific literacy skills [27], [28] and understanding NOS includes key elements for science literacy [29]. Understanding NOS can improve science learning outcomes and is an important component for understanding scientific literacy skills [30]. NOS characteristics consist of empirical basis, inferential nature, tentativeness, scientific theories/laws, human creativity/imagination, subjective nature, and social/cultural influences [21], [31].

Argumentation is part of scientific literacy skills which shows an important characteristic of NOS [32]. The argument is a particularly essential feature of scientific language practices. It is critical for the consistent production of new scientific understandings [33]. Toulmin's argumentation model or scheme or toulmin's argumentation pattern (TAP) [34] consists of six components, namely claims, data, warrants, backing, qualifiers, and rebuttals which can be illustrated in any field of practical reasoning, although argumentation procedures developed in various fields of knowledge. The argument referred to in this study is argument mapping (AM). Based on Toulmin [34] AM is a representation using a box graphic model and arrows of how to structure arguments [35]. AM can make it easier for students to construct arguments [36]. Argumentation-based inquiry can help students form a point of view through scientific questions and scientific discussions where the approach includes the process of scientific thinking, writing, and discussing [37].

Therefore, it is very important to examine how to modify the inquiry-based instructional model. The modification is intended so that the inquiry-based instructiona model can improve scientific literacy skills. Therefore, modifications are made by integrating the inquiry-based instructional model, NOS aspects, and argumentation. The type of instructional model used in this research is guided inquiry. The name of the learning model is the "inquiry-based NOS argumentation (IB-NOSA) instructional model". The IB-NOSA instructional model has a novelty in the resulting syntax because it combines an inquiry-based instructional model, NOS, and argumentation. The components of the instructional model in this study refer to [38], namely rational theory, syntax, principles of reaction, social systems, support systems, and instructional and nurturant effects. Each component of the IB-NOSA instructional model also has special characteristics that are different from other instructional models. This study is guided by the research questions: i) Does the treatment between IB-NOSA, guided inquiry, and discovery learning models show differences in pretest-posttest scores for scientific literacy skills? ii) Does the treatment between IB-NOSA, guided inquiry, and discovery learning model show an increase in pretest-posttest scores for scientific literacy skills? iii) What is the effective contribution of using the IB-NOSA instructional model in improving scientific literacy skills?

2. METHOD

2.1. Settings and participants

The research was carried out at a public junior high school in Sleman, Yogyakarta, Indonesia. This study focused on science disciplines, which are required for all junior high school pupils to take. This research was carried out with permission from the head of the research school. In the research process, researchers act as observers and help prepare practical requirements. Meanwhile, science teachers teach in IB-NOSA, guided inquiry, and discovery learning model.

The subjects of this research were class VIII students at Public Junior High School 2 Ngalik, Public Junior High School 2 Mlati, and Public Junior High School 4 Depok for the 2022/2023 academic year, totaling 288 students. The number of students in each IB-NOSA, guided inquiry and discovery learning model was 96 students. The average age of students is in the range of 13-14 years. This research sample was selected through cluster random sampling.

2.2. Research design and procedure

This study is a quasi-experimental study with a posttest-pretest control group design. This study aims to investigate the effect of the IB-NOSA instructional model to improve the scientific literacy skills of junior high school students on additives and addictive substances. Based on interviews with teachers during needs analysis, it is known that the discovery learning model is often used by junior high school science teachers at the location of this research. This study consisted of one independent variable (IB-NOSA instructional model) and one dependent variable (scientific literacy skills). At the end of the sixth meeting, the IB-NOSA instructional model was compared with the guided inquiry and discovery learning model. To see which instructional model had the most influence on students' scientific literacy skills. The research design is presented in Table 1.

The components of the IB-NOSA instructional model and its tools have been validated by 4 expert lecturers through focus group discussion (FGD) activities. The data analysis techniques were used to process the results of feasibility and practicality tests. The product practicality feasibility analysis technique referred to [39] can be seen in Table 2. Table 3 shows a summary of the validation results of the IB-NOSA instructional model. These results indicate that the average overall score is 4.56 which indicates a very good category, so it can be concluded that the IB-NOSA instructional model is feasible to use and is ready to be used in science learning.

Table 1. Research design

Group	Pretest	Posttest
IB-NOSA	O_1	O_2
Guided inquiry	O_3	O_4
Discovery	O_5	O_6

Note: O_1, O_3, and O_5 are pretest of scientific literacy skills; O_2, O_4, O_6 are posttest scientific literacy skills

Table 2. Reference for changing the average score into categories

No	Formula	Average score	Category
1	$X > \overline{X}_i + 1.8 \times sb_i$	> 4.2	Very good
2	$\overline{X}_i + 0.6 \times sb_i < X \leq \overline{X}_i + 1.8 \times sb_i$	> 3.4-4.2	Good
3	$\overline{X}_i - 0.6 \times sb_i < X \leq \overline{X}_i + 0.6 \times sb_i$	> 2.6-3.4	Average
4	$\overline{X}_i - 1.8 \times sb_i < X \leq \overline{X}_i - 0.6 \times sb_i$	> 1.8-2.6	Poor
5	$X \leq \overline{X}_i - 1.8 \times sb_i$	≤ 1.8	Very poor

Table 3. Validation results of components of the IB-NOSA instructional model

Aspect	Average score of each aspect				Average	Category
	Expert 1	Expert 2	Expert 3	Expert 4		
Rational theoretical model	4.50	4.75	4.75	4.75	4.68	Very good
Syntax	4.83	4.67	4.67	4.33	4.62	Very good
Social system	4.75	4.75	4.50	4.75	4.68	Very good
Principles of reaction	5.00	4.67	5.00	4.67	4.83	Very good
Support system	4.20	4.40	4.00	4.00	4.15	Good
Instructional and nurturant effects	4.50	4.75	4.00	4.50	4.43	Very good
	Average				4.56	Very good

2.3. Data analysis

The researcher used SPSS 24 to analyze the data in this study. Descriptive statistics were used to examine the profile's scientific literacy skills. The difference in the pretest-posttest of scientific literacy skills in each treatment was determined using a mixed-design analysis of variances (ANOVA) analysis. Before carrying out mixed-design ANOVA analysis, the assumption test must be met, namely normality and homogeneity, the results of which can be seen in Table 4.

Table 4. The normality and homogeneity test

Group	Pretest		Posttest	
	Normality	Homogeneity	Normality	Homogeneity
IB-NOSA	0.059		0.58	
Guided Inquiry	0.083	0.962	0.53	0.398
Discovery	0.052		0.53	

Based on the results in Table 4, the assumption test has been fulfilled ($p > 0.05$), so it can be continued with the mixed-design ANOVA analysis. The effect size was calculated to determine the strength of the difference in students' scientific literacy skills before and after treatment using the IB-NOSA, guided inquiry, and discovery learning model. The effect size value is seen in partial eta square with value provisions i) 0.01 or 1% are classified as small; ii) 0.06 or 6% are classified as medium; and iii) 0.138 or 13.8% are classified as large [40]. The level of learning effectiveness in IB-NOSA, guided inquiry, discovery learning model only was calculated based on the value of the gain score with Hake's formula [41] as in (1). The level of effectiveness is based on the above equation as $g \geq 0.7$ high; $0.7 > g \geq 0.3$ medium.

$$Gain\ (g) = \frac{x_{Posttest} - x_{Pretest}}{Maximum\ score - x_{Pretest}} \tag{1}$$

3. RESULT AND DISCUSSION

3.1. Result

The results of the effectiveness analysis were analyzed using ANOVA. The results of the analysis are the differences in pretest and posttest for each group, increased pretest and posttest scores for each group, and the effective contribution of using the IB-NOSA instructional model in improving scientific literacy skills. The following are the results of the effectiveness of using the IB-NOSA instructional model in improving scientific literacy skills.

3.1.1. Pretest-posttest differences in each group's scientific literacy skills

The difference in pretest-posttest scores of scientific literacy skills in the IB-NOSA, guided inquiry, and discovery learning model can be seen in Table 5. Table 5 shows that demonstrate a difference in the pretest-posttest scores of scientific literacy skills in the IB-NOSA, guided inquiry, and discovery learning (F = 12.381; p0.05). The presence of this difference suggests that the shift from pretest to posttest is significant in the IB-NOSA, guided inquiry, and discovery learning model.

Table 5. Result test of within-subjects

Source		Type III Sum of squares	df	Mean square	F	Sig.
Time * Group	Greenhouse-geisser	2585.448	2.000	1292.724	12.381	< 0.001

3.1.2. Pretest-posttest scores of scientific literacy skills increased in each group

Table 6 shows the effect of the IB-NOSA, guided inquiry, and discovery in increasing pretest-posttest scores on scientific literacy skills. The findings show that the significance level is 0.05, and there is a significant increase in the pretest-posttest scores of scientific literacy skills in the IB-NOSA, guided inquiry and discovery learning models. Furthermore, the Post Hoc test is being used to determine which groups differ from one another, as shown in Table 7. The results show that the IB-NOSA is significantly different from the guided inquiry group in terms of students' scientific literacy skills, while the IB-NOSA was significantly different from the discovery learning model, and the guided inquiry was significantly different from the discovery learning model.

Table 6. Result of pairwise comparisons

Group	(I) time	(J) time	Mean difference (I-J)	Std. Error	Sig.
IB-NOSA	Pretest	Posttest	-49.678	1.475	< 0.001
Guided inquiry	Pretest	Posttest	-45.365	1.475	< 0.001
Discovery	Pretest	Posttest	-39.354	1.475	< 0.001

Table 7. Result of post hoc test bonferroni type

(I) Group	(J) Group	Mean difference (I-J)	Std. Error	Sig.
IB-NOSA	Guided inquiry	5.05208*	1.67007	0.008
	Discovery	10.69792*	1.67007	< 0.001
Guided inquiry	IB-NOSA	-5.05208*	1.67007	0.008
	Discovery	5.05208*	1.67007	0.002
Discovery	IB-NOSA	10.69792*	1.67007	< 0.001

3.1.3. Effect size

The Multivariate Hotelling's Trace type test in the mixed method ANOVA was used to see the effective contribution of using the IB-NOSA, guided inquiry, and discovery learning model to students' scientific literacy skills. The effect size results can be seen in the Partial Eta-squared statistics in Table 8. Based on Table 8, show that the effective contribution of the IB-NOSA instructional model in increasing scientific literacy skills is 0.79 or 79%. The scientific literacy skills of students in the guided inquiry learning model are 0.76 or 76%. The effective contribution of the discovery learning model in improving students' scientific literacy skills was 0.71 or 71%. Based on the partial eta square value, the three models are in the large category for improving scientific literacy skills. However, the difference in scientific literacy skills scores with the IB-NOSA model is higher when compared with guided inquiry and discovery learning model. The comparison results of all groups analyzed using the gain score can be seen in Table 9.

The estimated marginal means graph shows the interaction between the IB-NOSA, guided inquiry, and discovery learning model. Figure 1 depicts the output graph of Estimated scientific literacy skills, which reveals the growth in scientific literacy skills in the IB-NOSA, guided inquiry, and discovery learning model. In addition, the achievement of the pretest-posttest average score for each aspect of scientific literacy skills can be seen in Figure 2. Figure 2 shows the results of a comparison of the average pretest and posttest scores for each aspect of scientific literacy skills from the IB-NOSA, guided inquiry, and discovery learning model treatments. The average percentage increase in posttests for each aspect of scientific literacy skills in the IB-NOSA instructional model is greater than in the guided inquiry and discovery learning model.

Table 8. Results of multivariate test hotelling's trace test between the three groups

Group	F	Sig.	Partial eta squared
IB-NOSA	1134.972[a]	< 0.001	0.799
Guided Inquiry	946.073[a]	< 0.001	0.768
Discovery	711.988[a]	< 0.001	0.714

Table 9. Gain score of all group

Group	Gain score	Description
IB-NOSA	0.49	Medium
Guided inquiry	0.45	Medium
Discovery	0.39	Medium

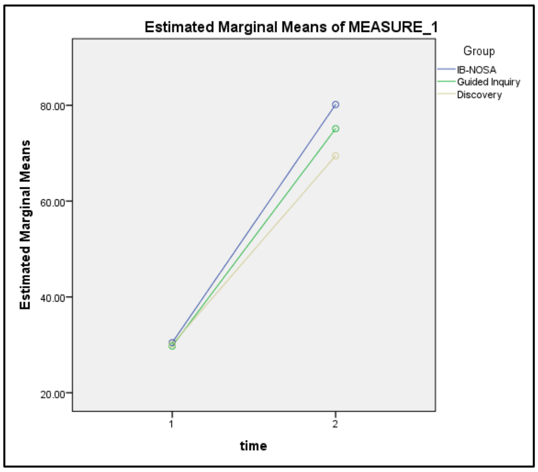

Figure 1. Profile graph plots of scientific literacy skills

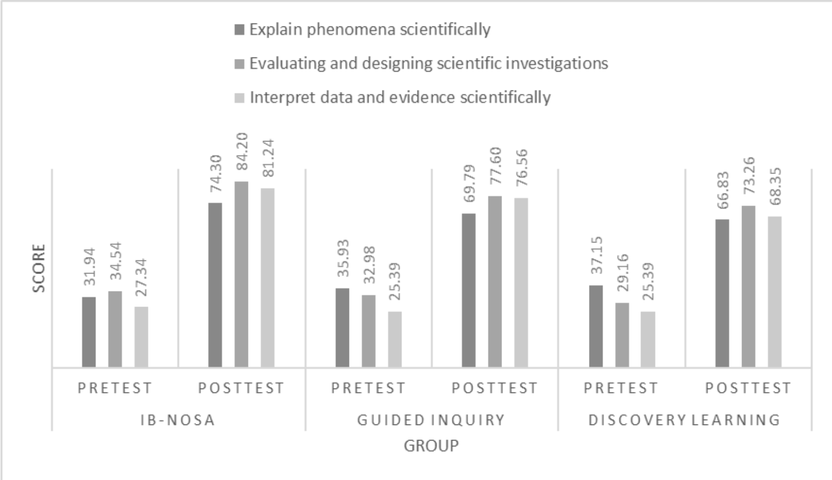

Figure 2. Comparison of the average value of the pretest-posttest aspects of scientific literacy skills

3.2. Discussion

The outcomes showed that when compared to the guided inquiry and discovery learning model, the IB-NOSA instructional model scored higher on scientific literacy skills. The IB-NOSA instructional model is oriented toward student-centered, and the teacher acts as a provider of facilities needed by students to support the process of actively and independently constructing students' knowledge. The high scientific literacy skills in the IB-NOSA instructional model were due to the characteristics of the model which is designed by creating a new syntax that can facilitate students' scientific literacy skills.

The syntax of the IB-NOSA instructional model is an innovative inquiry syntax that adds NOS aspects and AM activities as shown in Figures 3 and 4. Teaching NOS has shown the effectiveness of a constructive approach with an effective explicit emphasis on aspects of NOS about the inquiry learning model [42]. Inquiry and NOS are interrelated, which can teach various activities such as those carried out by scientists. Understanding the importance of observation and inference, as well as the tentative aspects, subjectivity, and scientific culture related to the development of science are the characteristics of NOS. Where the NOS aspect is related to the understanding of scientific inquiry [43]. The IB-NOSA instructional model has seven main syntaxes in facilitating the development of students' scientific literacy, namely orientation; identification of problems; conceptualization which consists of two sub-phases, namely formulating questions and create hypotheses; an investigation which consists of two sub-phases namely collecting data and analyzing data; create AM; conclusion; and reflection. Where each syntax can train students' scientific literacy skills.

Each syntax of the IB-NOSA instructional model is integrated with aspects of NOS in an explicitly reflective manner. After the activity takes place, the teacher must discuss the NOS aspects included in the activity explicitly through student participation. The selection of NOS aspects that are integrated with the IB-NOSA learning model is based on the characteristics of the learning materials used, namely additive and addictive substances. This is following Lederman's opinion [44] that all aspects of NOS do not have to appear in every learning activity. Focusing on several aspects of NOS that are appropriate to the learning material is better.

The NOS learning approach used in this research is explicit-reflective, where students reflect on what students do procedurally, why students do it, and what the implications are for the knowledge produced. The selection of NOS aspects that will be included in the IB-NOSA instructional model is based on the characteristics of the learning material. The integration of the IB-NOSA instructional model with NOS aspects can be seen in Figure 4.

Step 1: Orientation. At the orientation, the teacher introduces topics related to everyday life problems and introduces NOS. For the presentation of problem situations or events, it must be unclear which can arouse students' curiosity [45]. Orientation aims to get students started with a new topic to investigate. The orientation process aims to shape students' attitudes and knowledge that need to be built to overcome problems on a particular topic [46]. Orientation activities can help students construct student knowledge [47]. Fact and problem-oriented learning is one of the factors that can increase scientific literacy skills [48]. Observation activities at orientation will direct students to read the concepts of the natural phenomena presented. Through reading activities, students can practice scientific literacy in the aspect of scientific literacy, namely explaining phenomena scientifically. Based on the problem orientation given, students can build their thinking patterns to be able to formulate problems.

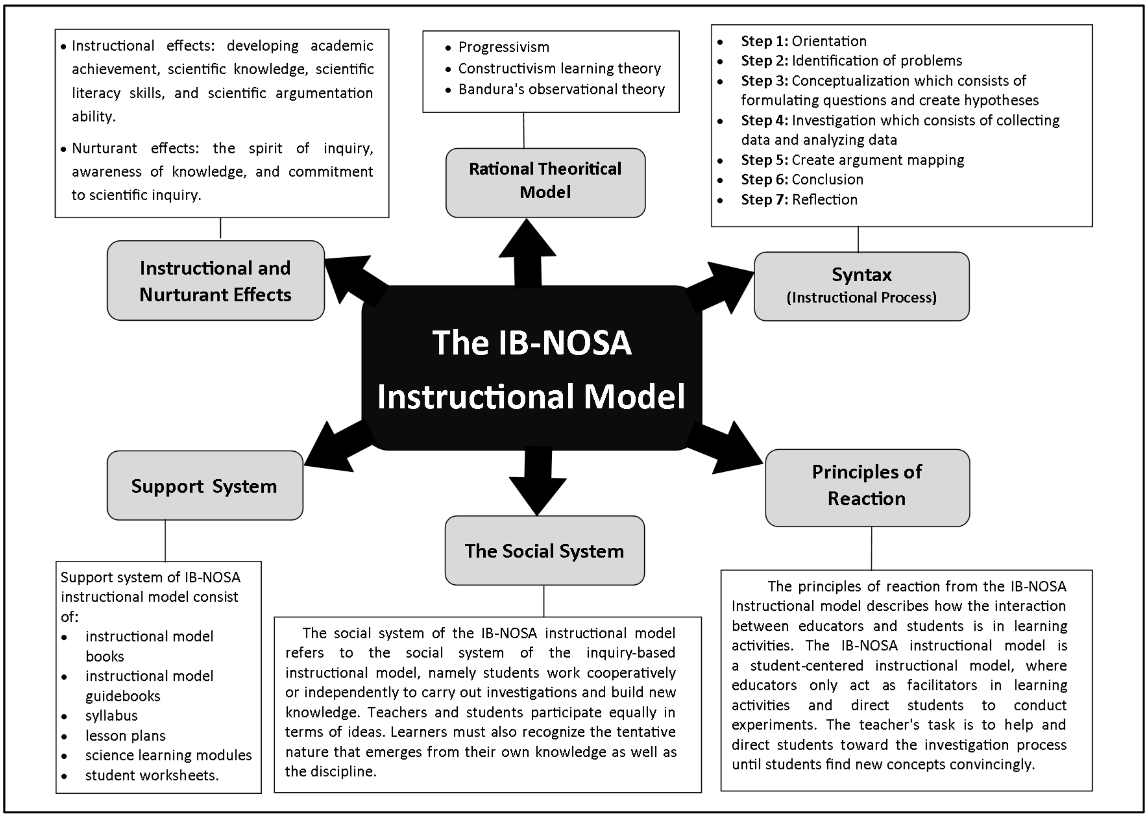

Figure 3. Components of the IB-NOSA instructional model

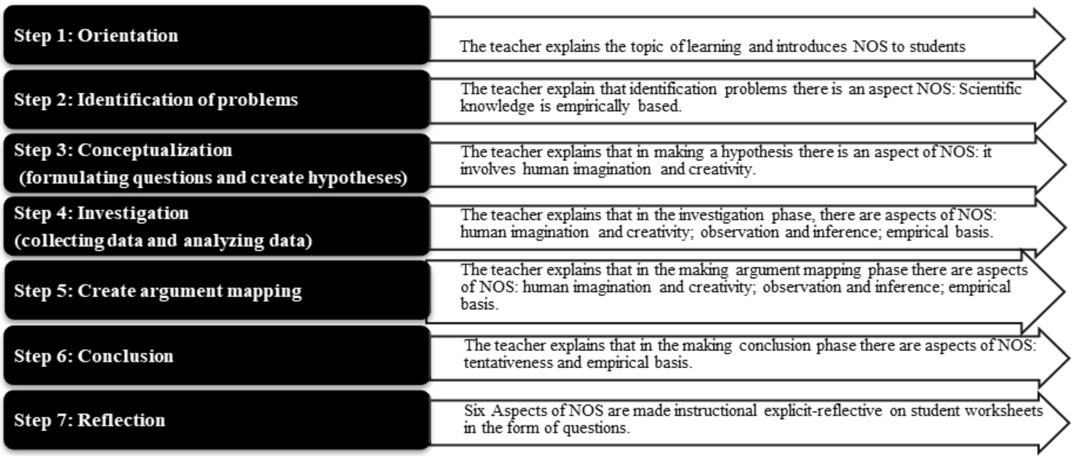

Figure 4. Integrating syntax of the IB-NOSA instructional model with aspects of NOS

Step 2: Identification of problems. The next phase is the identification of problems on the topic problems that have been given before. Problem identification is a very important first step in a research process [49]. At this stage, the teacher also ensures students have the knowledge and skills prerequisites for inquiry assignments before introducing the inquiry process which aims to increase the potential for successful learning. The teacher explains that identification problems there is an aspect of NOS: Scientific knowledge is empirically based.

Step 3: Conceptualization. The conceptualization phase consists of two sub-phases, namely formulating questions and creating hypotheses. In formulating questions, sub-phase students can develop their questions or engage in more targeted investigations [50]. Through the activity of formulating problems, indicators of identifying issues that may be investigated scientifically in the aspect of identifying and designing scientific investigations can be trained. In the hypothesis sub-phase, students develop hypotheses based on their past experiences and knowledge. The teacher explains that in making a hypothesis there is an aspect of NOS: it involves human imagination and creativity.

Step 4: Investigation. The investigation phase consists of two sub-phases, namely collecting data and analyzing data. In the investigative phase students design and carry out their investigations to answer the questions that have been made by planning procedures and carrying out investigations. In the data analysis phase, students are focused on making meaning from the collected data and synthesizing new knowledge. Through data analysis activities, students are trained in the dimensions of the scientific process in the aspect of explaining phenomena scientifically. Interpretation data makes students return to the hypothesis and draw conclusions about what was hypothesized [51]. The teacher explains that in the investigative phase, there are aspects of NOS: human imagination and creativity; observation and inference; and empirical basis.

Step 5: Create AM. The AM phase is a phase where students are trained to argue. The argument is considered a core practice of inquiry-based learning models [52]. AM is a technique that has been proven to improve students' critical thinking as measured by tests [53]. AM activities train students to increase their understanding of science [54]. In science learning, arguments are supported by evidence that has an important role in the aspect of scientific literacy, namely building explanations of natural phenomena [55]. To strengthen students' scientific literacy effectively, it is necessary to integrate debating to learn about topics related to everyday life problems [32]. This relates to the work of scientists using patterns of problem investigators and establishing hypotheses and arguments that have a clear connection between claims, data, support, guarantees, evidence, counterclaims, and rebuttals about these problems or hypotheses [56]. Scientific literacy is also the ability to make and evaluate arguments and draw conclusions based on evidence [57]. The teacher explains that in creating the AM phase there are aspects of NOS: human imagination and creativity; observation and inference; and empirical basis.

Step 6: Conclusion. The concluding phase is the conclusion about the IB-NOSA instructional model findings and response to the hypotheses. In the conclusion phase, it is used to synthesize the research that has been done [51]. The teacher explains that in the making conclusion phase there are aspects of NOS: tentativeness and empirical basis. The last phase is reflection which has an important role in science learning. Reflection is an activity of planning, justifying what is planned or has been done, and comparing the two actions [58].

Step 7: Reflection. The reflection phase is carried out through NOS aspects related to the material that has been taught previously. Aspects of NOS are made instructional explicit on student worksheets in the form of questions. According to activity theory, reflection is vital in learning [58]. The importance of including reflective elements in NOS aspects makes students learn more meaningfully and effectively [59]. Students who have good reflection can improve their understanding of scientific knowledge related to scientific literacy [60].

In the class that uses guided inquiry the average value of scientific literacy skills is better than the class that used discovery learning. Students are more interested in guided inquiry learning and the material presented is based on everyday life [61]. In addition, students are more likely to construct content understanding in an inquiry learning environment [62]. However, just doing inquiry learning is not enough to understand the NOS which causes students' low scientific literacy. Compared to the IB-NOSA instructional model which shows explicit-reflective instruction and AM are more effective in increasing students' understanding of NOS than implicit instruction which causes the average student's scientific literacy skills to be higher.

Like learning with guided inquiry, learning with a discovery learning model can push the students to be active in discovering a new concept. This model can motivate the students to learn by themselves independently. Discovery learning requires students to discover the contents of science through active involvement in learning by applying a scientific attitude [63]. But to increase scientific literacy, discovery learning needs to be combined with the NOS and argumentation. Compared to the IB-NOSA instructional model which shows explicit-reflective instruction and AM are more effective in increasing students' understanding of NOS than implicit instruction which causes the average student's scientific literacy skills to be higher.

The stages of the IB-NOSA instructional model do not only involve students in doing science which does not lead them to a proper understanding of NOS. Instead, engage in discussion and reflection about NOS. When compared with other learning models such as direct learning models, it tends to direct students as passive recipients of information and learn by rote. Students are not allowed to directly experience and apply concepts to achieve in-depth understanding. Students cannot develop a meaningful understanding of NOS simply by memorizing and reading a list of NOS concepts.

4. CONCLUSION

The result of the data analysis showed a difference in the pretest-posttest scores of scientific literacy skills in IB-NOSA, guided inquiry, and discovery learning. The pretest-posttest scores of scientific literacy skills grew significantly in each group. The IB-NOSA instructional model was more effective in improving students' scientific literacy skills than the guided inquiry and discovery learning model. It is suggested that science teachers must understand NOS, and how to teach NOS with explicit reflective learning in an instructional model. The meaning of importance of NOS can lead to the scientific literacy skills of every member of society in this world when encountering problems, in socio-scientific issues, for example, to achieve logical problem-solving. In addition, teachers must also often teach students to argue in class. Argumentation in science education plays a role in building students' knowledge based on the beliefs and reasons they have. Science learning requires students to think critically in finding concepts or solving problems.

The following recommendation is made for future studies. Future study is expected to increase the sample size by conducting interventions in several classrooms to show the IB-NOSA instructional model for enhancing students' scientific literacy and other skills. AM in this study is still done traditionally, namely using paper. Further research on creating AM can be done using technology.

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