



Effectiveness of Differentiated Learning Materials Oriented toward Nature of Science to Improve Scientific Literacy Skills

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Abstract: This research aimed to describe the effectiveness of differentiated learning materials oriented toward the nature of science (NoS) to improve students' scientific literacy skills. The research type is quasi-experiment with one group pretest-posttest design. The research was given to 31 students in VIII-A class of Junior High School 16 Gresik. The effectiveness of differentiated learning materials oriented toward the nature of science (NoS) was obtained from the scientific literacy skills test and student response questionnaire. The student's scientific literacy skills test showed an improvement in gain score between the pretest and posttest scores of 0.64, which is in the medium category; besides that, most students gave positive responses to the learning materials seen from the percentage of interest in learning materials 84.68% (very interested). The data obtained showed that differentiated learning materials oriented toward the nature of science were effective as learning materials to improve students' scientific literacy skills in Merdeka Curriculum.

Keywords: Differentiated Learning; Nature of Science (NoS); Scientific Literacy Skills

Introduction

Efforts to develop policies to improve the quality of education in Indonesia so that they are more evenly distributed to more schools and regions have prompted the Ministry of Education and Culture to initiate an Penggerak school program to create a Pancasila student profile that includes competency (literacy and numeracy) and character (Zamjani et al., 2020). One of the changes in the implementation is implementing the Merdeka curriculum. The Merdeka curriculum implemented in driving schools applies the principle of differentiated learning or Teaching at the Right Level (TaRL). The concept of Merdeka learning in the Merdeka curriculum is defined as the freedom of academic units (schools, teachers, and students) to innovate, be independent, and be creative in delivering education. There are four separate learning policies launched by the Ministry of Education and Culture, one of which is the change in the National Examination to a Minimum Competency Assessment related to literacy and numeracy as well as a character survey (Wijaya et al.,

2020). The capacity of students at minimum competency assessment is measured by the ability to reason using mathematics (numeration), maintain using language (literacy), and strengthen character education. The assessment is designed to provide a more decisive impetus toward innovative learning and is oriented toward the development of reasoning, not just memorization (Katman & Yusuf, 2021). Learning that is innovative and oriented towards the development of reason in the Merdeka curriculum is one of the learning planning products that have flexibility according to the needs of students.

Learning materials or learning designs based on the curriculum applied to achieve competency standards consist of teaching modules, assessments, and learning media. The preparation of the Merdeka Curriculum Learning materials involves differentiated learning, where learning focuses on differences in learning activities based on class and student characteristics based on the scope of material, various activities of teachers and students, as well as the method of assessing student learning outcomes (Tomlinson, 2017).

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Schools are only given curriculum implementation guides (toolkits), diagnostic assessment instruments, textbooks, and learning achievement formats for teaching modules, assessments, and Pancasila student projects. Teachers can use or modify the "Merdeka Mengajar" portal. Ideally, teachers can design learning materials that suit the learning needs of students and the school environment. Still, there need to be differentiated learning materials that train students' scientific literacy skills. The results of the 2018 PISA assessment showed that Indonesian students experienced a decrease in score to 396 from the average score of OECD countries, namely 489, and occupied 70 out of 78 countries (OECD, 2018). Based on research from Mahdianur et al. (2022), ideally, teachers must develop learning materials to the fullest. Still, many teachers do not understand the techniques for compiling and developing teaching modules in learning materials, especially in the independent learning curriculum.

Based on the results of preliminary research regarding the level of scientific literacy in science learning for 32 eight grade students of UPT SMP Negeri 16 Gresik, they obtained an average of 65.86 on a scale of 0-100, so based on the analysis of the average score of the scientific literacy test results, students included in the low category. This can be supported by interviews with five science teachers at UPT SMP Negeri 16 Gresik, which show that the learning model used is still teacher-centered and has yet to train students' scientific literacy skills.

Regarding research entitled "Scientific Literacy Analysis of Students of SMPN 1 Gresik," which states that students' scientific literacy achievements are in the moderate category with achievements the lowest achievement indicator is finding steps and deciding solutions from problem-solving (44%), and the indicator summarizes the results of graphical data analysis and identification results (48%). The percentage of hands that explain phenomena scientifically is (57%) (Rohmah & Hidayati, 2021). Undeniably, the current condition of the school environment also influences the low value of scientific literacy skills. The Covid-19 pandemic period was one of the unique conditions that caused learning loss which varied in the achievement of student competencies. Many Indonesian children need help understanding simple reading or applying basic mathematical concepts (Hanushek & Woessman, 2020).

Following research by Şentürk & Sari (2018) entitled Investigation of the Contribution of Differentiated Instruction into Science Literacy, it was found that differentiated learning effectively increased students' scientific literacy abilities by stimulating curiosity and exploring according to their interests, level of readiness. And students' learning profiles and directing them to their areas of interest individually or in groups, but in atomic and compound material with

abstract material characteristics and containing many theories, it is necessary to support a differentiated learning strategy. One of the supports for updating teaching modules that can be applied is through the Nature of Science (NoS) orientation. This is supported by the concept of NoS, which can teach scientific literacy in concrete and abstract concepts. One of the reasons supporting the NoS-oriented learning model can help students improve 21st-century competencies is the educational practice in NoS accommodating students in reading, discussing, studying independently, conducting experiments, analyzing data, and testing abilities.

Basic notions regarding the nature of science (NoS) is considered a core component for scientific literacy of the citizenry. There are several reasons to support this educational goal, but one of the most relevant is to prepare citizens to critically and responsibly participate in public or social issues related to science (Taber, 2017). The nature of science as a way of thinking, a way of investigating, a body of knowledge, and its interactions with technology and society. NoS-oriented learning has six main steps: (1) Background readings, (2) Case study discussions, (3) Inquiry lessons, (4) Inquiry Labs, (5) Historical studies, (6) Multiple Assessment. Achievement of students' scientific literacy can be pursued through teaching science in class that focuses on the ability of the nature of science or an understanding of the characteristics of natural science as a form of knowledge and inquiry (Clough, 2018).

Differentiated learning is effective to be considered when designing a lesson plan to help students relate well to learning activities to maximize learning experiences that can improve students' scientific literacy abilities (Palines & Cruz, 2021). Differentiated instruction has been shown to have a positive impact on student increase scientific literacy skills. The best practices of teachers who differentiate instruction involve (a) the collection of information about student interests, learning profiles, and student readiness; (b) cultivation of a community in the classroom, (c) distribution of students into groups that can be easily changed based on the activity, and (d) use of formative assessment for learning (Beck & Beasley, 2021). There are four differentiation strategies that can be applied in learning, namely content differentiation, product differentiation, process differentiation, and learning environment differentiation. Differentiation in its highlighting of student interests, needs, readiness, and motivation.

NoS-oriented Middle School Science teaching materials contain local wisdom on the topic of material classification, and its changes to support scientific literacy are proven to be able to meet the validity criteria with a value of >0.80; this shows that NoS-oriented Middle School Science teaching materials are verified can support students' scientific literacy (Permataningsih

et al., 2021). Based on this explanation, researchers want to know the effectiveness of differentiated learning materials oriented toward the nature of science (NoS) to improve students' scientific literacy skills in the independent curriculum on the elemental, compound, and mixed material.

Method

This research used a quantitative approach with the experimental research method type quasi-experimental design. The study was conducted using a one-group pretest-posttest design because this research used one group without a comparison group.

The study began with the analysis of student needs, assignments, and materials. The design by making a lattice of indicators of scientific literacy skills on the learning materials. The development of learning materials includes lesson plans, worksheet, and assessment sheets. These materials had been validated through expert judgments and declared valid. Implementation in this study was conducted in the academic year of 2022/2023 with 31 eighth-grade students at junior high school 16 Gresik as the research participants. The effectiveness of the learning materials can also be examined based on students' responses after conducting the teaching and learning process using learning materials; this is part of the evaluation.

The test consists of five indicators of students' scientific literacy skills, namely explaining scientific phenomena with scientific knowledge, applying scientific knowledge in life, understanding research design elements and their impact on scientific discoveries, interpreting basic statistics (e.g., data, graphic patterns, and simple calculations), and draw the correct conclusions. In the first stage, students were given a pretest and trained in learning scientific literacy skills for three meetings. At the end of the learning process, students are given a posttest. The increase in scientific literacy ability scores was analyzed descriptively using normalized gain (N-gain). Differentiated learning materials oriented to the nature of science (NoS) to improve students' scientific literacy skills in good category are effective if they have an N-gain test score above 0.3 (Triyana, 2016).

Result and Discussion

The effectiveness of differentiated learning materials toward the nature of science (NoS) oriented was obtained by increasing the students' pretest and post-test scores. The increase in students' scientific literacy skills can be presented in Table 1.

Table 1. Student Scientific Literacy Skills Data

	Mean			Category
	Pretest	Posttest	N-Gain	
Completeness Value	53.61	83.74	0.64	Medium

Based on the N-Gain analysis in table 1, the percentage of classical completeness after learning using differentiated learning materials oriented toward the nature of science (NoS) is 100.00%. In addition, there was an increase in the gain score, which was 0.64 in the medium category. This shows that differentiated learning materials oriented toward the nature of science (NoS) effectively improve students' scientific literacy skills. Figure 1 shows the distribution of scientific literacy skills data.

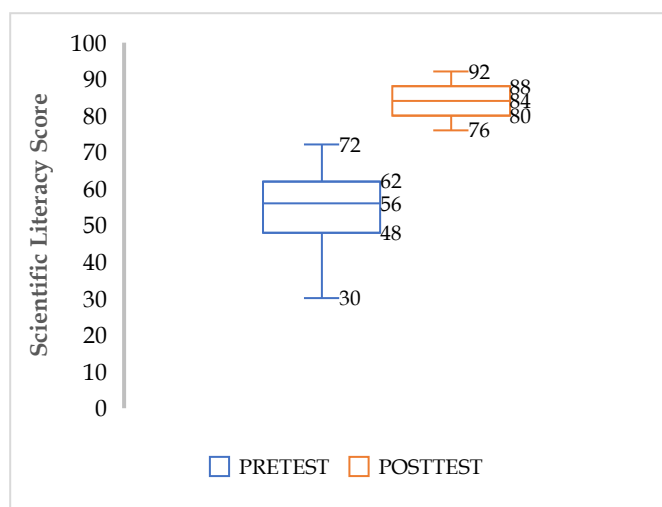


Figure 1. Distribution of Scientific Literacy Skills Data 8A

Based on the distribution of Scientific Literacy Skills Data presented in Figure 1, the pretest results showed that no students scored above minimum score, so the classical completeness was 0.00%. In the distribution of posttest scores, all 31 students achieved completeness with scores above minimum score, so the percentage of classical completeness was 100.00%. This shows that differentiated learning materials oriented to the nature of science (NoS) can train the scientific literacy skills of class 8A students in the elemental, compound, and mixed materials individually and classically.

The understanding aspects of NoS must be the main pillar in scientific literacy skills. Addressing this understanding in science education can provide students with informed ideas about how science works, so that they can critically analyze information in everyday life. This can be seen in the NoS learning step in the first stage which is embodied in differentiated learning materials, namely background readings where the researcher instructs them to read books or scientific articles and make reports on a particular material, so that

students can compile the background of the learning being carried out. Books and or articles read by students are adjusted to the material being studied. This can improve scientific literacy skills in the indicator of explaining scientific phenomena with scientific knowledge (García-Carmona, 2021).

In the next stage, case study discussions open a discussion space to collect questions posed by students which can help improve students' scientific literacy skills in indicators of applying science knowledge in life. The discussion room assists students in raising issues and conducting discussions through their initial scientific knowledge to be able to propose a solution. Discussions conducted based on plans, and carries out varied approaches to content, the process, and/or the product in anticipation of or in response to student differences in readiness, interests and learning needs that underlie differentiated learning (Gibbs, 2022).

NoS-oriented learning also facilitates students to carry out inquiry learning in the third and fourth steps, namely inquiry lessons and inquiry labs. This can improve the ability of indicators to understand research design elements and their impact on scientific findings and interpret basic statistics (data, graphical patterns, and or simple calculations). The importance of comprehensively understanding the contents of the Nature of Science and being able to communicate this understanding effectively to others through various strategies or learning approaches. This approach to learning that is based on constructivism and can provide authentic learning experiences is inquiry. The results of this study indicate that the application of inquiry to science learning has a positive effect on cognitive outcomes, processing abilities, and attitudes toward science (Widowati et al., 2017).

The fifth and sixth stages, namely Historical studies and multiple assessments aimed at improving the skills of making conclusions correctly and applying the concepts that have been studied. Students are guided to be able to present a description of the benefits of learning carried out, not only regarding their understanding of NoS and the ability to uncover and apply understanding of natural phenomena, but also the development of students' attitudes and perceptions of the material that is the object of learning. At the multiple assessment stage, students are trained in planning skills, implementing skills, presentation skills, written reporting skills, oral reporting skills, periodic journal making, focus on understanding NoS, attitudes and students' perceptions of the lesson (Prachagool & Nuangchalerm, 2019).

Effectiveness differentiated learning materials occurred at the pre-planning phase by the teachers

setting clear key learning goals for each unit of work and lesson. Central to this phase is the collection of student data about learner characteristics which is critical to ensure that the needs of all students are met. Furthermore, participants scaffold formative and summative assessment tasks to match the abilities and needs of specific students. Assessment exemplars are provided by some teachers, adjusting the task (e.g. providing sentence starters, highlighting key words, as is scaffolding assessments by checking for student understanding on process differentiation and product differentiation strategies (Gibbs, 2022).

Nature of Science is influential in increasing scientific literacy skills by discussing NoS and using terms related to aspects of NoS accurately such as combined with differentiated learning. The students' use of NoS vocabulary, even in conversations among peers, shows that they have developed an identity as individuals with NoS as part of their role in society. The researcher provided an overview of NoS for students, and helped them make explicit connections to aspects of NoS. Further emphasizing NoS through this research the idea of assisting students in conceptualizing NoS not only as a content area, but also as an area for which they have knowledge and expertise in such a way that they develop a NoS identity (Elcan Kaynak et al., 2020). Concerning the relationship of differentiated learning and other teaching domains, results showed that learning climate, classroom management, clarity of instruction, activating learning and teaching learning strategies are correlates of differentiated instruction with NoS to improve scientific literacy skills (Maulana et al., 2020).

These results are relevant to the research of Mutasam et al. (2020) that NoS-integrated learning can increase scientific literacy because it emphasizes learning activities on investigations development of explanations of natural phenomena accompanied by measurable data according to students' interests. The results of research by Şentürk & Sari (2018) also state that differentiated learning contributes to scientific literacy, where students share knowledge and experience gained in science with the public, inform the public about innovations in this field and introduce learning outcomes to the community.

The results of students' scientific literacy abilities were also analyzed for each indicator used. Increasing students' scientific literacy abilities in the elemental, compound, and mixed material based on the completeness of scientific literacy indicators are presented in Table 2.

Table 2. The Data of Scientific Literacy Skills Improvement Indicators

Indicators of Scientific Literacy Skills	X _{Pretest}	X _{Posttest}	N-Gain	Category
Explain scientific phenomena with scientific knowledge	61.29	87.10	0.67	Medium
Apply scientific knowledge in life	79.03	85.48	0.31	Medium
Understand the elements of research design and their impact on scientific findings	19.35	80.65	0.76	High
Interpret basic statistics (e.g., data, graphical patterns, and or simple calculations)	48.39	77.42	0.56	Medium
Make the correct conclusions	58.06	85.48	0.65	Medium
Mean			0.59	Medium

Table 2 shows that the scientific literacy skill indicator used as a measuring tool has increased based on a gain score of 0.59 in the medium category. All indicators have obtained a final completeness percentage of >75%, so they can be categorized as "complete." The indicator of scientific literacy skills with the highest increase is obtained by understanding the elements of research design and their impact on scientific findings hand, which gets an N-Gain of 0.76 in the high category. While the scientific literacy ability indicator that has the lowest increase is the apply scientific knowledge in life indicator, which gets an N-Gain of 0.31 in the medium category. This shows that differentiated learning oriented toward the nature of science (NoS) is effective in completing all indicators of scientific literacy.

This is following research by Wardhana et al. (2022), which states that the use of Nature of Science (NoS)-based media in atomic theory development material is effective in increasing scientific literacy. In addition to supporting the material characteristics of the development of nuclear theory which is considered abstract because students are less able to visualize the particles that makeup atoms and must be able to understand various atomic ideas that scientists have put forward. Integration between differentiated learning and the nature of science (NoS) can improve scientific literacy skills in each indicator.

Despite increasing students' scientific literacy skills, the effectiveness of differentiated learning oriented toward the nature of science (NoS) can also be observed from the results of students' responses to learning. Data on the results of student responses were obtained through a questionnaire filled out by all students after carrying out all the learning phases. The overall average of student response questionnaires regarding Nature of Science (NoS) oriented differentiated learning obtained a percentage of 84.68% with very good criteria.

The results of students' responses to learning self-evaluations by teachers. This gives the teacher an overview of the weaknesses in the implementation of learning and as a guide in making plans to improve the quality of learning activities that will be carried out next. Based on the results of students' responses to learning, it can be concluded that the application of differentiated

learning oriented toward the nature of science (NoS) effectively increases students' scientific literacy skills.

Conclusion

Based on the results and discussion, both individuals and classically experienced an increase in scientific literacy skills, which was shown in the completeness of the students by 100.00% and the N-Gain acquisition of 0.64 with the acquisition of a medium increase. In addition, it was found that the five indicators of scientific literacy ability showed an increase in the medium category with an N-gain value of 0.59. As well as the overall average student response regarding differentiated learning oriented toward the nature of science (NoS), percentage of 84.68% was obtained with very good criteria. Thus it can be concluded that differentiated learning oriented toward the nature of science (NoS) materials can improve the literacy skills of students in the Merdeka curriculum.

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