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# Representation of Nature of Science (NoS) in Indonesian Physics Textbooks: A case of heat and temperature concepts

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## Abstract

Learning science including physics cannot be separated from the nature of science or Nature of Science (NoS). Understanding of NoS is very important in the world of education in schools because by understanding NoS students will find it easier to understand the concept of physics in learning at school. For this reason, this study aims to determine the representation of NoS in eleventh grade high school physics textbooks for the concepts of temperature and heat using the content analysis method. The research sample was taken using a purposive sampling technique. Of all the physics textbooks for eleventh grade of high school, only 5 physics textbooks with different publishers analyzed 10 aspects of NoS. The results showed that the frequency of the appearance of the ten aspects of NoS in the five physics textbooks for eleventh grade was different. Book 1 (Erlangga) has 36.64 percent, book 2 (Mediatama) has 18.32 percent, book 3 (Grafindo Media Pratama) and book 4 (Yrama Widya) has the same percentage, namely 14.50 percent. Meanwhile, book 5 (Yudhistira) has an appearance frequency of 16.03 percent. The number of NoS aspects of the five books mostly raises aspects of social and cultural cultivation in science. On the other hand, the aspect that is not raised at all in the five textbooks above is the creative aspect. In general, the five physics textbooks that were analyzed had explicit aspects of NoS, but some were conveyed implicitly. Based on the results of this study it can be concluded that the five physics textbooks have not conveyed aspects of NoS explicitly, correctly and completely.

**Keywords:** Nature of Science (NoS), physics textbooks, heat dan temperature

## 1. Introduction

Learning science is inseparable from the nature of science or Nature of Science (NoS). NoS is information about how science works. NoS has aspects in science learning, ranging from logical strategies to the position of science in the eyes of the public. Students' understanding of NoS includes information about how science explains phenomena that occur in nature. Previous research underlined that NoS is the ability to read science and is seen as fundamental to science learning. There are 10 aspects of NoS, namely empirical, inferential, creative, theory driven, tentative, scientific

method, scientific theory, scientific law, social dimensions of science, and social and cultural cultivation in science (Abd-El-Khalick, Waters, and Le 2008).

In learning at school, textbooks have an essential position to develop the quality of education. Textbooks, especially good physics textbooks can relate science to life, can describe science, and explain how science and humans are always related to each other. These are all elements of NoS. Thus, the existence of NoS in science textbooks, especially physics, is very important.

There are several previous studies that analyzed the NoS representation in Physics-Science textbooks. For example, research conducted by others researchers that analyzed the representation of NoS in three tenth grade physics textbooks (Jannah, Suyana, and Novia 2019). The results of this study indicate that the representation of NoS in the book is still contained in an explicit, correct, consistent, and comprehensive manner. It can be seen from the scores of the three textbooks that got 18, 8, and 12 from the maximum value of rubric 30. In another study analyzed the NoS representation in two tenth grade physics textbooks for the material of harmonic vibrations (Dhamayanti, Putra, and Handayani 2019). The results of this study reveal that the aspects of NoS in the two textbooks are still dominated by aspects of theory and the laws of physics. Meanwhile, the tentative aspects in the two books do not appear at all. Meanwhile, analyzes the NoS representation in two eleventh grade high school physics textbooks (NOVIANA, Fathurohman, and Yusup 2021). The results of this study indicate that many aspects of NoS are found in thermodynamic materials by reaching the proportions of 80 percent and 86 percent of the NoS representation value that should exist. However, although many studies investigate the representation of NoS in physics textbooks, so far there is empirical evidence showing how the representation of NoS in the concepts of temperature and heat is in high school physics textbooks. Whereas the concept of temperature and heat is one of the important concepts so that it is always taught at every level of education from elementary to high school.

Representation of NoS in textbooks is very important to do to assess subject matter so that it is in line with educational goals and the applicable curriculum. Aspects of NoS need to be conveyed in physics textbooks to support the science learning process in class. Therefore, this study aims to expand the study of NoS representation in eleventh grade high school physics textbooks for the subject matter of temperature and heat. The expansion of this research is marked by analyzing the representation of NoS for five physics textbooks from different publishers. There are two reasons why the representation of NoS in this study focuses on the material Temperature and Heat. First, this material concept is identified and closely related to everyday life. Second, understanding the concept of this material is the beginning of understanding other different material concepts (Ma'rifah 2016). This means that if students' conceptual understanding of this material is low, students will have difficulty further understanding other material such as the concept of thermodynamics. Based on the reasons stated by the researcher, the current research title focuses on the representation of NoS in Indonesian physics textbooks for temperature and heat.

## 2. Literature Framework

### 2.1 Scientific literacy

Scientific literacy is a combination of 2 words, namely *litteratus* which means marked with letters and *scientia* which means knowledge or can be called scientific literacy. Scientific literacy is an important ability for students to have in order to keep up with the times (Agustin *et al.* 2021). Organizations for Economic Cooperation and Development (OECD) through the Program for International Student Assessment (PISA) reveal that scientific literacy is the ability to use scientific knowledge, identify questions and provide conclusions based on data to understand natural phenomena that exist in the universe and make decisions. regarding human interaction with life in nature (Kaya and Elster 2018).

Scientific literacy has aspects related to science textbooks and includes the dimensions of the process and context of science. These aspects are knowledge, science as a way of thinking, and the

interaction of science, technology, and society. The knowledge aspect has the aim of displaying, classifying and helping students to obtain information about concepts, principles, theories and laws in NoS investigations in textbooks. Meanwhile, science as a way of thinking has the goal of providing an overview of how science functions, especially when scientists conduct experiments. This aspect describes the thinking, development, and illustration of science. In the aspect of the interaction of science, technology and society, this aspect has the aim of providing an overview of the impact of science on society, the application of science and how technology can help people live in society (Agustin et al. 2021).

To improve students' scientific literacy skills, one of them is by way of students' understanding of NoS. This is in line with what was stated by (8) that NoS is an element of science that is important for students to have an understanding of scientific literacy, because the basic thing of scientific literacy is NoS. To improve students' scientific literacy skills, namely by increasing the understanding of NoS. NoS is the basis of scientific literacy because the NoS aspect refers to knowledge, science as a way of thinking, and the interaction of science, technology, and society.

**Table 1.** Aspects of NoS

No	Aspects	Information
1	Empirical	Implies that statements in science rely on data or research evidence on natural phenomena. Scientists observe science using man-made tools. An example is a working x-ray with a cathode ray tube covered with a black protective paper.
2	Inferential	Observations are descriptive, statements about natural phenomena that cannot be reached by the senses directly. An example is an object falling to the ground due to gravity. Gravity can only be felt and reached for its consequences and benefits (Lederman, Abd-El-Khalick, and Lederman 2020)
3	Creative	Creative produces scientific knowledge that involves human creativity. An example is Thomson's atomic model. Based on Thomson's creativity, the electron in an atom is analogous to raisin bread.
4	Theory driven	Contains previous theories, commitments, beliefs, prior knowledge, training and disciplines from scientists. For example, from Thomson's atomic model, Rutherford made observations about other atomic models until he succeeded in finding his own atomic model.
5	Tentative	Science can change depending on the evidence for new discoveries generated by scientific developments and the reinterpretation of existing research. An example is the development of the atomic model (Dalton, Thomson, Rutherford, Bohr).
6	Scientific method	Researchers pay attention, measure, think about, test, theorize, speculate, make thoughts and formulate hypotheses and clarifications. Examples of steps that must be taken in solving scientific problems.
7	Scientific theory	Scientific theory is an explanation or clarification that is concluded for natural phenomena that occur. Scientific law is a descriptive statement about the relationship between phenomena. An example is the sound of Newton's law and the law of conservation of momentum.
8	Scientific Law	Scientific law is a descriptive statement about the relationship between phenomena. An example is the sound of Newton's law and the law of conservation of momentum.
9	Social Science	Scientific knowledge of how society plays a role in the development of science and public appreciation of the findings. An example is the phenomenon of electricity
10	Embedding social culture in science	Knowledge develops based on community needs. For example, diagnostic tools used to determine the state of the body such as CT scans and MRIs.

## 2.2 Nature of Science (NoS)

NoS is a combination of social science with cognitive science that can describe what science is, how science functions, how science is used in life, and how science can affect society (Olson 2018). NoS is part of science from science, defined as complex knowledge involving philosophy, sociology and history (Vincent-Ruz and Schunn 2018). NoS understanding includes empirical statements, imaginative, social and cultural cultivation, as well as tentative nature. NoS is characterized as a science that refers to the epistemology and sociology of science, specifically information about how science functions which is used as a method of knowing and evaluating which is the idea of information about science (Lederman, Abd-El-Khalick, and Lederman 2020).

NoS has aspects in science learning, ranging from logical strategies to the position of science in the eyes of the public. Researchers underlined that NoS is the ability to read science and is seen as fundamental to science learning (Abd-El-Khalick, Waters, and Le 2008). There are 10 aspects of NoS, namely empirical, inferential, creative, theory driven, tentative, scientific method, scientific theory, scientific law, social dimension of science, and social and cultural cultivation. The 10 aspects of NoS can be seen in Table 1.

In learning at school, textbooks have an essential position to develop the quality of education. Textbooks are one of the learning media that greatly affect the quality of education, because they can function as learning media to achieve national education goals. Textbooks contain descriptions of discussion material on certain subjects (Lederman *et al.* 2002). According to Permendiknas No. 2 of 2008, states that textbooks are reference books that are mandatory for use in schools which contain learning materials to build self-confidence and piety, the ability to master science and innovation, capacity and imagination, actual potential and welfare depending on national standards. education. Textbooks have an important function in the learning process in schools. The function of textbooks in learning is to provide references or guidelines for student learning, provide teaching methods and resources for teachers, provide materials and questions for the learning process (Harsani *et al.* 2020).

## 3. Research Method

### 3.1 Research design

The research design used is descriptive qualitative research. In descriptive qualitative research, do not change, add or manipulate data (Abd-El-Khalick, Waters, and Le 2008). The method in this research is content analysis or content analysis. Content analysis has an important role in qualitative research. Content analysis is a research method used to find out the content using documentation studies or data collection sourced from documents as study material (Liu and Khine 2016; Gumilar and Ismail 2021). Content analysis is used for biographies, books, documents, manuscripts, notes, catalogs, and other materials that can be used as main or supporting data in data mining in the field (Liu and Khine 2016). Based on this description, this content analysis is appropriate to be used to represent NoS in high school physics textbooks for the concepts of temperature and heat.

### 3.2 Sample

The population in this study were all physics chapters in eleventh grade physics textbooks. Thus, the sample in this study was a material chapter in an eleventh-grade high school physics textbook on temperature and heat. To take the research sample using purposive sampling technique. Of all eleventh-grade high school physics textbooks, only 5 physics textbooks from different publishers analyzed 10 aspects of NoS. The identity of the physics textbooks can be seen in table 2.

Collecting data in this study using documentation techniques. Documentation is the process of finding information about something such as looking for information in books, notes, transcripts, newspapers and others (Eyisi 2016). In this study, the aspects of NoS contained in eleventh grade high school physics textbooks with different publishers are the observed variables. These variables are assessed based on the assessment rubric and then arranged according to the coding category.

There are 6 coding categories in content analysis, namely syllables, syllable expressions, sentences, paragraphs, themes, and all text contents Gumilar and Ismail 2021.

**Table 2.** Samples of the chapter

No	Writers	Publishers	Year	Chapter
1	Marthen Kanginan	Erlangga	2016	Heat and Temperature
2	Indarti, Aries Prasetyo, Naila Hilmiyana	Mediatama	2016	Heat and temperature
3	Ketut Kamajaya, Wawan Purnama	Grafindo Mediapratama	2016	Heat and temperature
4	Sunardi, Paramitha Retno, Andreas, Darmawan	Yrama Widya	2016	Heat and temperature
5	Bambang Ruwanto	Yudistira	2016	Heat and temperature

### 3.3 Data analysis

In this study, the data analysis carried out is to represent excerpts from the book under study. The assessment of the quotations made by the researcher was then reviewed by two raters. Not all NoS in the textbooks were reviewed by the evaluator, only 40 percent of the textbooks (2 textbooks) were subjected to NoS review by the evaluator. To see consistency in the assessment.

In this study, the representation of NoS is arranged from the empirical aspect to the social and cultural inculcation in science. There are four categories that are used to represent the aspects of NoS in the physics textbooks used, namely true and explicit delivery, true but implicit, false and explicit, and false but implicit. The quotes in the five books that have aspects of NoS are compiled and classified into these 4 categories. The following is an assessment rubric used which can be seen in table 3.

**Table 3.** Rubric for evaluation

Score	Explanation
3	explicit and true quotes
2	explicit and true quotes, implicit and true quotes
1	implicit and true quotes
0	no quotes
-1	explicit and wrong quotes
-2	explicit and wrong quotes, implicit and wrong quotes
-3	implicit and wrong quotes

**Table 4.** Interpretation of Kappa Score

Kappa Coefficient	Interpretation
<0.00	very bad
0.00-0.20	bad
0.21-0.40	not enough
0.41-0.60	intermediate
0.61-0.80	good
0.81-1.00	very good

The last step is to test the reliability. Reliability is something that indicates the extent to which a measurement can be trusted because of its determination (Eyisi 2016). Reliability was tested by

measuring the reliability between raters. The reliability test uses the Kappa Coefficient. This equation can be formulated:  $K = (P_A - P_C)/(1 - P_C)$ . For example,  $P_A$  is the equal probability of statements between the two observers and  $P_C$  is the marginal distribution of the number of categories in the contingency table. The interpretation of the Kappa coefficient value indicates the reliability of the study (Rigby 2000) which can be seen in table 3. A good Kappa coefficient value is between 0.61 – 0.80 so that the results between the two raters can be said to be reliable and valid. Based on the calculation results, the Kappa coefficient value is 0.474. This means that the results of the analysis are included in the moderate criteria and indicate that the results of the study can be stated to be quite reliable and valid.

## 4. Result of the research

### 4.1 Frequency of NoS in Indonesian physics textbooks

Based on the research conducted, the frequency of the appearance of the ten aspects of NoS in the concepts of Temperature and Heat in the five eleventh grade physics textbooks are different. All aspects of NoS are analyzed using a scoring rubric, either explicitly or implicitly. The frequency of occurrence of the NoS aspects of the five eleventh grade high school physics textbooks is presented in table 5.

Based on table 5, the book that raises the NoS aspect the most is physics textbook 1 (Erlangga) as much as 36.64 percent. These textbook displays 7 aspects out of 10 existing aspects. The second highest percentage (18.32 percent) in presenting the NoS aspect is physics textbook 2 (Mediatama). This physics textbook displays 6 aspects of the 10 existing aspects. The third highest percentage (16.03 percent) in presenting the NoS aspect is physics textbook 5 (Yudhisthira). This physics textbook displays 5 aspects of the 10 existing aspects. And the books that show the least NoS aspects are physics textbooks 3 (Grafindo Media Pratama) and physics textbooks 4 (Yrama Widya) which have the same percentage, which is 14.50 percent. Physics textbook 3 displays 7 aspects of the 10 existing aspects. Meanwhile, physics textbook 4 displays 4 aspects out of 10 existing aspects.

**Table 5.** Frequency of NoS Aspects

Aspects of NoS	Frequency in each book					Total percentage
	1	2	3	4	5	
Empirical	1	1	1	0	0	2.29
Inferential	2	1	1	0	0	3.05
Creative	0	0	0	0	0	0.00
Theory-driven	2	0	0	0	1	2.29
Tentative	1	0	0	0	0	0.79
Scientific method	8	6	2	5	6	20.61
Scientific theory	0	0	2	0	1	2.29
Scientific law	0	1	1	2	0	3.05
Social Science	7	4	2	5	1	14.50
Embedding social culture	27	11	10	7	12	58.78
Total number	48	24	19	19	21	131
Percentage	36.64	18.32	14.50	14.50	16.03	

### 4.2 Frequency of NoS in each aspect

#### 4.2.1 Empirical aspect

The definition of the empirical aspect refers to data obtained from observations or evidence obtained from experiments or practicum. In this empirical aspect, the quotation has been conveyed explicitly. Explicit delivery of empirical aspects, for example, is found in book 1 (Erlangga), namely:

*In 1879, Joseph Stefan measured the total energy emitted by a perfect black body. He stated that the total power emitted by a black body is perfect. He stated that the total power is proportional to the fourth power of the absolute temperature (Page 250)*

The quote “power measurement” shows the retrieval of data that shows an explanation of how the data relates to the concept of the fourth power of absolute temperature. The frequency of occurrence of empirical aspects from the five eleventh grade high school physics textbooks is different. It can be seen that the empirical aspects of the five books have appeared as many as 3 quotes. Book 1 (Erlangga), book 2 (Mediatama), and book 3 (Grafindo Media Pratama) have the same frequency of occurrence, namely 1 quote. Meanwhile, book 4 (Yrama Widya) and book 5 (Yudhisthira) do not appear or there are no quotations regarding the empirical aspect.

#### 4.2.2 Inferential aspect

The definition of inferential aspects refers to observations that are descriptive in nature, namely statements about natural phenomena that cannot be reached by the senses directly and are the result of a process to explain what is observed. In this inferential aspect, the quotation is conveyed explicitly and implicitly. Explicitly correct and implicitly correct submissions, for example, are found in Erlangga’s book publisher, namely:

*Coins that we hit with a hammer and then we touch will feel warm. This is because the hammer blow causes the particles to move faster which means the average kinetic energy of the particles also increases. It appears that temperature is a measure of the average kinetic energy of the particles in an object (Page. 198)*

The inferential section looks at the section relating the notion of temperature to kinetic energy explicitly. However, the section that mentions the relationship between the beating process and kinetic energy is explained implicitly. The frequency of occurrence of the inferential aspects of the five high school physics textbooks for eleventh grade is different. It can be seen that the inferential aspects of the five books have been raised as many as 4 quotations. In book 1 (Erlangga) 2 quotes appear. Meanwhile, book 2 (Mediatama) and book 3 (Grafindo Media Pratama) have the same frequency of occurrence of 1 quote. Finally, book 4 (Yrama Widya) and book 5 (Yudhisthira) do not have any quotations regarding the inferential aspect.

#### 4.2.3 Creative aspect

The definition of the creative aspect refers to the results of human creativity and imagination. For the creative aspect in the five physics textbooks, it does not appear or there are no citations regarding the creative aspect.

#### 4.2.4 Theory driven aspect

The definition of theory-driven aspects or containing previous theories refers to assumptions based on existing theories or based on links with previous research. In this theory-driven aspect, citations are conveyed explicitly but not evenly distributed in each citation. For example, the explicit submission of quotations is found in the book publisher Erlangga, namely:



*After people learned that heat is a form of energy, in the mid-nineteenth century, scientists developed a new theory to replace the caloric theory. This theory is based on the assumption that matter is composed of very small particles that are always moving faster. In a hot object, the particles move faster, and therefore have more energy than the particles in a cooler object. This theory is called the kinetic theory (Page. 214).*

The quote shows the development of a new theory to replace the caloric theory called the kinetic theory. The frequency of occurrence of the theory-driven aspect of the five high school physics textbooks for eleventh grade is different. It can be seen that the theory-driven aspects of the five books have appeared as many as 3 quotes. Book 1 (Erlangga) has 2 quotes and Book 5 (Yudhisthira) has 1 quote. Meanwhile, book 2 (Mediatama), book 3 (Grafindo Media Pratama), and book 4 (Yrama Widya) do not appear or there are no quotations regarding the theory-driven aspect.

#### 4.2.5 Tentative aspect

The definition of the tentative aspect refers to the statement that science can change according to scientific and technological progress or the presence of new evidence. In this tentative aspect, quotations are conveyed explicitly and implicitly. Explicitly correct and implicitly correct submissions, for example, are found in Erlangga's book publisher, namely:

*In 1879, Joseph Stefan made a measurement of the total power emitted by a perfect black body. He stated that the total power emitted by a black body is perfect. He stated that the total power is proportional to the fourth power of the absolute temperature. Five years later, Ludwig Boltzmann inherited the same relationship. The equation obtained from this relationship is called the Stefan-Boltzmann Law, which reads: the energy emitted by a black surface in the form of heat radiation per unit time ( $Q/t$ ), is proportional to the surface area ( $A$ ) and proportional to the fourth power of the absolute temperature of the surface it ( $T^4$ ) (Page. 250)*

In these quotations, there are explicit new findings whose contents reinforce old opinions and implicit quotations, namely quotations written only as statements of the stages of discovery without explaining the nature of the science. The frequency of occurrence of the tentative aspects of the five eleventh grade high school physics textbooks is presented in different ways. It can be seen that the tentative aspect only appears in book 1 (Erlangga) as much as 1 quote. Meanwhile, book 2 (Mediatama), book 3 (Grafindo Media Pratama), book 4 (Yrama Widya), and book 5 (Yudhisthira) do not appear or there are no quotations regarding tentative aspects.

#### 4.2.6 Scientific method aspect

The definition of aspects of the scientific method refers to the steps in planning or conducting an investigation using the scientific method. In this aspect of the scientific method, quotations are conveyed explicitly. Explicit submissions, for example, are found in Yudhisthira's book publisher (see figure 4.5). Overall, the aspects of the scientific method in the five books have appeared as many as 27 citations with the percentage shown in Figure 4.6. Based on the analysis, book 1 (Elangga) has 8 citations, book 2 (Mediatama) has 6 citations, book 3 (Grafindo Media Pratama) has 2 citations, book 4 (Yrama Widya) has 5 citations, and book 5 (Yudhishtira) appears as many as 6 quotes.

#### 4.2.7 Scientific theory aspect

The definition of an aspect of scientific theory refers to an inferred explanation of observed phenomena. In this aspect of scientific theory, the quotation is conveyed explicitly. Explicit submissions, for example, are found in book 3 (Grafindo Media Pratama), namely:



*Matter is composed of atoms. Groups of atoms make up molecules. The molecules that make up matter are always in motion and create attractive forces. When a substance is heated, its molecules move faster. This causes a push between one molecule and another molecule so that the intermolecular distance becomes larger. The molecules will occupy a larger space. This event is called expansion (Page. 106)*

The quote "expansion" is an inferred explanation of the observed phenomenon. The frequency of occurrence of aspects of scientific theory from the five eleventh grade high school physics textbooks was found to be different. Based on the analysis, it can be seen that the aspects of scientific theory have been raised as many as 3 quotes. Book 3 (Grafindo Media Pratama) has 2 quotes and Book 5 (Yudhistira) has 1 quote. Meanwhile, book 1 (Erlangga), book 2 (Mediatama), and book 4 (Yrama Widya) did not appear or there were no quotations regarding aspects of scientific theory.

#### 4.2.8 Scientific law aspect

The definition of scientific legal aspects refers to descriptive statements regarding the relationship between phenomena. In this scientific law the quotation is conveyed implicitly. Implicit submissions, for example, are found in book 4 (Yrama Widya), namely:

*The law of the conservation of energy for heat fulfills the principle proposed by Joseph Black, namely "In mixing two substances, the amount of heat released by the substance with a higher temperature is equal to the amount of heat absorbed by the substance with a lower temperature." The law of conservation of energy for heat only applies to closed systems (Page.131)*

The quote only mentions examples from the law and does not explain the meaning of law. The frequency of appearances of aspects of scientific law from the five eleventh grade high school physics textbooks is presented differently. Based on the analysis, it can be seen that in the aspect of scientific law, 4 citations have been raised. Book 2 (Mediatama) and book 3 (Grafindo Media Pratama) have the same frequency of occurrence, namely 1 citation appears. Book 4 (Yrama Widya) appears in 2 quotations. Meanwhile, book 1 (Erlangga) and book 5 (Yudhistira) do not appear or there are no citations regarding aspects of scientific law.

#### 4.2.9 Social science aspect

The definition of the social aspect of science refers to the publication of the findings and appreciation from the public for the findings. In this aspect of social science, quotations are conveyed implicitly. Implicit submissions, for example, are found in book 1 (Elangga), namely:

*In daily use in the United States, thermometers with the Fahrenheit scale are still used. On the Fahrenheit scale, the melting point of ice is 32 and the boiling point of water is 212. This scale is named after the scientist who first created it, namely the German physicist Gabriel Fahrenheit (1686-1736). (Pages. 198-199).*

The quote shows an example of implicit acknowledgment in the form of using the findings. The frequency of emergence of social science aspects from the five eleventh grade high school physics textbooks is presented differently. It can be seen that the social aspect of science in the five books has appeared as many as 19 citations. Book 1 (Elangga) has 7 citations, book 2 (Mediatama) has 4 citations, book 3 (Grafindo Media Pratama) has 2 citations, book 4 (Yrama Widya) has 5 citations, and book 5 (Yudhistira) has 1 quote.

#### 4.2.10 *Embedding social culture in science aspect*

The definition of aspects of social and cultural cultivation in science refers to the statement that knowledge develops based on the needs of society and applies knowledge to the everyday environment. In this aspect of social and cultural cultivation in science, quotations are conveyed explicitly. Explicit submissions, for example, are found in book 1 (Elangga), namely:

*When sunlight hits the glass of a greenhouse, visible light can penetrate the glass, while ultraviolet and infrared are reflected back by the glass. The radiant heat of visible light is absorbed by the soil and plants in the greenhouse so that the soil and plants become warm. We can classify warm soil and plants as a cooler source than the very high temperature of the sun. Soil and plants as cooler heat sources will re-emit the heat they receive in the form of infrared radiation with a longer wavelength (or smaller energy). Infrared radiation heat energy that is emitted again is not able to penetrate the glass. As a result, this heat energy is trapped inside the greenhouse, and the greenhouse becomes warm. The temperature inside the greenhouse can remain higher than the outside temperature. This situation allows plants to thrive (Page. 252)*

The quote shows explicitly the applications of knowledge in everyday life. The frequency of emergence of social and cultural planting aspects in science from the five eleventh grade high school physics textbooks is presented differently. Based on the analysis, it can be seen that as many as 67 citations have been raised about aspects of social and cultural cultivation in science. This aspect is the most common in all five books. Book 1 (Elangga) has 27 citations, book 2 (Mediatama) has 11 citations, book 3 (Grafindo Media Pratama) has 10 citations, book 4 (Yrama Widya) has 19 citations, and book 5 (Yudhistira) has 12 citations

## 5. Discussion

From the research results, the frequency of the appearance of the ten aspects of NoS in the five eleventh grade physics textbooks were different. The results are in line with other studies which reveal that the number of aspects of NoS in the five physics textbooks in China also varies, only two textbooks represent all aspects of NoS (Abd-El-Khalick, Waters, and Le 2008). In addition, the results of this study indicate that the number of NoS aspects of the five physics textbooks mostly raises aspects of social and cultural planting in science, although there are aspects that are not raised at all, namely creative aspects. These findings are in line with research conducted by analyzing the representation of NoS in five high school physics textbooks in China where the representation of NoS in textbooks is inadequate or only raises certain aspects.

In general, the five physics textbooks analyzed have explicitly addressed aspects of NoS, although some were conveyed implicitly. This is in line with other studies which reveal that the explicit representation of NoS in physics textbooks is more dominant than the implicit representation of NoS (Agustin *et al.* 2021). Physics textbooks should be able to bring up aspects of NoS as a whole, both explicitly and implicitly, in a balanced proportion. For example, in the tentative aspect of a new finding, namely Stefan Boltzman's Law, the quote is conveyed explicitly and implicitly. In these quotations, there are explicit new findings whose contents reinforce old opinions and implicit quotations, namely quotations written only as statements of the stages of discovery without explaining the nature of the science.

In the context of Erlangga's physics textbook, this book has the highest number of occurrences of NoS aspects. However, it has not yet presented all aspects of NoS. The findings only explicitly show aspects of socio-cultural inculcation in science in the applications of knowledge in everyday life. These findings are in line with research conducted by researcher who analyzed the representation of NoS in three tenth grade physics textbooks where the results of his research indicated that these textbooks still had several aspects that had not been raised such as inferential, creative and theory driven aspects (Abd-El-Khalick, Waters, and Le 2008). Submission of aspects of NoS has not been

conveyed in an explicit, correct, consistent, and comprehensive manner. The results of this study are also in line with which analyzes the representation of NoS in five twelfth grade physics textbooks (Lederman et al. 2002); The results of this study indicate that in general the five textbooks still have some aspects of NoS that have not been raised such as inferential, creative and tentative aspects. Other studies also reveal similar things in analyzing the representation of NoS in two tenth grade physics textbooks for harmonic vibration material, where the results of their research show that aspects of NoS in the two textbooks are still dominated by aspects of theory and physical laws (Dhamayanti, Putra, and Handayani 2019)

## 6. conclusion

Finally, the results of the analysis show that the eleventh-grade high school physics textbooks have raised some aspects of NoS. This shows that even though NoS is one of the main objectives in learning science, the textbook still cannot fully represent NoS (18). Therefore, special attention is needed so that the ten aspects are raised explicitly or implicitly so that they can provide a complete picture of NoS for students. Thus, students can be motivated to want to learn science, especially NoS. In addition, in classroom learning, teachers must convey aspects of NoS explicitly and students must also be given the opportunity to reflect on aspects of NoS in learning activities in class.

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