

Research Article

Analysis of Physics Textbooks Used in Senior High School for Insertion of the Nature of Science

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Abstract.

The study analyzed two grade X physics textbooks published by Erlangga and Yudhistira. The analyzed textbooks emphasized the insertion of four aspects of the nature of science (NOS), consisting of science as a body of knowledge, science as a way of investigating; science as a way of thinking; and science and its interaction with technology and society. The content analyzed is the subject matter in the odd semester. The raters consisted of one physics lecturer (rater 1) and two teachers (rater 2 and 3). The raters used the scoring rubric developed by the researchers based on indicators from the four aspects of NOS. The results stated that Erlangga's Textbook inserted (a) the first 58.46% of the NOS aspects; (b) 26.28% second aspect of NOS; (c) 31.78% of the third aspect of NOS; and (d) 16.86% of the fourth aspect of NOS. Also, the results in Yudhistira's book revealed that (a) the first 49.55% of the NOS aspects; (b) 13.88% second aspect of NOS; (c) 24.55% third aspect of NOS; and (d) 12.01% of the fourth aspect of NOS. The percentage of inter-rater agreements ranged from 70-88%. The percent agreement strengthens with the interval of kappa value from 0.60 to 0.88. The results indicated that the two books devoted half of the learning material that reflected science as a body of knowledge but neglected science as a way of investigating, and science and its interaction with technology and society.

Keywords: physics textbooks, insertion, nature of science

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1. INTRODUCTION

From elementary to higher education levels, textbooks influence the success and effectiveness of the learning processes. Since textbooks have become an integral part of the learning process, many educational researchers have become the research focus. The research results by Alwasilah [1] stated that the teaching materials became identical to the material contained in the books. Consequently, most teachers wrote specific pages or chapters of the books in the lesson plan to indicate the source of the learning materials.

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Supriadi [2] reported that the learners' ownership of books positively and significantly correlated with student learning outcomes. It means that the higher learners' access to textbooks, the higher the learning achievement that the learners may achieve. Since the role of textbooks in Indonesia's educational system plays a vital factor in students' learning activities and the teacher's teaching, the use of particular textbooks at a certain educational level needs to be declared feasible by the Ministry of Education and Culture (Permendikbud No. 8, Tahun 2016). Thus, every compulsory book used by students and teachers at every level of education must pass a selection process and have the letter of government's recommendation displayed on the book's back cover.

Due to the reliance of the educational process on textbooks, [3] carried out a literature review of 183 research articles on textbooks published between 2000 and 2008. They concluded that the USA and Europe researchers performed most academic papers examined in science textbooks for secondary schools.

Some researchers have previously analyzed physics textbooks used by teachers from tenth to 12th graders. For example, [4] analyzed experimental physics ideas contained in 30 physics textbooks for grades 10, grade 11, and class 12 published from 2009 to 2017 and concluded that the experimental ideas presented in physics textbooks are unable to employ as an introduction in conveying scientific knowledge to students. Almost 70% of the physical books analyzed are sufficient and lacking in presenting experimental ideas.

In senior high school, physics textbooks play (a) the primary guide for developing physics subject matter that students master and (b) physics textbooks present detailed explanations of the subject matter for students to accomplish. The availability of high-quality textbooks is a component that supports the success of the learning process. Most physics textbooks have met the book development standards recommended by the National Education Standards Agency (BSNP). However, there is a tendency for the presentation of science subject material to be more focused on one of the themes of NOS. [5] stated that most Physics textbooks published between 1967 and 1997 emphasize the theme of science as a body of knowledge and less emphasis on presenting physics material as a way of thinking. Research on textbooks based on scientific literacy as the conceptual framework confirms that the seven textbooks tend not to integrate the four NOS themes in a balanced way [6].

1.1. Nature of Science (NOS)

Researchers have not agreed on the nature of science (NOS) definition. However, they defined NOS as an epistemology of science. More specifically, researchers considered NOS as one component of epistemology as a way to know and believe in the values inherent in science and the influence of society, culture, and technology on science. Furthermore, [7] stated that NOS denotes the values and suppositions inherent to scientific knowledge and the development of scientific knowledge.

Following the curriculum, the Textbook guides the teacher to determine the depth and breadth of the subject matter developed in the lesson plans and taught to students. Due to this fact, textbooks used by teachers and students must ensure that textbooks have NOS included. NOS is urgent and inherent in a textbook because science teachers had difficulties implementing NOS into science teaching [8]. Through the use of textbooks that present NOS in textbooks, teachers are likely to be helped to convey NOS to students due to many aspects of NOS that are relevant to K-12 students [9].

2. RESEARCH method

The investigation aimed to analyze two physics textbooks employed by teachers and grader X in Bengkulu city. The focus of the content analysis of the books is to determine the emphasis given to the four themes of NOS and the descriptors adopted from , as displayed in Table 1.

Defining the conceptual framework before analyzing the Textbook is essential because researchers need the themes and descriptors derived from the conceptual framework. Previous textbook analysis researchers used the conceptual framework to analyze textbook content. For example, [10] uses science literacy, including knowledge, investigation, thinking, and society, as the conceptual framework for analyzing science textbooks. [11] adapted the nature of the scientific conceptual framework by adding several descriptors adjusted to the research objectives and based on the latest research reports.

The book analysis provides information on the percentage of four aspects of NOS covered by the two most widely used physics textbooks in Bengkulu city high school. Table 2 presents the properties of two textbooks assessed in this study.

The considerations for the two books to be analyzed are (1) Both books are based on the 2013 National Curriculum, (2) The two textbooks have fulfilled the national standards declared by Badan Standar Nasional Pendidikan (the National Education Standards

TABLE 1: Four themes and their descriptors used to evaluate the NOS in physics textbooks.

No	Themes of the Nature of Science	Descriptors
1	Science as a body of knowledge	facts, concepts, laws, and principles
		hypotheses, theories, models
		questions asking for the recall of information
2	Science as a way of investigating	learns through the use of materials
		learns through the use of tables and charts
		makes calculations
		reasons out an answer
		participated in a thought experiment
3	Science as a way of thinking	gets information from the internet
		describes how a scientist discovered or experimented
		shows the historical development of ideas
		illustrates the empirical basis of science
		models the use of assumptions
		employs inductive or deductive reasoning
4	Science and its interaction with Technology and Society (STS)	shows cause and effect relationships, gives evidence and proof
		presents methods of science and problem solving
		describes the use of science or technology
		presents adverse effects of science or technology
		addresses societal issues related to science or technology
		discusses careers in science or technology

TABLE 2: The identities of the two textbooks as an object of study.

No.	The properties of Textbooks	Code of Textbooks	
		Textbook A	Textbook B
1	The title of textbook t	Fisika 1 untuk SMA/MA kelas X	Fisika 1 SMA kelas X
2	Publishing (Year)	Erlangga (2016)	Yudhistira (2016)
3	Number of the chapter (pages)	Eight (476)	Ten (264)
4	Textbook size	25 cm x 17.5 cm	25 cm x 17.5 cm
5	Theme Fonts (font size)	Adobe Garamond Pro (11 pt)	Adobe Garamond Pro (11 pt)
6	No. ISBN	978-602- 241-465-0	978-602-299-510-4

Agency), (3) The subject matter in two textbooks are arranged on core competencies,

and basic competencies provided in the 2013 National Curriculum, and (4) The two texts also consider to be widely used in other high school classrooms in other cities in Bengkulu province.

The number of chapters and pages in Textbook A consists of eight and 476 pages, but the student learned the four chapters in the first and second semesters. On the contrary, textbook B has ten chapters and 264 pages learned by grader X during the first semester. Since book analysis focused on the learning material learned in the first semester, the analysis unit consisted of four chapters in textbook A and ten in textbook B.

TABLE 3: Total of chapters and pages for textbook A and textbook B.

Textbook		Chapters Number									
		1	2	3	4	5	6	7	8	9	10
A	Number of Chapters	84	44	29	67	37	77	127	166		
	Number of Pages	54	43	17	50	20	37	56	75		
B	Number of Chapters	30	54	51	56	60	63	44	46	37	32
	Number of Pages	9	19	5	15	35	28	19	28	20	13

Paragraphs analyzed are based on the content of each paragraph on each page, so the unit of analysis excluded equations, examples, and problems, as shown in Table 3. Based on Table 3, the number of pages is different for each chapter in either the same or different books. The number of pages assigned to analyze this study adopted the benchmarks proposed by [11] as in Table 4.

TABLE 4: Benchmarks for determining the percent of pages and inter-rater reliability.

No	Page interval	Percent of pages	Kappa Value	Level of agreement	% of Data Reliable
1	5 - 9 pages	80	0 – 0.20	None	0 – 4%
2	10 - 14 pages	40	0.21 – 0.39	Minimal	4 – 15%
3	15 -19 pages	25	0.40 – 0.59	Weak	15 – 35%
4	20 - 24 pages	20	0.60 – 0.79	Moderate	35 – 63%
5	> 25 pages	15	0.80 – 0.90	Strong	64 – 81%
			Above 0.90	Almost perfect	82 – 100%

Following the development of the instrument with the use of four themes of NOS and indicators (see Table 1), the raters independently performed the content analysis techniques to identify NOS in every paragraph on each page selected randomly. The page number in each chapter was copied and numbered before the document was

provided for analysis by three raters. After each rater finished assigning every unit of analysis to one of four themes of NOS, Cohen’s kappa statistic was used to compute a degree of agreement among the three raters. Many researchers, such as [11], applied the value of kappa to an indicated degree agree among raters. Furthermore, inter-rater reliability among raters used percent agreement and Cohen kappa (cited in McHugh, 2012) (see Table 4). The previous reports concerning the book analysis used the particular cut-off percentage of agreement and kappa values. For example, Chiappetta, Fillman, and Sethna (1991) applied an inter-rater agreement of at least 80% and a kappa value of 0.73.

3. result and discussion

The result of content analysis was conducting three raters to identify NOS in every unit of analysis present for every textbook. Table 5 presents how textbook A encompasses a chapter concerning four themes of NOS. Inspection of the table shows that science as a body of knowledge is the majority theme and ranges from 34.68% to 57.50%. Following the first theme of NOS, the learning material devoted to science as a way of thinking is from 19.38% to 27.04%. Next, science as a way of investigating is from 15.00 % to 24.46%. Lastly, science and its interaction with technology and society is 4.50% to 18.02%. Therefore, physics textbook A has the highest percentage of science as a body of knowledge among the four-chapter analyzed.

TABLE 5: Percentage of themes of NOS identified in textbook A.

No	The themes of NOS	Title of Chapters				Overall Mean
		Physic quantities and units (%)	Motion in One Dimension (%)	Uniform Circular Motion (%)	Particle Dynamics (%)	
1	Knowledge	34.68	38.43	44.64	57.50	58.46
2	Investigation	24.46	24.17	15.20	15.00	26.28
3	Thinking	27.04	19.38	25.91	23.00	31.78
4	STS	13.82	18.02	14.25	4.50	16.86

Table 2 displays the percentage of inter-rater agreement among raters and kappa value among raters involved in analyzing textbook A concerning four themes of NOS. Percent agreement between the two authors (VA/VB) ranges from 70% to 87%, with the interval of value kappa from 0.60 to 0.82. (Table 6). The interval of inter-rater agreement between the first authors and the physics teacher (VA/VC) is 71% to 87%, and its kappa value is from 0.61 to 0.82. The percentage of agreement between the second author

and the physics teacher (VB/BC) is 70% to 90%, with the interval of kappa value from 0.60 to 0.89. Based on Table 6, the percent agreement in all of these ranges reached the level of agreement with categorizing moderate (0.60 – 0.79) and strong (0.80 – 0.90).

TABLE 6: Inter-rater agreement for analysis of physics textbook-a among three raters.

Title of Chapter	VA versus VB		VA versus VC		VB versus VC.		Mean	
	% agree	kappa	% agree	kappa	% agree	kappa	% agree	kappa
Physic quantities and units	82	0.77	85	0.80	88	0.84	85	0.80
Motion One in Dimension	85	0.82	87	0.82	90	0.86	87	0.84
Uniform Circular Motion	87	0.82	86	0.81	92	0.89	88	0.84
Particle Dynamics	70	0.60	71	0.61	70	0.60	70	0.60

Note. A= first author, B = second author, C = the physics teacher. Cohen kappa formula: $k = \frac{(p_0 - p_c)}{(1 - p_c)}$

The percentage of the occurrence of the NOS themes in textbook B presents in Table 7. The mean percentages of the four themes found in ten chapters of physics textbook B are devoted predominantly to science as a body of knowledge (Mean = 49.55). The second most emphasized theme is science as a way of thinking (Mean = 24.55), followed by science as a way of investigating (Mean = 13.88). However, science and its interaction with technology and society (Mean = 12.01) seem to be the least common occurrence of the NOS themes analyzed in textbook B. In this case, the textbook author emphasizes that physics as science is a collection of facts, concepts, laws, and principles to learn and memorize terms.

TABLE 7: Percentage of themes of nature of science identified in textbook B.

Chapter	Title of Chapters	Themes of Nature of Science			
		Knowledge	Investigation	Thinking	STS
1	Nature of physics and science process	33.09	11.76	26.38	28.77
2.	Measurement	20.09	20.54	38.82	20.55
3.	Vector	57.64	15.28	17.43	9.65
4.	Motion in One Dimension	56.2	16.67	21.32	5.81
5	Hyperbole Motion and Circular Motion	54.34	11.84	23.49	10.33
6	Newton’s Laws	47.52	13.74	30.18	8.56
7	Gravitation	56.58	11.68	19.76	11.98
8	Work and Energy	54.54	13.16	23.52	8.78
9	Momentum and Impulse	57.81	13.02	21.88	7.29
10	Harmonic Motion	57.72	11.12	22.76	8.40
	Overall mean	49.55	13.88	24.55	12.01

Table 8 displays the inter-rater agreement for inquiry of the ten chapters in textbook B related to four themes of NOS. The overall mean of the percentage of inter-rater reliability between raters ranges from 79% to 84%. Moreover, the lowest and highest kappa values are from 0.61 to 0.89. Based on Table 4, the overall mean of the level agreement between raters is strong or almost perfect. The overall mean of percent agreement and kappa value reached the acceptable percent agreement (80%) and kappa value ?? that set in their earlier report.

TABLE 8: Inter-rater agreement for analysis of physics textbook-B among three raters.

Title of Chapters	VA versus VB.		VA versus VC		VB versus VC.	
	% Agree	Kappa	% Agree	Kappa	% Agree	Kappa
Nature of physics and Science Process	80	0.73	87	0.82	79	0.72
Measurement	82	0.76	83	0.77	72	0.63
Vector	79	0.72	72	0.63	71	0.61
Motion in One Dimension	86	0.82	88	0.84	78	0.72
Hyperbole Motion and Circular Motion	85	0.80	87	0.82	86	0.82
Newton's Laws	92	0.89	93	0.91	86	0.82
Gravitation	90	0.87	89	0.85	83	0.77
Work and Energy	72	0.63	71	0.61	60	0.47
Momentum and Impulse	71	0.61	83	0.77	85	0.80
Harmonic Motion	83	0.77	90	0.87	91	0.88
Overall mean	82	0.76	84	0.79	79	0.72

High School Physics textbooks are a significant learning resource that supplies the subject matter content for many students learning in physics classrooms. From the content analysis of two physics textbooks used widely in Indonesian high schools, particularly in Bengkulu City, a reasonable unbalance of NOS themes was identified in the writing and activities presented in the two-analyzed textbooks. The two textbooks devoted the highest percentage of text to science as a body of knowledge, followed by science as a way of thinking (see Tables 5 and 7). Similarly, the research report published by [11] stated that the highest percentage of the subject matter in science textbooks was assigned to science as a body of knowledge.

Since more than half of the learning material in textbooks reflected knowledge, science as a way of investigating, and science and its interaction with technology and society tended to be neglected. Ideally, physics textbooks must contain a reasonable balance of four NOS themes [5]. Although the researcher focused on this issue almost a decade ago, the balanced treatment of NOS by the experts who wrote the high school physics textbooks needs to be attended to, particularly in Indonesian schooling.

4. CONCLUSION

It is evident from the percentage of the theme of NOS inserted in Erlangga's and Yudhistira's textbooks that both textbooks emphasized science as a body of knowledge, followed by science as a way of thinking, science as an investigating, and science and its interaction with technology and society. However, the physics textbook used in the senior high school classroom should contain a reasonable balance of four-NOS themes to indicate a good physics textbook since a textbook provides primary learning resources that offer detailed explanations for high school students.

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