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Nature of Science: A Comparative Analysis of the High School Physics Textbooks in Indonesia and Korea

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Abstract. Over the past two decades, the goal of supporting students and teachers in developing views on the Nature of Science (NoS) has been increasingly central to the vision and discourse goals for global physics education reform. Understanding the Nos is a critical and essential component of scientific literacy. The main objective of this study is to present a comprehensive picture of the NoS in physics textbooks in Indonesia and South Korea. This research is a descriptive study, and the data source consisted of 10 high school physics textbooks (five textbooks from each country). The textbooks were chosen based on the results of a Google Forms survey about the most common use of physics textbooks in schools. The results show that the total number of NoS elements presented in Indonesian physics textbooks is 71, of which 47 are on the cognitive-epistemic aspect, and 24 relate to the social-institutional aspect. In contrast, the number of NoS items presented in Korean physics textbooks is 84, with 54 on the cognitive-epistemic aspect and 30 on the social-institutional aspect. This study also revealed that 59% of the NoS in Indonesian physics textbooks were located in the main text, 35% were found in secondary texts, while 6% were presented in both. Similarly, 48% of NoS items in Korean physics textbooks were located in the main text, 44% in secondary texts, and 8% were presented together. Therefore, this study concludes that Korean high school physics textbooks contain more NoS than Indonesian high school physics textbooks.

Keywords: Nature of science; Indonesian physics textbooks; Korean physics textbooks

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1. Background of the study

This study attempts to present a comprehensive picture of the NoS representation in Indonesian and South Korean physics textbooks. The NoS is an essential element of scientific literacy that enriches students' comprehension of science concepts. The promotion of scientific literacy is the primary goal of physics education in almost all schools globally today (Abd-El-Khalick et al., 2017; Australian Curriculum Assessment and Reporting Authority [ACARA], 2016; McDonald & Abd-El-Khalick, 2018; Next Generation Science Standards [NGSS Lead States], 2013) and one of the foundations for achieving this goal is the growth of students' awareness of NoS (Abd-El-Khalick et al., 2017; Ayık & Coştu, 2020; Bugingo et al., 2022; Liang et al., 2009). Therefore, over the past two decades, the goal of assisting students and teachers in developing perspectives on the NoS has increasingly become the core of visions and document discourse on global science education reform (Abd-El-Khalick et al., 2017; Brunner & Abd-El-Khalick, 2020; McDonald & Abd-El-Khalick, 2018; Park et al., 2019; So & Kang, 2014). Understanding the NoS is now regarded as a significant outcome of school-level physics education and a critical component of scientific literacy (Cofré et al., 2014; McComas & Clough, 2020). It is necessary for teachers to elaborate on parts of the NoS in physics education since it can assist students in understanding their environment (Bancong & Song, 2020; Karampelas, 2018; Upahi et al., 2020; Zhang et al., 2022). Furthermore, an understanding of the scientific enterprise, including how scientific knowledge is created, as well as its strengths and limitations, will be aided by having an informed view of NoS (Abd-El-Khalick et al., 2008; Ayık & Coştu, 2020).

South Korea is known universally for offering high-quality education. According to the Program for International Student Assessment (PISA), around 86% of Korean students attained level 2 or better in science in 2018 (Organisation for Economic Co-operation and Development [OECD], 2019). This means that 86% of Korean students can recognize and identify valid explanations for common scientific events, in basic cases, for example, to determine whether a conclusion is valid based on the data provided. Additionally, 12% of Korean students are excellent in science, indicating that they can creatively and independently use their understanding and application of science to a range of situations, including those that are unfamiliar (OECD, 2019).

In contrast, in Indonesia, only about 40% of students reach Level 2 or higher in science, with the OECD average of 78% (OECD, 2019). This means that in Indonesia, only around 40% of students have the ability to recognize the right explanations for common scientific phenomena and can use that knowledge to identify them, in simple cases, for example, to determine whether a conclusion is valid based on the data provided. In addition, although 7% of OECD students are considered to be at Level 5 or 6 proficiency in science (OECD, 2019), only 1% of Indonesian students achieve this level.

Ardwiyanti et al. (2021) and Dhamayanti et al. (2019) have examined NoS in Indonesian high school physics textbooks. Both of them claimed that NoS is still not properly and comprehensively stressed in high school physics textbooks.

Only theories and laws indicators receive more attention than other indicators. Furthermore, there has been no cross-country comparative research on this topic in Indonesia. According to Liang et al. (2009), teachers in China, America, and Turkey have different understandings of NoS owing to cultural differences. Similarly, Zhang et al. (2022) reported that pre-service teachers in Canada have a higher comprehension of NoS than pre-service teachers in China. Therefore, in order to learn more about NoS as well as enhancing the related literature, this study was designed to compare NoS in physics textbooks between Indonesia and Korea.

This study enhances the existing body of worldwide literature by broadening the understanding of the NoS throughout diverse educational contexts. The outcomes of this investigation will contribute to the advancement of research on the NoS as a subject of inquiry within the Indonesian context. Moreover, these findings will have practical implications for physics educators, specifically in Indonesia and Korea, as well as in countries with similar educational contexts, on how to prepare textbooks rich in NoS aspects.

Therefore, this study aims to investigate the comparison of NoS aspects in physics textbooks in Indonesia and Korea. The research questions in this study are as follows:

1) Which aspects of NoS are addressed in high school physics textbooks in Indonesia and Korea?
2) How is NoS presented in Indonesian and Korean high school physics textbooks?

2. Literature reviews

2.1. Nature of science

NoS is not a description of how science works but rather how a scientific enterprise works (Abd-El-Khalick et al., 2017; Upahi et al., 2020). Similar to scientists, persons interested in the NoS seek an understanding of how scientists work and engage with one another, how science answers questions, and how science generates knowledge about nature. What science is, how it functions (including epistemological and ontological concerns), how science influences and is influenced by society, and how scientists conduct their professional and personal lives are all topics that are explored in the NoS (Ayık & Coştu, 2020; Kaya & Erduran, 2016; McComas & Clough, 2020).

According to Brunner and Abd-El-Khalick (2020), there are three aspects of NoS, namely empirical, inferential, and creative. Scientific claims that rely on evidence gathered through the senses or the extension of the senses are referred to be empirical NoS. This is connected to the distinction between observation and inference. Observations are descriptions of natural happenings that are generally simple to achieve. In contrast, an inferential conclusion is one that is consistent with observations that cannot be witnessed directly. The term "creative NoS" refers to the requirement for scientists to employ their imagination and creativity in order to generate ideas, explanations, and hypotheses.

The framework of NoS, as created by Kaya and Erduran (2016), offers a holistic depiction of the scientific enterprise, encompassing its goals and values to methods and scientific knowledge and also considering its social impacts. This framework conceptualizes science as a cognitive-epistemic system that includes inquiry processes, goals and values, methods and methodological rules, and scientific knowledge. Additionally, it recognizes science as a socio-institutional system comprising professional activities, scientific ethos, social certification and dissemination of scientific knowledge, and social values. This form of representation has the potential to aid teachers in gaining an understanding of the elements that are absent in the teaching of NoS, as well as in making decisions about which aspects should be prioritized and why this should be so in teaching science in schools. Furthermore, the incorporation of socio-institutional elements within the framework of NoS holds the promise of engaging a wider spectrum of students, including those who exhibit aversion towards the predominantly cognitive features emphasized in the classroom. Figure 1 shows the family resemblance approach (FRA) of the NoS:

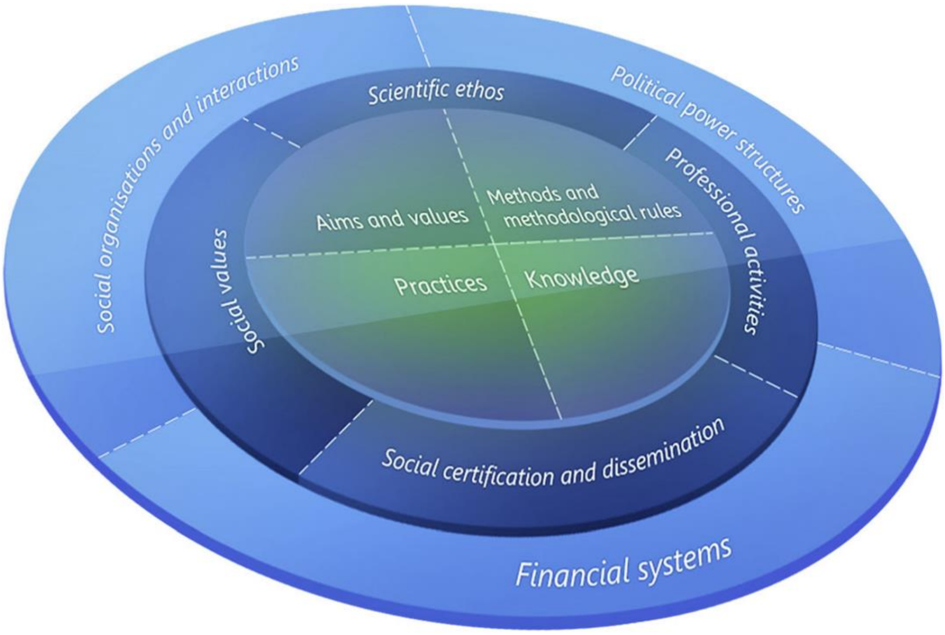

Figure 1: FRA framework of NoS

2.2. Previous studies on NoS

A number of studies have been reported that specifically examine the representation of NoS in physics textbooks in schools. This analysis aims to examine and evaluate whether the textbooks are in accordance with the curriculum and learning objectives of physics globally. Abd-El-Khalick et al. (2017) analyzed NoS in 18 physics textbooks commonly used in the United States (US) over the past decade. The results showed that the representation of the NoS in every physics textbook in the US does not differ based on aspects of the NoS. It has simply not increased substantially over the past few years. This trend is not comparable to the curriculum in the US, which places more emphasis on high school students' developing the concept of NoS.

McDonald and Abd-El-Khalick (2018) also examined four scientific textbooks often used by physics teachers in Australia. According to the findings of their investigation, there were four textbooks that exclusively and implicitly offered NoS in various organizational forms and formats. Furthermore, Park et al. (2019) analyzed aspects of the NoS in five physics textbooks based on the 2015 curriculum in South Korea. The results of their study revealed that the indicators of NoS, such as scientific knowledge, scientific practice, scientific methods, and professional activities of scientists, have been well described in the five physics textbooks. The feature of science as a socio-institutional system, on the other hand, was not adequately depicted in the five textbooks.

Several comparative studies have also been conducted on aspects of the NoS across countries. Liang et al. (2009) investigated the perspectives of pre-service teachers in the US, China, and Turkey on the six elements of NoS: observations and inferences, tentativeness, scientific theories and laws, social and cultural embeddedness, creativity and imagination, and scientific methods. A total of 640 pre-service teachers from the US, 212 from China, and 219 from Turkey took part in their research survey. The results show that Chinese pre-service teachers received the highest scores of the three countries, while Turkish pre-service teachers received the lowest scores.

Park et al. (2014) also compared students' understanding of the NoS in Canada and Korea. The findings show that country differences have an effect on subjectivity variance, empirical testability, and methods but are not significant for tentative concepts. Students' perspectives on aspects of the NoS are influenced by the national situation and curriculum content. According to Zhang et al. (2022), the differences in understanding of NoS between students in Canada and China may be related to relevant teacher education policies, curricula, and pedagogy. Recently, Bugingo et al. (2022) reported on an analysis of the representation of NoS aspects in science curricula, particularly in the physics syllabus in four East African countriies, namely Burundi, Rwanda, Tanzania, and Uganda. Their findings revealed that aspects of the NoS were not explicitly represented in the four physics curricula studied in these four East African countries. They also claim that in the four physics syllabuses reviewed, much attention has been paid to competencies without overt links to the works of scientists.

Ardwiyanti et al. (2021) and Dhamayanti et al. (2019) have examined NoS in high school physics textbooks in Indonesia. However, these two studies only looked at class X high school physics textbooks. Furthermore, Dhamayanti et al. (2019) limited their study to one chapter in two types of high school physics textbooks for class X. Then, another study only looked at three chapters for three different types of high school physics textbooks for class X (Ardwiyanti et al., 2021). The findings of this study provided an overview of the NoS in Indonesian high school physics textbooks. However, there have been no cross-country comparative studies on this topic despite the fact that different cultures will provide different understandings of NoS (Liang et al., 2009; Zhang et al., 2022). Thus, to determine the level and advance the relevant literature on NoS, this study was designed comparatively to investigate NoS in physics textbooks between Indonesia and Korea.

3. Methods

This study was a descriptive in nature and aimed to describe the various aspects of the NoS as a whole as well as the actual situation in high school physics textbooks in Indonesia and South Korea. Ten physics textbooks were analyzed in this study, namely five physics textbooks for each country. The textbooks were chosen based on the results of a Google Forms survey on the most widely used physics textbooks in schools. Table 1 shows the profile of the physics textbooks used as the source of research data, both commonly used by students and teachers in Indonesia and South Korea:

Table 1: Profile of Indonesian and Korean physics textbooks

No.	Indonesian physics textbooks			Korean physics textbooks		
	Authors	**Publisher**	**Publication year**	**Authors**	**Publisher**	**Publication year**
1	Marthen Kanginan	Erlangga	2018	N. Kang, H. Choi, W. Choi, S. Lim, T. Kang et al.	Chunjae Education Inc	2018
2	Hari Subagya	Bumi Aksara	2018	Y. Kim, I. Kim, S. Kim, B. Park, B. Cheong et al.	Kyohak Publishing	2011
3	Bambang Ruwanto	Yudhistira	2017	S. Kwak, S. Ryu, D. Kim, J. Ahn, O. Lee et al.	Chunjae Education Inc	2011
4	Sunardi, Retno, P. and Darmawan, A.	Yrama Widya	2016	Y. Kwak, S. Ryu, E. Kim and J. Park	YBM books publishing	2018
5	Widodo, T., and Suparmo	Departmen Pendidikan Nasional	2009	J. Son, B. Lee, H. Moon, S. Park, S. Lee, et al.	Visang Education Inc	2018

The data collection procedure began with a thorough reading of the chapter that serves as the research sample. The relativity chapter was chosen for this study because it was thought to contain many aspects of the NoS. This material included narrative text, pictures, diagrams, and other representations that explain the concept of relativity. Each author marked every word, sentence, and other representation that is an aspect of the NoS while reading the material chapter. The results of each author's identification of NoS data were then discussed in order to obtain real data.

The data analysis technique employed the content analysis method because the object of this research was a document in the form of physics textbooks that represented the NoS without any modifications. Furthermore, an analytical framework is required in content analysis, which is used as a lens in the investigation to obtain data that is consistent with the research objectives. The analytical framework used was FRA as the NoS category, which consisted of two main aspects and 11 indicators. This FRA was adapted from an instrument that had been developed by Kaya and Erduran (2016). This instrument had been used by several researchers who analyzed the NoS in textbooks (Chen et al., 2022; Park et al., 2019; Yeh et al., 2022). Table 2 shows the aspects and indicators of the NoS:

Table 2: The aspects and indicators of NoS

No	Indicator	Description
Science as a cognitive-epistemic system		
1	Aims and values	Science's primary cognitive and epistemic aims, such as precision and objectivity
2	Methods	Both manipulative and non-manipulative strategies that facilitate the process of scientific investigation
3	Scientific practices	A prominent collection of epistemic and cognitive methodologies that facilitate the acquisition and validation of scientific knowledge through a process of social certification
4	Scientific knowledge	A range of concepts, including theories, rules, and explanations, which serve to substantiate the outcomes derived from scientific inquiries
Science as a socio-institutional system		
5	Social certification and dissemination	The processes by which scientific information is reviewed, evaluated, and validated by scientists. This is commonly achieved through methods such as journal peer-review
6	Scientific ethos	The norms that scientists adhere to in their research endeavors and in their professional dealings with fellow peers
7	Social values	A range of principles that are highly regarded within a given society. These values may include but are not limited to concepts such as individual freedom, the preservation, and respect for the environment, as well as the promotion of social usefulness
8	Professional activities	Involvement of scientists in professional activities, including active participation in conferences and doing critical evaluations of scholarly publications
9	Social organizations and interactions	How science is organized in institutional settings such as universities and research institutes
10	Financial systems	The financial aspect that supports knowledge, including financing systems
11	Political power structures	The power dynamics that are present among scientists and within the scientific community

Member checking was used to ensure the reliability of the analysis in this study (Miles et al., 2014). Two professionals in the field of science education were invited to join the discussion. The discussion amongst researchers and experts led to inter-rater reliability for NoS representation of 90%. During the discussion, the observation notes were referred to in order to deepen the understanding of the discourse. Finally, triangulation of the data was performed, and reliable results were gathered.

4. Research results

The comparison of NoS provided in high school physics textbooks in Indonesia and Korea was based on two main questions: (a) the most stressed aspect of NoS, and (b) the manner in which NoS is presented. The following is the result of the data analysis of the NoS comparison between Indonesian physics textbooks and Korean physics textbooks:

4.1. The most stressed NoS aspect in high school physics textbooks in Indonesia and Korea

Based on data analysis, there are 71 NoS items presented in Indonesian high school physics textbooks, with 47 NoS on the cognitive-epistemic aspect and only 24 on the social-institutional aspect. When the two aspects of NoS were compared, it was found that 66.20% of cognitive-epistemic aspects appear in physics textbooks, while only 33.80% appear in socio-institutional questions. This means that the NoS presented in Indonesian high school physics textbooks emphasizes the cognitive-epistemic aspect rather than the social-institutional. In contrast, there were 84 representations of the NoS in Korean physics textbooks, with 54 elements of the NoS on the cognitive-epistemic aspect and 30 on the social-institutional aspect. When the two aspects of NoS were compared, the cognitive-epistemic aspect had a percentage of 64.29%, while the socio-institutional aspect had a percentage of 35.71%. In general, both Indonesian and Korean physics textbooks emphasize cognitive-epistemic aspects rather than social-institutional aspects.

As shown in Figure 2, of the four NoS indicators on the cognitive-epistemic aspect, Indonesian physics textbooks perform well only on the scientific knowledge indicator. The results of the data analysis show that there are 26 items that discuss scientific knowledge in five Indonesian physics textbooks. Meanwhile, the indicator of aims and values is minimally presented in Indonesian high school physics textbooks (five items). Similarly, the methods and scientific practice indicators were only mentioned eight times. Unlike in Korean high school physics textbooks, the frequency of appearance of indicators for scientific knowledge, methods, and scientific practice is almost balanced. In Korea there are 18 items presented in high school physics textbooks related to scientific knowledge, 16 related to scientific practices, and 14 related to methods. The aims and values indicator appears only six times in five high school physics textbooks in Korea. Figure 2 shows a comparison of the NoS presented in high school physics textbooks between Indonesia and Korea on the cognitive-epistemic aspect.

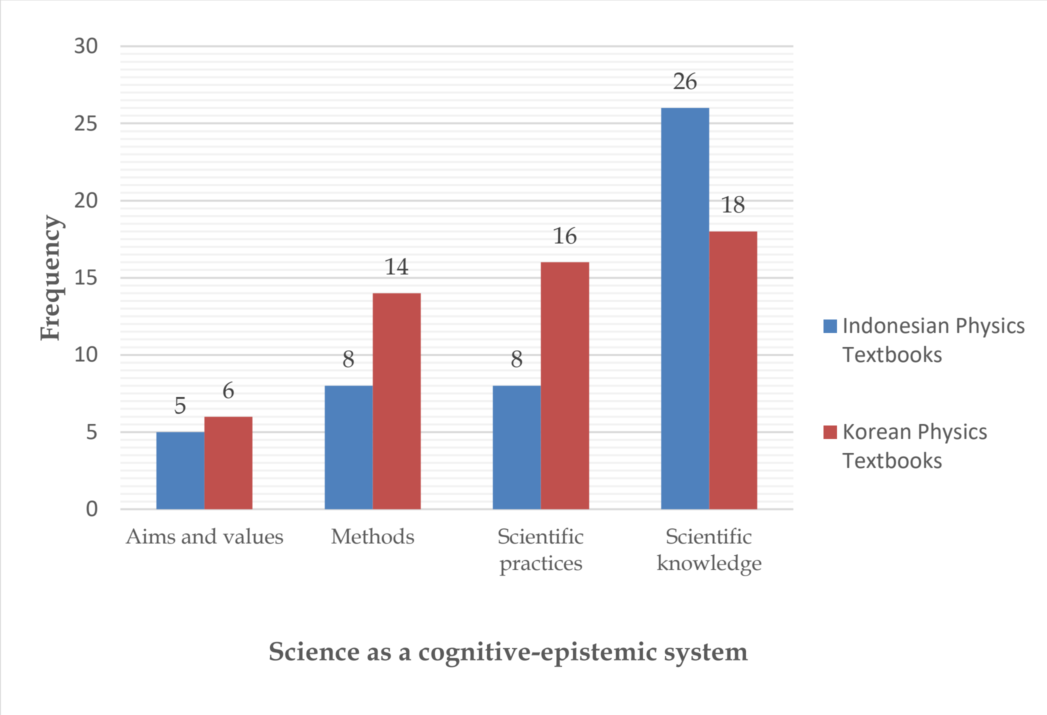

Figure 2: Comparison of NoS in Indonesian and Korean physics textbooks on the aspect of science as a cognitive-epistemic system

Furthermore, Figure 3 shows a comparison of the NoS in terms of the socio-institutional aspect. The Indonesian high school physics textbook performs well on only one of the seven NoS indicators on the socio-institutional aspect, namely scientific ethos. In total, 24 items in Indonesian high school physics textbooks discuss the NoS regarding socio-institutional aspects. Social certification and dissemination indicators are presented in four of the 24 items. Each of the scientific ethos and social values indicators has five items. In contrast to Korean high school physics textbooks, there are 30 items that discuss NoS from social-institutional aspects. The Korean high school physics textbook excels in indicators of social certification and dissemination (5), social values (6), and professional activities (8). Similar to Indonesian high school physics textbooks, social organization and interaction indicators are presented three times in Korean high school physics textbooks.

Furthermore, indicators of the financial system and political power structures are indicators of the NoS that are least discussed in the two countries' high school physics textbooks. The results of the data analysis show that there are only two items each related to the financial system and political power structures indicators in high school physics textbooks in the two countries. Figure 3 depicts the comparison of the NoS presented in Indonesian and Korean high school physics textbooks on the socio-institutional aspect:

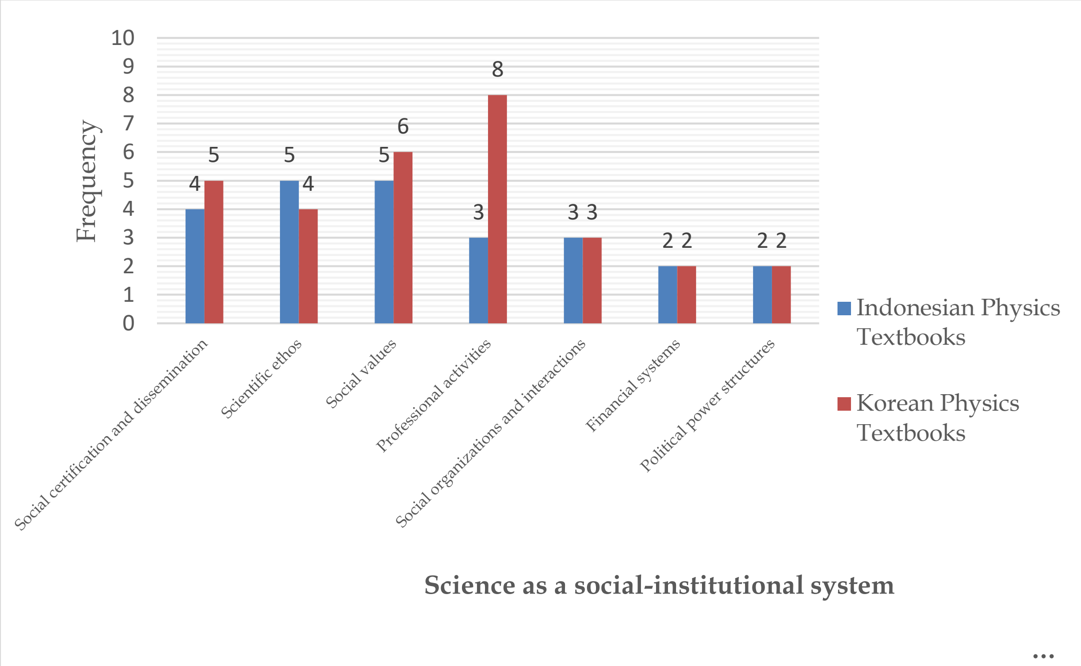

Figure 3: Comparison of NoS in Indonesian and Korean physics textbooks on the aspect of science as a social-institutional system

4.2. The way NoS is presented in Indonesian and Korean high school physics textbooks

Based on data analysis, 59% of the 71 NoS items presented in Indonesian high school physics textbooks were found in the main text, while 35% were found in secondary texts (boxes, graphs, sidebars, experimental activities, student assignments, science stories, and physics in everyday life). The remaining 6% were presented as a combined text of the main text and secondary text. Similar to Korean high school physics textbooks, 48% of the 84 NoS representations were found in the main text, 44% in secondary texts (boxes, graphs, sidebars, experimental activities, student assignments, science stories, physics in everyday life) and 8% were presented in both the main text and secondary elements. The text combination means that the NoS indicator is presented in the main text, followed by a description in the secondary text. For example, the main text describes the method used by Michelson and Morley in observing interference patterns using the equipment developed. Then, in the box, there is a picture of the experimental equipment and the method used by Michelson and Morley in observing the interference pattern. Figure 4 depicts a comparison of the way NoS is presented in Indonesian and Korean physics textbooks:

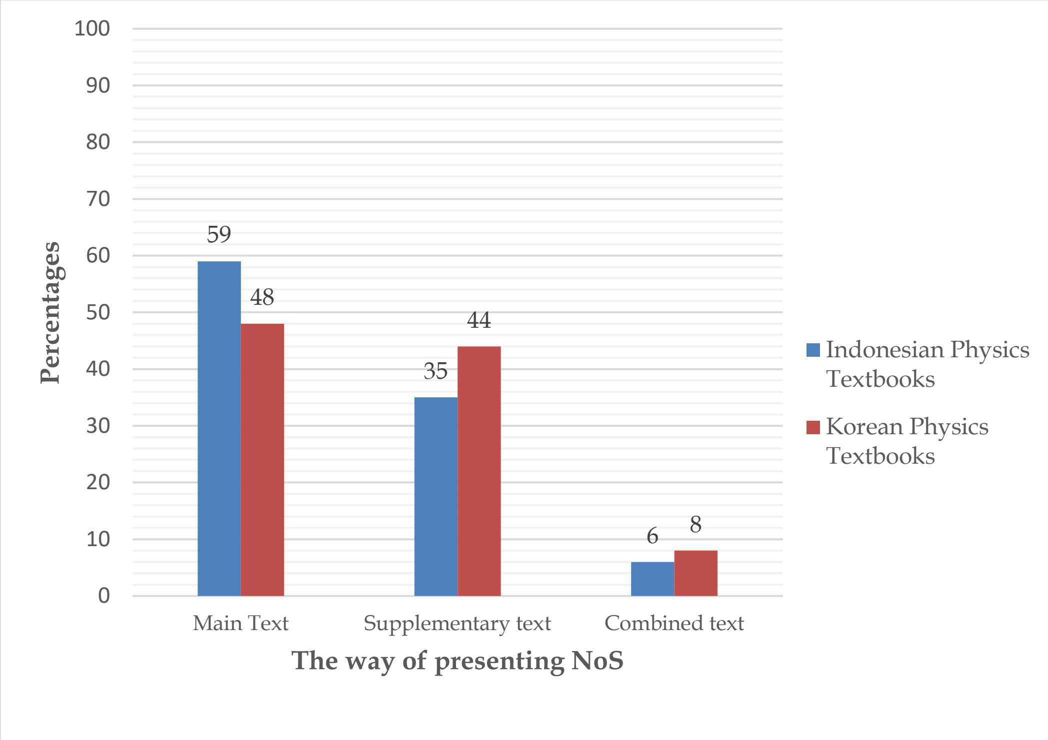

Figure 4: Comparison of how NoS is presented in Indonesian and Korean physics textbooks

There are several examples of how the NoS is presented in high school physics textbooks in Indonesia and South Korea. The following is an example of an aims and value indicator that discusses the accuracy of the instrument used by Michelson and Morley in detecting the presence of ether. The following quote is taken from a Korean physics textbook (Kwak et al., 2011, p. 54):

> *After Maxwell discovered that light was an electromagnetic wave, scientists thought that light also needed a medium. People called this imaginary medium ether, and Michelson and Molly repeated the complex experiment several times but could not see changes in the speed of light. That is, as a result of the experiment, it was found that there is no ether.*

Another example that discusses the method indicators used by Michelson and Morley in observing interference patterns on the equipment they are developing can be seen in the excerpt below. This quote is taken from an Indonesian physics textbook (Sunardi et al., 2016, p. 192):

> *The Michelson-Morley experimental apparatus is rotated 90^0 about a vertical axis. In this case, the direction of the ether velocity does not change, but the rays coming from the M1 and M2 mirrors change places. This position exchange is expected to cause a shift in the location of the light-dark bands in the interference pattern. However, even though the experiment was repeated several times, there was never a shift in the interference pattern.*

Scientific practices are a series of epistemic and cognitive practices that lead to scientific knowledge through social certification. Keywords that are usually used for scientific practice indicators are observation, experimentation, data, explanation, model, argumentation, classification, and prediction. In this study, there are 24 items that discuss indicators of scientific practices in the ten physics textbooks analyzed. The following is an example of scientific practices presented in Indonesian physics textbooks (Kanginan, 2018, p. 279):

> *The understanding of the second postulate is illustrated as follows. For example, on a train moving at a speed of 66 km/hour, there are two passengers traveling in the carriage in the direction of the train's motion at a speed of 4 km/hour. In general, we would say that the speed of the person relative to the ground (the person at rest about the edge of the rail) is 70 km/h. Does this addition apply if the person on the train is replaced by a flash of light on a train whose speed is 3 x 108 m/s. The 2nd postulate categorically says no. Why? According to the 2nd postulate, the speed of light is the same in all directions, and this is true throughout my universe regardless of the motion of the light source or the observer.*

Furthermore, the financial systems indicator is a NoS indicator, which is discussed a little in high school physics textbooks in Indonesia and Korea. Only two of the 71 NoS indicators discussed in the five Indonesian physics textbooks discuss the financial systems indicator. The following is an excerpt relating to financial system indicators taken from Indonesian physics textbooks (Ruwanto, 2017, p. 154):

> *From 1939 to 1945, the US government has spent about 2 billion dollars for the Manhattan Project. At 5:29:45 local time, July 16, 1945, a blinding white flash flashed across the horizon from the Jemez desert valley in northern New Mexico.*

Similar to financial systems, an indicator of political power structure is also rarely discussed in high school physics textbooks in both Indonesia and Korea. The following is an excerpt relating to indicators of political power structure taken from Korean physics textbooks (Kim et al., 2011, p. 67):

> *On August 2, 1939, just before the outbreak of the second world war, Albert Einstein wrote a letter addressed to President Franklin D. Roosevelt. In the letter, it was announced that Nazi-Germany was actively purifying U-235 and that this material might be prepared for the manufacture of atomic bombs. Not long after, the American government held a secret project called the Manhattan Project.*

5. Discussion

The results of this study showed that the representation of NoS in Korean high school physics textbooks was higher than in Indonesian physics textbooks. On the cognitive-epistemic aspect, 47 NoS items were found in Indonesian high school physics textbooks, while 54 items were found in Korean high school physics textbooks. The main distinction is in the scientific knowledge indicator, where this indicator is more emphasized in Indonesian high school physics textbooks. This indicator relates to theories, laws, and explanations that support the results of scientific investigations. Other indicators, such as aims and values, methods, and scientific practice, are undervalued in Indonesian physics textbooks. Unlike in Korean high school physics textbooks, the indicators of methods and scientific practice are also emphasized in a balanced way. The methods indicator is a manipulative and non-manipulative technique that supports scientific inquiry, while the scientific practice indicator is a series of epistemic and cognitive practices that lead to scientific knowledge. This provides students with a wealth of experience and knowledge regarding a range of epistemic practices and manipulative and non-manipulative techniques that support scientific theories and laws. Therefore, the difference in scientific literacy between Indonesian and Korean students could be attributed to the NoS aspects emphasized in different physics textbooks.

On the socio-institutional aspect, physics textbooks for Indonesian high schools only excel on the scientific ethos indicator. This indicator is concerned with the norms that scientists employ in their work and interactions with colleagues. The indicator of professional activities is the most emphasized of the 30 items in the Korean high school physics textbook. A total of eight items were found representing this indicator, whereas the Indonesian high school physics textbook contained only three items. This indicator relates to how scientists engage in professional settings such as attending conferences and doing publications. In Indonesia and Korea, the indicators of the financial system and political power structures are the least discussed in high school physics textbooks. According to data analysis, there are only two items in each country's high school physics textbooks related to the financial system and political power structures indicators. This finding aligns with the research findings of Park et al. (2019), namely that these two indicators receive less attention in Korean high school physics textbooks.

Furthermore, the findings of this study are in line with previous research by Dhamayanti et al. (2019) that theNoS is still not emphasized in Indonesian high school physics textbooks. The indicators emphasized among those investigated are those of scientific theory and laws. More than half of the NoS indicators in the Indonesian high school physics textbook for class X are indicators of theory and law. Ardwiyanti et al. (2021) also revealed that the Indonesian high school physics textbook for class X did not yet explicitly, correctly, or completely include aspects of the NoS. The aspects of scientific laws and the application of science in social and cultural contexts were the most emphasized in the three high school physics textbooks that they examined. Because of this, there needs to be an effort from authors of textbooks, the government, and stakeholders on how physics textbooks in Indonesia describe aspects of the NoS explicitly, correctly, and completely. Furthermore, most science teachers use textbooks as the primary source of information when teaching science in the classroom (Bancong & Song, 2018). The textbooks that are rich in the NoS will have a positive impact on students' scientific literacy skills (Abd-El-Khalick et al., 2017; Bugingo et al., 2022; Thao-Do & Yuenyoung, 2013; Ha, 2018; McDonald & Abd-El-Khalick, 2018).

These findings are also consistent with those of Zhang et al. (2022), who found that cultural and curriculum differences influence students' and teachers' perceptions of the NoS. Teachers in China tend to rely more on what is written in textbooks. Whenever they come across a point of view that has never been studied in textbooks, they cannot provide examples to support that view. Conversely, teachers in Canada can explain this view by giving concrete examples that are not in the textbooks. Park et al. (2014) also revealed that country differences can have an effect on subjectivity variance, empirical testability, and the methods used to explain scientific theories or laws. Nonetheless, textbooks as the primary guide for teachers in school teaching must be enhanced with NoS aspects. According to Liang et al. (2009), Turkish pre-service teachers scored the lowest in all aspects of the NoS because Turkish textbooks included misleading assumptions about NoS. As a result, a large number of Turkish participants displayed a naïve view of several aspects of the NoS. Therefore, the future physics curriculum, especially in Indonesia, must include the currently known NoS concept and place it in a social and cultural context.

6. Conclusion

Understanding NoS is now widely recognized as an important component of studying physics at the high school level. The purpose of this study was to learn more about the NoS and contribute to related literature by comparing aspects of the NoS in physics textbooks used in Indonesia and Korea. This study found that Indonesian high school physics textbooks (71) have fewer NoS elements than Korean physics textbooks (84). The NoS in Indonesian high school physics textbooks emphasizes cognitive-epistemic aspects (66.20%) over socio-institutional aspects (33.80%). Similarly, Korean high school physics textbooks place more emphasis on cognitive-epistemic aspects (64.29%) than on socio-institutional aspects (35.71%).

The main distinction is in the scientific knowledge indicator, which has a higher priority in Indonesian high school physics textbooks. This indicator is concerned with theories, laws, and explanations that support the findings of scientific investigations. In contrast to Korean high school physics textbooks, the indicators of scientific knowledge, methods, and scientific practice are all given the same significance. On the socio-institutional aspect, physics textbooks for Indonesian high schools only excel on the scientific ethos indicator. Furthermore, 59% of the 71 NoS elements presented in Indonesian high school physics textbooks were found in the main text, 35% in the secondary text, and 6% were presented in both. Similar to Korean high school physics textbooks, 48% of the 84 NoS presented were found in the main text, 44% in secondary texts, and 8% were presented together in both the main text and secondary texts.

This study has several limitations, including the fact that only five high school physics textbooks were examined for each country, and there was no qualitative data to back up the quantitative data. Therefore, future research is required to support and strengthen this study by using a larger sample of physics textbooks and also collecting qualitative data, such as interviews with high school physics teachers and authors of the textbooks, to supplement the results of this study.

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