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Exploring Science and Engineering Practices in Indonesian Physics Textbook about Heat and Temperature

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Abstract

During the distance learning, science lesson needs to adapt to the online class. This adaptation drives the need for student's independence of learning. It has been argued that students' understanding of science ideas and concepts is based on their engagement in science and engineering practices. However, research studying science and engineering practices engaging in high school textbooks in Indonesia is particularly limited. The present study investigates the level at which science and engineering practices engage in Indonesian high school Physics textbooks about heat and temperature. The analysis was carried out on a total of five books that are widely used in the school. Reports and activities were analyzed using content analysis through an assessment rubric called "Science and Engineering Practices Analytic Rubric" (SEPAR) by two ratters. The results analysis shows that the students could use science and engineering practices, but these school textbooks direct it. The books have not facilitated the opportunities to create and develop science and engineering practices at these points. The results mean that these school textbooks are at a low level because there is only one book at a high level. Therefore, there is a need to engage more clearly the science engineering practices in physics textbooks.

Keywords: Science and engineering practices, School physics textbooks, High school

1 Introduction

Physics learning in schools is carried out by following the steps of the contextual and scientific methods. Using a scientific approach, can help students think critically, understand nature, apply science in real-life practice, and influence students' skills and motivation in learning (Nurul, Azkia, & Fatni, 2020). So that teaching materials are needed in accordance with these aspects. The textbook is the main guide in the teaching and learning process for students (Rofidah, Junus, & Hakim, 2020). School textbooks directly affect student learning where students interact with textbooks and indirectly influence student learning through their effects on teachers during the teaching process (Papakonstantinou & Skoumios, 2021). Therefore, textbooks are very important in learning physics and other learning.

In learning physics, student activity is essential (Alifa, Azzahroh, & Pangestu, 2018). Student engagement was very high during STEM activities, including engagement associated with the topic of the STEM activity, the design activity itself, and students' relationships with their peers (Sulaeman et al., 2021). Thus, this is very much in line with the application of STEM. STEM is effective learning because it combines knowledge, mathematics, technology, and techniques so that students can apply and practice the basic content of STEM in the situations they face in life (Almuharomah, Mayasari, & Kurniadi, 2019). 21st-century skills are also needed this day because it is include learning skills, creating innovation, mastering technology and media, and being able to solve problems creatively. So that the application of STEM in books can support learning because it includes 21st-century skills (Nurul, Asrizal, & Fatni, 2020).

Temperature and heat are physical materials that have many applications in life. Temperature and heat contain material about the energy contained in an object, so there is a transfer in its use (Sofianto & Irawati, 2020). In this material, there are science and engineering practices that can be taught to students. In its application, students can practice science and engineering on this material, by making a simple vaccine temperature box (Siverling et al., 2016). However, in textbooks, the practice of science and engineering still

does not involve students' skills. So in this case, science and engineering (STEM) practical activities to be applied to textbooks are needed, especially on temperature and heat material.

Although many books have been researched, findings of STEM components in books are still rare. This can be seen from the research on critical thinking skills of students of class XI science in public schools in Banjarmasin the, test results show that students' critical thinking skills are still not trained. These results can be seen from the indicators of skills in formulating questions and answers which are categorized as low, indicators of analyzing and reporting experimental results are categorized as sufficient, drawing conclusions, determining actions and formulating alternative solutions are classified as low (Hartini, Mariani, Misbah & Sulaeman, 2020). Therefore, STEM textbook is needed to improve skills in these aspects where the STEM component in the textbook can be used as a support. Researchers want to analyze the STEM components in several physics textbooks, especially on the material of temperature and heat. So, from this study, the high and low level of the STEM component in the textbook can be seen.

2 Methodology

This research on heat and temperature textbooks were analyzed using content analysis. The analysis focuses on five high school physics textbooks for XI class which are widely used in schools. This analysis aims to identify science and engineering practices in school textbooks, where students are involved in science and engineering practices in selected school textbooks to be analyzed. The research process is divided into three phases. The first phase is to collect five high school physics textbooks. Then, examine the book's contents on the temperature and heat material chapter using the SEPAR framework. After analyzing, data is processed and a conclusion is drawn.

The instrument used in this research is the Analytical Rubric of Science and Engineering Practice (SEPAR), to evaluates the level at which students engage science and engineering practices in school textbooks (Papakonstantinou & Skoumios, 2021). This framework is a rubric consisting of 4 levels with eight aspects. The unit analysis involved the levels according to the extent of science and engineering practice in school textbooks. When school textbooks do not allow student to engage in science and engineering practices, it is

classified at level 0. The other levels (1, 2, and 3) show school textbooks opportunities for students to improve their abilities in practising science and engineering. The unit analysis (classification level) relates to the level of involvement on each of the eight aspects based on the SEPAR rubric.

Two researchers from science education carried out content analysis. The analysis results carried out by these researchers were then calculated by descriptive statistical analysis, by calculating the precentage of each aspect of the assessment contained in the SEPAR rubric (Arisya & Holiwarni, 2021). The equation used is:

$$R = \frac{f}{n} \, x \, 100\% \qquad (1)$$

R = score percentage

f = amount of aspect value

n = amount of textbooks

The average is calculated using the inter rate agreement (Sucahyanti et al., 2018). The equation used is as follows:

$$inter - rater\ agreement = \frac{Number\ of\ cases\ with\ same\ score\ from\ two\ rarets}{Number\ of\ cases} \times 100 \quad (2)$$

3 Results and Discussion

The results of the data analysis identified the level of practice involved in the content about temperature and heat included in the High School Physics book.

Tabel 1. Identification of aspects

Aspek	Book 1	Book 2	Book 3	Book 4	Book 5
Asking questions and defining problems	1	1	1	1	1
Developing and using models	1	2	3	0	2
Planning and carrying out investigations	1	1	3	1	1
Analyzing and interpreting data	1	2	2	0	2
Using mathematics and computational thinking	2	1	2	2	2
Constructing explanations and	2	2	2	0	2

designing solution					
Engaging in argument from evidence	1	1	1	0	1
Obtaining evaluating and communicating information	3	3	3	1	1

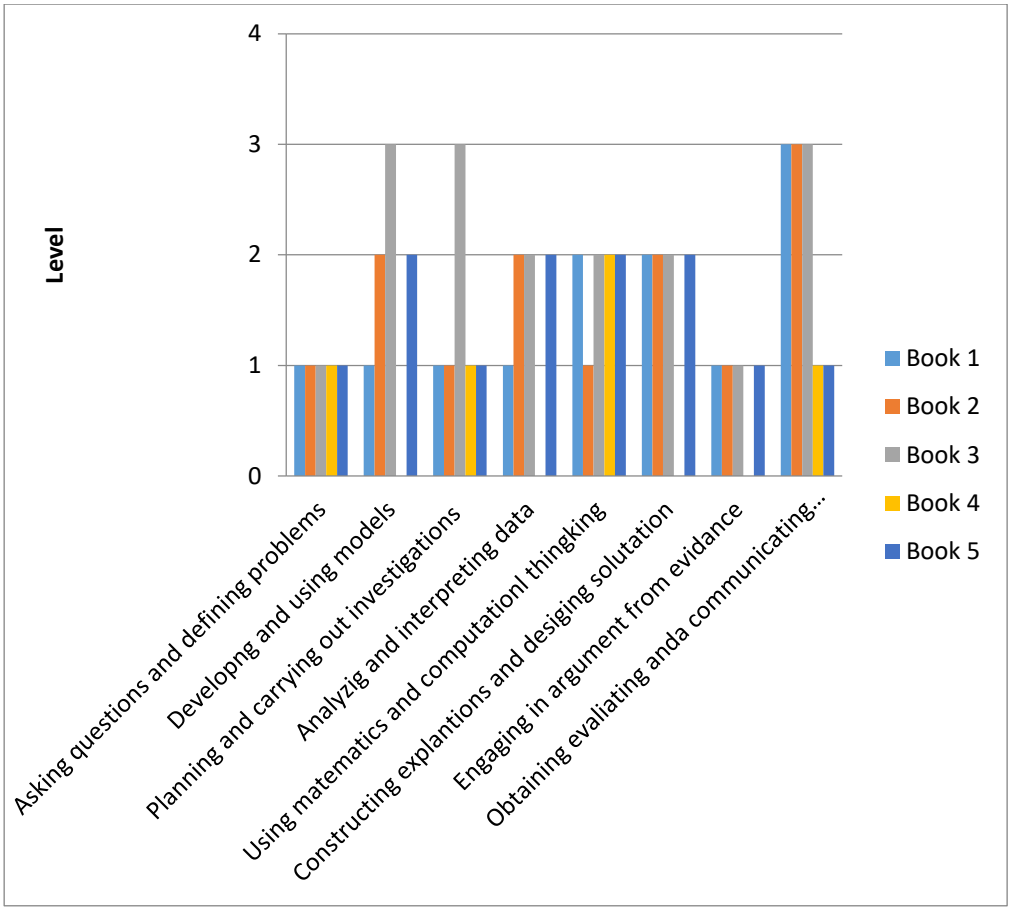

Figure 1. Result by NGSS Aspects

Asking questions and defining problems

There is a practice of asking questions and defining problems in the five books that were analyzed. There is the opportunity for students to ask, but it is not explained whether the questions to be discussed must be scientific or non-scientific. This test book also provides opportunities for students to define problems that can be solved (using previously acquired knowledge) through the development of an object, tool, process or system, and determine

criteria related to the time or cost of solving the problem to be determined. The text book also provides opportunities for students to define problems that can be solved (using previously acquired knowledge) through the development of an object, tool, process or system, and determine criteria related to the time or cost of solving the problem. However, it has been underlined that when students are given the opportunity to ask questions or define problems, their active involvement in the research process can be increased, as shown by the data.

Developing and using models

In this aspect, regarding to the practice of developing and using models, these several textbooks have provided opportunities for students to use models that aim to describe natural phenomena. The students were also asked to predict and explain based on the phenomena that were obtained. However, one of the books, namely book 4, it does not provide opportunities for students to develop their abilities by making models. Therefore, a textbook that gives students the opportunity to develop a model is needed. It can increase students interest in the lesson. The research data also shows that the model development by students makes their participation in the learning process.

Planning and carrying out investigation

In the practice of designing and conducting investigations, textbooks provide an opportunity to design or conduct an investigation for data collection. However, in this case, student engagement is guided by the textbook. But in one of the books, namely book 3, students are given the opportunity to make decisions about experimental and control variables.

Analysis and interpreting thinking

In the practice of analyzing and interpreting data, the three analyzed textbooks provide opportunities for students to work with data to organize or group the data in tables or graphics. This opportunity can supports the students in drawing inferences from data through recognizing patterns and in nature relation. But in the two books that have been analyzed, one of them provides opportunities for students to work with data without drawing conclusions from pattern recognition and in nature relation. And in other textbooks, it only gives students the opportunity to record data but not to analyze it.

Using mathematics and computational thinking

The practice of using mathematics and computational thinking, the four textbooks that were analyzed, provides an opportunity to use mathematical skills or concepts and connected computational thinking to answer scientific questions. This is shown in every activity in the book, which aims to develop students' abilities to us mathematics and computational thinking. However, one book it gives students the opportunity to use mathematical skills or concepts of computational thinking without being connected to answer questions.

Constructing explanations and designing solution

The practise of constructing explanations and designing solutions can be found in 4 textbooks. Some activities give students the opportunity to build scientific explanations by encouraging them to use appropriate evidence to support explanations or design solutions for problems by applying scientific ideas, although without generating and comparing multiple solutions to the problem. This is shown in activities such as discussions in one of the textbooks. But another book shows a low level where students are not given the opportunity to construct scientific explanations (related to how or why a phenomenon) or design a solution. The practise of engaging in evidence-based arguments is at a low level. In 4 textbooks, students are only given the opportunity to engage in arguments by encouraging them to support claims with evidence or reasons. However, their discourse is guided by the textbooks. And one of the other textbooks did not give students the opportunity to engage in self-guided arguments where they could be assessed by themselves and their classmates.

Engaging in argument form evidence

The practise of engaging in evidence-based arguments is at a low level. In 4 textbooks students are only given the opportunity to engage in arguments by encouraging them to support claims with evidence or reasons. However, their discourse is guided by the textbook. And one of the other textbooks did not give students the opportunity to engage in self-guided arguments so that they could be assessed by themselves and their classmates.

Obtaining evaluating and communicating informating

In 3 textbooks, students are given the opportunity to read and use texts to obtain scientific information. They are encouraged to distinguish or combine the information from many texts by examining the strength of the information and its sources. Two books provide the access to scientific information from "additional" texts. At the same time, while they are

not asked to find this information or to compare or combine information from various texts by examining the strength of this information and its sources.

4. Conclusions

Based on this research, the purpose was to explore the practise of science and engineering involved in Indonesian textbooks with the temperature and heat material contained in high school physics textbooks. Base on the results of the analysis, it was found that these textbooks have not facilitated the opportunity to design and develop the practice of science and engineering in each activity. So the results show that this school textbook is at a low level. Because there is only 1 textbook that is at a high level, it can be said that the textbook facilitates activities in designing and developing science and engineering practice. Therefore, textbooks that involve more science and engineering practice are needed.

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