COMPARISON OF SCIENCE LITERACY LEVELS IN STUDENTS' BIOLOGY TEXTBOOKS IN UNITED KINGDOM, MALAYSIA, AND INDONESIA ON THE TOPIC OF RESPIRATORY SYSTEM

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INFO ARTIKEL

ABSTRACT

This research aims to compare scientific literacy levels in textbooks from three different publishers in three countries. This study is a qualitative approach with a content or document analysis method by describing the level of science literacy of biology textbooks based on aspects of science literacy. Samples were obtained from Indonesia's textbooks from Erlangga publisher, Malaysia's textbook from UG Press Sdn, Bhd, and Cambridge publisher. The result shows that the aspect of science as a body of knowledge has the highest average of 67.40% (good), the aspect of science as a way of investigating with the average of 21.31% (deficient), the aspect of science as a way of thinking with the average of 21.31% (deficient), the aspect interaction of science, technology, and society with the average of 6.66% (poor).

INTRODUCTION

Science literacy is the capacity to use scientific knowledge, identify questions, and draw conclusions based on facts to understand the universe and make decisions from changes occurring due to human activity (OECD, 2003). Scientific literacy skills are essential for people to develop and to deal with issues related to science on a routine basis in everyday life (Kelp et al., 2023). An individual with scientific literacy is willing to engage in activities about science and technology, which require competencies to explain phenomena scientifically, evaluate and design scientific investigations, and analyze data and evidence scientifically (OECD, 2015). It can be interpreted that science literacy is closely related to a person's ability to solve problems in daily life based on scientific knowledge.

From 2000 to 2022, Indonesian students' average score in science literacy skills has remained below the completeness standard set by PISA. This indicates a lack of understanding among students about the scientific processes and concepts and the application of scientific knowledge in everyday life. Indonesia's performance in the science literacy assessment has been consistently low over the years.

In 2000 and 2003, with 41 and 40 participating countries respectively, Indonesia ranked 38th. In 2006, Indonesia's rank dropped to 50th out of 56 participating countries. In 2009, Indonesia ranked 60th out of 65 countries. In 2012, Indonesia's rank dropped from second to last, at 64th out of 65 countries. In 2015, Indonesia's rank improved slightly to 62nd out of 69 participating countries. The assessment in 2018 revealed that Indonesia's ranking had dropped further to 71st out of 79 participating countries. The 2022 science literacy assessment indicates that Indonesia ranks 67th among 81 countries, which is an improvement of 5-6 positions from PISA 2018. However, the country's average science literacy score in PISA 2022 is 383, which is 13 points lower than the PISA 2018 average score. The global average score in PISA 2022 is 485, The data shows that the student scores in Indonesia on the PISA test are still at the lowest score.

One of the factors that causes the low level of science literacy is the quality of learning resources. One of the main learning resources for learners is using textbooks provided by the school. Textbooks play an important role in the success of the learning process. The suitability and quality of textbooks can affect the quality of learning outcomes, which means that good-quality textbooks will help students acquire knowledge and information, and teachers will find it easier to guide students in the learning process (Puslitjakdikbud, 2017). It can be concluded that the role of textbooks is very important to improve students' knowledge and abilities, including improving science literacy skills.

It is important to understand the existence and role of science textbooks, especially Biology textbooks. If the Biology textbook applies aspects of the nature of science, it will increase students' potential to learn science and science process skills. Improving science process skills will be able to improve students' scientific literacy. Scientific literacy is concerned with how students understand science and apply scientific thinking in daily life.

Analysis of science textbooks that have been carried out by previous researchers such as Ginting and Suriani (2018) shows that the results of the study analyzed the scientific literacy of high school biology textbooks measured by referring to the rubric of scientific literacy dimension instrument assessment. The highest value is found in the science of the body of knowledge at 77.20% with fairly good criteria, based on the dimensions of science literacy as an investigative process with an average of 11.32% with unfavorable criteria, based on the dimensions of science literacy as a way of thinking with an average of 3.39% with unfavorable criteria, based on the dimensions of science literacy as a technology and society relationship with an average of 8.09% with unfavorable criteria (Ginting & Suriani, 2018). Therefore, it can be seen that the dimensions of science literacy are unbalanced, with three dimensions of science having poor criteria.

Research on the meta-analysis of misconceptions in grade XI biology textbooks from Hanifah & Zulyusri (2021), showed that in the three grade XI biology textbooks analyzed, misconceptions were found in textbooks with the

category of oversimplifications, which is the concept put forward too simply so that the concept becomes incomplete or even wrong. Simplification of a concept should follow the main concept, not reduce or even lead to misconceptions. The book contains obsolete concepts and terms. The order of misconception categories from the largest to the smallest found in several Grade XI high school biology textbooks are oversimplifications, misidentifications, overgeneralizations, undergeneralizations, and obsolete concepts and terms Based on the result of the PISA test about Indonesia's low science literacy score compared to other countries, it is necessary to analyze the comparison of the level of science literacy in biology textbooks used by Indonesian students and other countries which has a higher PISA test score than Indonesia based on four aspects of science literacy according to Chiapetta et al., (2007), include the knowledge of science, the investigative of science, science as a way of thinking and the interactions of science, technology and society. (Hanifah & Zulyusri, 2021). This can be one of the reasons why Indonesian students have difficulty in answering questions contained in the PISA test.

METHOD

Research Place

This research was carried out at the Universitas Negeri Medan.

Procedure

The research procedure in this study includes 3 stages. Preparatory stage (Begins with a literature study to formulate a problem. Search and list textbooks used in various countries. The textbook taken for research is the student textbook of Biology of respiratory system topic), Execution Levels (Selection of biology textbooks from the three countries, sampling is conducted by selecting one chapter in the book, data collection was carried out by analyzing each paragraph on the respiratory system according to the statement of empirical indicators of the scientific literacy dimension), Final Stage (Calculates the percentage of occurrence of each dimension of scientific literacy of the analyzed textbook).

Data Analysis

The data analysis method in this study uses descriptive statistical methods. The analysis of the scientific literacy dimension is intended to determine the level of scientific literacy in biology textbooks. The analysis was carried out by calculating the percentage of scientific literacy dimensions in each book analyzed.

The results of filling out the assessment sheet were analyzed using the formula of Hamidah et al. (2020). And the percentage range of science literacy levels using the scoring scale of Riduwan (2015).

Percentage of science literacy categories $=$

$$\frac{\sum Indicators\ by\ category}{\sum Indicators\ Total\ Category}\ x\ 100\%$$

Table 1. The Percentage Range of Science Literacy Levels in Biology Textbooks

Percentage	Criteria
81% - 100%	Excellent
61% - 80%	Good
41% - 60%	Average
21% - 40%	Deficient
0% - 20%	Poor

RESULT AND DISCUSSION

Result

The results show that the Science as a Body of Knowledge aspect has the highest percentage of scientific literacy occurrences among the three other aspects. Namely, book 2 (Sdn.Bhd, Malaysia) achieved the highest score (68.06%), followed by book 1 (Erlangga, Indonesia) (67.40%), and book 3 (Cambridge, UK) (56.55%). In general, the lowest score of scientific literacy was the aspect of science, technology, and social interaction. Book 2 (sdn.Bhd Malaysia) scored 0.00%, book 3 (Cambridge, UK) scored 0.81%, and book 1 (Erlangga, Indonesia) scored 6.66%.

The aspects of scientific literacy that appear in each biology textbook show varying percentages. The results of the recapitulation of science literacy aspects for Book 1, Book 2, and Book 3 are presented in Table 2. The analysis revealed that the aspects of scientific knowledge appear more frequently in Book 2, with a percentage of 68.06%. While, the interaction between science,

technology, and society is lower than other aspects, with book 2 showing a percentage of 0.00% and book 3 showing a percentage of 0.81%. It can be observed that Book 2 has a higher percentage of science as a body of Knowledge. In the aspect of Science as a way of investigating, book 3 has the highest percentage. In the aspect of science as a way of thinking, book 3 has the highest score and in the aspect of the interaction between science, technology, and society, book 1 has the highest score.

Table 2. Book Analysis Recapitulation Result

Science Literacy Indicators	BOOK I (Erlangga textbook)		BOOK II (Sdn. Bhd textbook)		BOOK III (Cambridge textbook)		TOTAL	%
	Statement Count	percentage %	Statement Count	percentage %	Statement Count	percentage %		
1. Science as a body of knowledge	91	67,40%	81	68,06%	69	56,55%	241	64,09%
2. Science as a way of investigating	19	14,07%	18	15,12%	26	21,31%	63	16,75%
3. Science as a way of thinking	16	11,85%	20	16,80%	26	21,31%	62	16,48%
4. Interaction of science, technology and society	9	66,6%	0	0,00	1	0,81%	10	2,65%
TOTAL	135	100%	119	100%	122	100%	376	100%

Discussion

The result of the analysis of science literacy for the topic of the respiratory system in 3 different biology textbooks namely, Erlangga Textbook from Indonesia, Sdn.Bhd Textbook from Malaysia, and Cambridge textbook From the United Kingdom. Show that in general, the total percentage of scientific literacy indicators appearing in each book, namely, in book 1 (Erlangga), the total appearance of scientific literacy indicators is 135 with a percentage of 35.90%. In book 2 (Sdn.Bhd Malaysia), the total occurrence of scientific literacy indicators was 119 with a percentage of 31.64%. In book 3 (Cambridge), the total appearance of scientific literacy indicators was 122 with a percentage of 32.44%. So, based on the total percentage of overall scientific literacy in each book, the Erlangga book has the highest total score, followed by the Cambridge book, then the Malaysian Sdn.Bhd book.

Further, based on the scientific literacy aspect, the number of occurrences of the scientific literacy aspect in textbooks is explained as follows:

Aspect Science as a Body of Knowledge

The three books analyzed in this research more focus on science as a body of knowledge. It contain a lot of subject matter with facts, concepts, principles, laws, and questions that ask students to remember knowledge or information. This can be seen in the recapitulation results table, the science category as a body of knowledge has a different percentage frequency. The percentage for the science category as a body of knowledge in these three books has the largest percentage and frequency compared to the other three categories.

Based on several types of statements that appear in the scientific knowledge category, the types of questions that present facts, concepts and principles are the ones that appear most frequently. In Indonesian books, the number of concept presentations has the highest percentage of 79.12%, while in Malaysian books it is 65.43%, and in Cambridge books 53.62%.

In general, Biology textbooks in Indonesia and Malaysia have presented aspects of Science as a Body of Knowledge in good percentages. Although the presence of Science as a Body of Knowledge

aspect in Cambridge Biology textbooks is less than Indonesian and Malaysian textbooks, the Cambridge Biology textbook presents a straightforward and detailed explanation of the content.

Out of the three books, it focuses more on describing aspects of scientific knowledge than other aspects. The information found in textbooks means that students only have to memorize information without engaging in thinking, experimenting, or investigating activities.

Aspect Science as a way of Investigating

Biology textbooks analyzed show that investigations into the nature of science are still lacking in biology texts. In this dimension of the Nature of Science, book 3 was higher than textbooks 1 and 2. The results show that the percentage value of book 3 has a greater score than book 1 and book 2.

The Nature of Science Investigation indicator stimulates students to think and do something by assigning students to investigate. It's meant by investigating that books contain learning that involves students with methods and processes in science, such as observing, identifying, calculating, conducting experiments and so on.

Based on these categories, the analysis of the 3 books obtained several differences. In book 3, the book presents many questions that require students to answer through the use of graphs, tables, charts, and diagrams, making calculations, and the book also contains several student investigation activities. However, in the Book category presenting evaluation questions, the Malaysian book contains more evaluation questions compared to books 2 and 3.

Implementing investigations into the nature of science can help students train their thinking skills by exploring further how things happen in science. Andriani & Ismet (2017) found a result in their research, that textbooks that emphasize the nature of science should be able to help students change their perspective, which tends to use memorization to master science.

Science as a Way of Thinking

Science as a way of thinking referred to in biology textbooks is a description of how a scientist has a significant impact on students' learning. As expressed by Lailatul et al. (2015), that the impact of a higher dominant aspect of science knowledge, students will become less skilled at applying the knowledge they have.

Facts show that Indonesian students are very good at memorizing, but less skilled at applying their knowledge. The imbalance in scientific literacy conducts experiments, shows the historical development of an idea, emphasizes the empirical nature and objectivity of science, shows cause-and-effect relationships, and presents scientific methods and problem-solving (Chiappetta & Fillman, 2007).

Differences can be seen in several categories based on the aspects analyzed, such as in the Books category which presents situations that can arouse students' curiosity and imagination about natural phenomena. Book 3 has more of this category compared to books 1 and 2. Also, a significant difference can be seen in the Book category presenting material that invites students to think critically and be scientific. Book 3 has more categories than books 1 and 2. Book 3 also contains several activities and experiments which are included on the CD contained in the book.

Looking at the results of the analysis of the three books that have been carried out, the scores show that the three books are still in the weak category. Science as a way of thinking has an important role in developing scientific literacy, because science has a causal relationship between observed natural phenomena. Therefore, science textbooks should develop students' thinking abilities so that they have broad insight and can see scientific relationships and relate them to the knowledge they have.

Several indicators are not found in student books, including the historical development of a scientific idea, and books describing how a scientist conducts experiments. The book does not explain how scientists conduct experiments, so it does not provide information on how to describe the methods used by scientists to improve understanding of lessons and experiments. The importance of a process for teaching students, according to Rusilowati (2018), because the

emergence of science begins with a process of thinking, and learning, accompanied by creativity. Indicators illustrate the use of assumptions, show how science proceeds using inductive and deductive considerations, present scientific methods and problem-solving, describe the characteristics of scientists, and show various ways to understand the world. These indicators do not appear in student books

Interaction of Science, Technology, and Society

In the aspect of the interaction of science, technology, and society, this category is related to the dimension of the scientific context, which presents everything related to science and technology in everyday life.

In this research, the results of the analysis of biology books in book 1 were 6.66% with poor criteria, book 2 was 0.00% with poor criteria and book 3 was 0.81% with poor criteria. We can see that the biology textbooks we use tend to focus on concepts.

Judging from the number of results obtained, and the content of the material presented, books 1 and 3 show more of the indicator "books present a positive impact on the use of science and technology on society". Meanwhile, book 2 does not contain aspects of the interaction between science, technology, and society with results showing 0.00%. Only a few of the three books show aspects of the interaction of science, technology, and society.

The low appearance of indicators for scientific, technological, and societal literacy also occurred in previous research conducted by Lailatul, et al (2015). This category appears in fourth place in the analysis, namely 0.8%. In the aspect of the interaction between science, technology, and society, is the most interesting aspect for students in reading a biology book, because this aspect includes indicators that describe events that are often found in everyday life, especially in the field of biology (Wahyu et al., 2016).

Comparative Qualitative Analysis of the Content

Based on qualitative analysis, The Cambridge biology textbook offers significant academic benefits in its presentation of the material The book published by Erlangga and Sdn. Bhd Malaysia provides a more general discussion of the material. The Cambridge version of the biology textbook uses simpler language and avoids too technical terms. An emphasis on relevant analogies, simplified language, and a focus on key components make explanations accessible and understandable to students from a variety of backgrounds and learning styles.

As an example :

Cambridge Textbook Approach:

Before entering into a discussion of the respiratory system, the Cambridge version contains information and statements that can stimulate students' critical thinking skills, using the analogy "If fish can breathe underwater, why can't we?". This question will stimulate students' critical thinking skills about the differences in how humans and fish breathe.

This explanation emphasizes the differences in breathing abilities in fish and humans. Like why humans can't breathe underwater, and vice versa. Not only that, the initial explanation of this book also contains information about humans and several mammal species that can dive to very deep depths and survive underwater for long periods. Also in Visual Representation, the use of pictures or illustrations can further improve understanding and make concepts more interesting.

Erlangga and Sdn.Bhd Malaysia Textbook approach, there is no initial explanation that stimulates students' critical thinking skills. The explanations in both books directly contain the meaning of breathing and the process of breathing. The high aspect of Science as a body of knowledge, especially conceptual, is because of the Erlangga and Sdn.Bhd Malaysia books contain coherent explanations and material and use very technical explanations, including all explanations in detail without paying attention to the ability to absorb language according to the age of the students.

The book's approach is based on the definition of breathing:

Cambridge version

"To make air move in and out of the lungs, you must keep changing the volume of your thorax. First, you make it large so that air is sucked in. Then you make

it smaller again so that air is squeezed out. This is called breathing." [page 146]

Erlangga version

"Secara umum, pernapasan (respirasi) merupakan proses menghirup dan mengembuskan udara." [page 297]

Sdn.Bhd Malaysia version

"Pernafasan merupakan proses menyedut udara atau menarik nafas dan menghembus udara oleh peparu. Sistem di dalam badan yang membantu kita bernafas dikenali sebagai sistem respirasi manusia" [page 46]

The Cambridge version is interesting because it provides clear, concise, and engaging explanations. The Cambridge book provides an understanding of breathing, which immediately asks students to practice it themselves to find out the meaning of breathing.

Cambridge textbooks also use the analogy of "sucking in" and "squeezing out" air to make the concept relatable, and make it easy to understand, because it uses simple language that students use every day. However, in the other books, the books uses straightforward language and the general definition may not be as interesting for students who want a more detailed explanation.

In the Cambridge version, the meaning of respiration is not directly defined. However, there is a repetition of topics related to living cells and energy, which are then connected to the meaning of respiration.

[...The main nutrient used to provide energy in cells is glucose. Glucose contains a lot of chemical energy. To make use of this energy, cells have to break down the glucose molecules and release the energy from them. They do this in a series of metabolic reactions called respiration. Like all metabolic reactions, respiration involves the action of enzymes.] page 141.

In the process or mechanism of gas exchange in humans in the Cambridge book, there is a sentence that asks students to recall the previous discussion or explanation, namely about aerobic and anaerobic respiration, which are still related to energy, and explains how carbon dioxide is formed.

"If you look back at the aerobic respiration equation on page 141, you will see that two substances are needed. They are glucose and oxygen."

Not only that, the book also asks students to remember relevant previous chapters.

"The way in which cells obtain glucose is described in Chapters 6 and 7. Animals get sugar from carbohydrates which they eat. Plants make them by photosynthesis."

In other situations:

Erlangga Textbook Approach:

"Mekanisme pernapasan diatur dan dikendalikan oleh sistem saraf pada medula oblongata, pons Varolii di otak, dan serabut aferen nervus vagus yang berasal dari reseptor saluran pernapasan dan paru-paru. Ketika kandungan O_2 dalam darah sedikit atau darah banyak mengandung CO_2, pH darah akan berubah. Perubahan pH darah tersebut dideteksi oleh medula oblongata. Selanjutnya, medula oblongata mengirimkan impuls ke otot tulang rusuk atau diafragma untuk berkontraksi lebih kuat sehingga volume rongga dada menjadi lebih besar dan napas akan lebih dalam. Akibatnya, lebih banyak O_2 yang diikat oleh darah dalam kapiler."

Cambridge IGCSE Biology Third Edition Approach:

"Oxygen is obtained differently. Animals and plants get their oxygen directly from their surroundings. If you look again at the aerobic respiration equation you can see that carbon dioxide is made. This is a waste product and it must be removed from the organism. In organisms, there are special areas where the oxygen enters and carbon dioxide leaves. One gas is entering, and the other leaving, so these are surfaces for gas exchange. These surfaces have to be permeable. They have other characteristics which help the process to be quick and efficient."

Key Differences:

Language: The Cambridge IGCSE Biology Third Edition version uses simpler language and avoids overly technical terms, making it more accessible to students at this level.

Analogy: The "waste product" analogy makes this concept easier to understand.

Real World Connection: Linking carbon dioxide removal to daily activities reinforces its importance.

Focus on Key Concepts: Explanations focus on important aspects of gas exchange without going into excessive physiological detail.

Aspects of scientific literacy in books should be presented in balanced proportions in each aspect, namely, scientific knowledge, investigation of the nature of science, science as a way of thinking, and interactions between science, technology, and society. This balance of each aspect of scientific literacy can result in students' scientific literacy abilities increasing and can improve the quality of students' science education. The impact that occurs if the proportion between the four aspects of scientific literacy is not balanced is that it will affect students' scientific literacy abilities. Because scientific literacy itself has a very important role in building students' scientific skills so they can face various challenges they will face in everyday life (Martiasari et al., 2022).

CONCLUSION

The three biology textbooks show scientific literacy indicators in varying percentages. The level of scientific literacy in biology textbooks on the topic of respiratory system, based on the aspect science as the body of knowledge is the highest and most dominant in book 2 with a score of 68.06% with good criteria. Based on the Science as a Way of Investigating aspect with a score of 21 .31% with deficiency criteria in book 3, based on the Science as a Way of Thinking aspect with a score of 21.31% with deficiency criteria in book 3, and the Interaction of Science, Technology and Society aspect with a score of 6.66% with Poor criteria .

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