Chemined 13 (1) (2024)

Chemistry in Education

https://journal.unnes.ac.id/journals/chemined

Analysis of Science Literacy and Chemical Literacy Content on Green Chemistry Materials in Chemistry Textbooks Class X High School in Palangka Raya City

Angel Manik, Suandi Sidauruk, Ruli Meiliawati

Chemistry Education Study Program, Palangka Raya University, Indonesia

Info Artikel

Accepted: 07-02-2024
Approved: 11-12-2024
Published: 12-24-2024

Keywords:
Science Literacy, Chemical Literacy, Textbooks, Green Chemistry

Abstract

The continuous advancement of science and technology requires 21st-century education to equip students with literacy skills. PISA results show that students' literacy skills in Indonesia are still relatively low. One of the factors influencing students' literacy skills and directly affecting the learning process is the availability of textbooks. Therefore, textbooks that can enhance students' literacy skills are needed. This study aims to examine the presence of *scientific literacy* and *chemical literacy* indicators in grade X chemistry textbooks on *green chemistry* material. This study uses a *descriptive method* with a *quantitative approach*. The sample consists of grade X chemistry textbooks that are most commonly used in *SMA Negeri Palangka Raya* for *green chemistry* material in the *Merdeka Curriculum*. The research instrument used is an identification sheet containing a table for analyzing *scientific literacy* and *chemical literacy* indicators. The results of this study show that the presence of *scientific literacy* indicators in both textbooks is nearly balanced. The analysis of both books revealed the average occurrence in each category: *scientific knowledge* (37.96%), *science as a way of investigating* (22.11%), *science as a way of thinking* (19.05%), and *the interaction of science, technology, and society* (20.88%). However, the presence of *chemical literacy* indicators in both textbooks is still uneven, with an unbalanced proportion. The analysis showed the average occurrence for each aspect: *content* (47.18%), *context* (14.10%), *competence* (13.69%), and *attitude* (25.03%).

Correspondence address:
E-mail: angelmanik58@gmail.com

P-ISSN 2252-6609
E-ISSN 2502-6852

INTRODUCTION

The 21st century, also known as the era of globalization, is a time of rapid advancements in science and technology. The continuous development of science and technology presents challenges for education. 21st-century education is required to equip students with 21st-century skills, which consist of four main categories: literacy, inventive thinking, effective communication, and high productivity (Nurdini et al., 2018). Among these categories, scientific literacy plays a crucial role.

Arohman et al. (2016) state that scientific literacy is essential for students because individuals with strong scientific literacy skills can apply scientific concepts, utilize scientific processes to make informed decisions related to daily life, society, and the environment, and understand social and economic developments. Scientific literacy consists of four categories: the knowledge of science, the investigative nature of science, science as a way of thinking, and the interaction of science, technology, and society (Chiappetta et al., 1991).

Chemistry is a branch of science, meaning that students' scientific literacy skills will indirectly impact their chemical literacy skills. The fundamental difference between scientific literacy and chemical literacy is that chemical literacy involves the ability to understand particulate matter in nature, chemical reactions, chemical laws and theories, and the application of modern chemistry in everyday life (Celik, 2014). Chemical literacy consists of four categories: content aspect, context aspect, competence aspect, and attitude aspect (Shwartz et al., 2006).

The Programme for International Student Assessment (PISA) is an internationally recognized test used to evaluate education systems by measuring students' scientific literacy skills. It is initiated by the Organization for Economic Cooperation and Development (OECD) and is conducted every three years. The performance of Indonesian students as assessed by PISA can be seen in Table 1 below.

Table 1. Results of the Science Literacy Study of Indonesian Learners from 2006-2022 (Permatasari, 2020; OECD, 2023)

Year	2006	2009	2012	2015	2018	2022
Score average	393	383	382	403	396	383
Rank	50/57	60/65	64/65	62/70	71/79	67/81

The results of the 2022 PISA study show that Indonesia's student performance ranking increased by six positions compared to 2018 (Kemdikbud, 2023). However, this ranking improvement did not align with the actual scores. Indonesia experienced a decline in scientific literacy scores, dropping by 13 points, which is above the international average decline of 12 points. This indicates that students' scientific literacy skills in Indonesia remain relatively low.

The low levels of scientific literacy and chemical literacy among Indonesian students can be influenced by several factors, including the education system and curriculum, the teaching methods and models used by teachers, learning facilities, instructional materials, and learning resources (Rahayu, 2018). One of the most critical components affecting literacy and directly impacting students is the availability of learning resources. In this context, textbooks play a significant role, as they have traditionally been the primary learning resource for students in schools.

Green chemistry is one of the topics in the Merdeka Curriculum, primarily aimed at helping students understand the impact of chemistry on the environment and promoting sustainable environmental conservation (Sheldon & Norton, 2020). Green chemistry serves as an approach to addressing environmental issues caused by chemical substances (Wirama, 2022).

In other words, green chemistry integrates chemistry with environmental science, making it essential to analyze scientific literacy and chemical literacy indicators in textbooks covering green chemistry, as these books serve as instructional materials in schools. The issues outlined above have motivated researchers to conduct a study titled, "Analysis of Scientific Literacy and Chemical Literacy Content in Green Chemistry Topics in Grade X Chemistry Textbooks in Palangka Raya City."

METHODS

This study employs a descriptive method with a quantitative approach. A descriptive research method with a quantitative approach aims to describe or explain events or occurrences in the form of meaningful numerical data (Sudjana & Ibrahim, 2004). The research data consist of scientific literacy and chemical literacy categories found in Grade X chemistry textbooks covering Green Chemistry material used in high schools in Palangka Raya City.

The data sources for this study are two Grade X high school chemistry textbooks based on the Merdeka Curriculum, which are the most widely used in high schools in Palangka Raya City. These textbooks have different authors and publishers. The sampling technique used in this study is purposive sampling, selecting Bumi Aksara (Book A) and Intan Pariwara (Book B) as the analyzed textbooks.

The data collection technique involves documentation analysis, using research instruments in the form of an identification sheet for scientific literacy indicators and an identification sheet for chemical literacy indicators. The collected data are analyzed by calculating the percentage of occurrences of scientific literacy and chemical literacy indicators and assessing observation reliability through triangulation techniques

RESULT AND DISCUSSION

Science Literacy

The research data obtained consists of statements or explanations of Green Chemistry material in Grade X chemistry textbooks, recorded in the scientific literacy indicator identification sheet. The validity of the research data was then tested by calculating the inter-rater agreement coefficient. The raters observed the occurrence of both indicators in the identification sheet prepared by the researcher. After calculating the agreement coefficient, a result of 0.94 was obtained, indicating an inter-rater agreement level categorized as "Very Good."

Table 2. Number and Percentage of Scientific Literacy Indicator Occurrences

No.	Science Literacy Aspect	Book A		Book B		AVG (%)
		∑	%	∑	%	
1	Science Knowledge	29	38,16	37	37,76	37,96
2	Science as a way of investigating	15	19,73	24	24,49	22,11
3	Science as a way of thinking	15	19,73	18	18,37	19,05
4	Science, Technology, and Society Interaction Society	17	22,37	19	19,39	20,88
Total		**76**	**100**	**98**	**100**	**100**

Table 2 shows that the percentage distribution indicates a balanced proportion. According to Wilkinson (1999), a scientific literacy category is considered approximately balanced if it falls

within the following proportions: 42% or 38% for scientific knowledge, 19% or 26% for science as a way of investigating, 19% or 13% for science as a way of thinking, and 20% or 23% for the interaction of science, technology, and society.

Science Knowledge

The scientific knowledge category is an indicator that contains a vast amount of information that students need to learn. It includes explanations of material related to facts, concepts, principles, laws, theories, hypotheses, models, and understanding of knowledge.

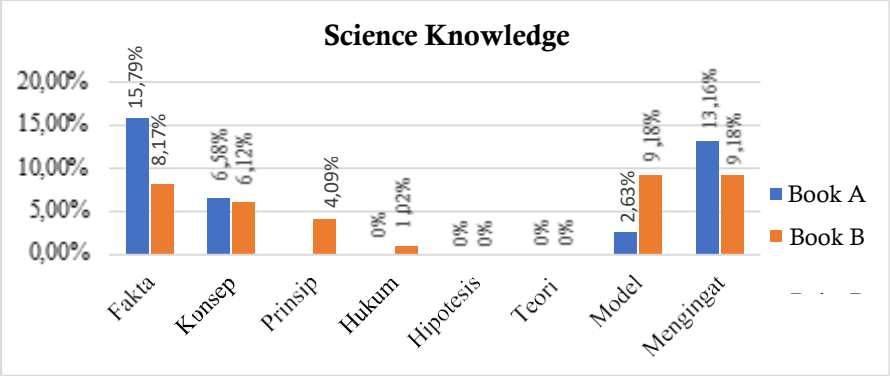

Figure 1. Occurrence of Science Knowledge Indicators

The most frequently occurring indicators in the scientific knowledge category are "Presenting facts, concepts, principles, and laws" and "Asking students to recall knowledge or information." Figure 1 shows that in Book B, the sub-indicator "Presenting principles and laws" appears, whereas it does not appear at all in Book A. This difference is due to the presence of the subtopic "Chemical Reaction Equations" in Book B, which is not included in Book A.

Science as a way of investigating

This category aims to encourage students to think critically and take action by providing instructions for conducting research or observations, similar to how scientists perform experiments.

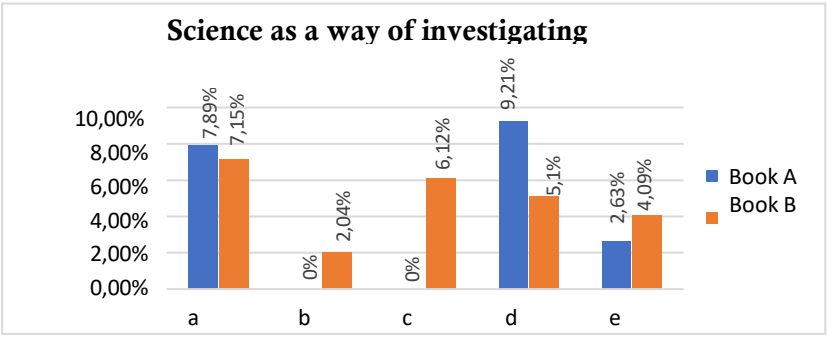

Figure 2. Occurrence of Science as a Way of Investigating Indicators

Description :

a) Asking learners to answer questions through the use of materials.
b) Asking learners to answer questions through the use of graphs, tables, and so on.
c) Asking learners to answer the question using calculations.

d) Asking learners to give reasons for their answers.
e) Involving learners in activities or experiments.

The most frequently occurring indicators in both textbook samples are "Asking students to answer questions using provided materials or content" and "Asking students to provide reasoning for their answers." Figure 5 shows that in Book B, the indicator "Asking students to answer questions using calculations, graphs, tables, etc." appears, whereas it does not appear at all in Book A.

The Principles of Green Chemistry is one of the main topics in Green Chemistry material, explaining the 12 principles of green chemistry, which include "Maximizing the economic value of atoms" and "Using catalysts."

Science as a Way of Thinking

Science is related to thinking processes and the use of reasoning to understand natural phenomena occurring in the surrounding environment.

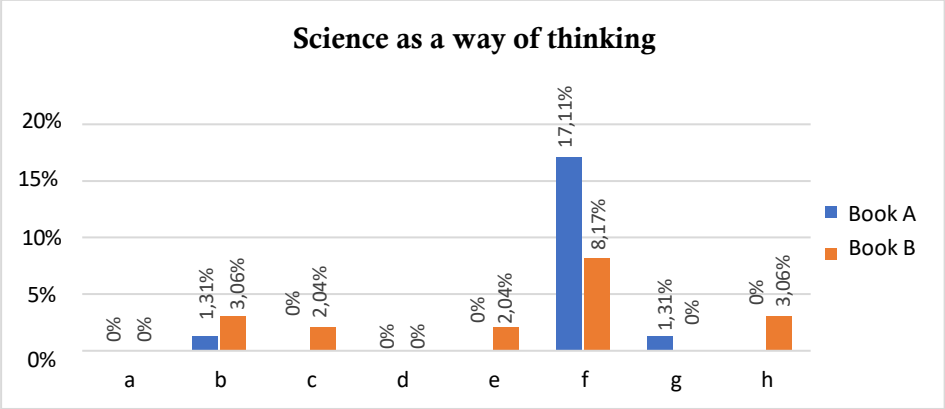

Figure 3. Indicator occurrence of Science as a Way of Thinking

Description:

a) Describe how scientists experiment.
b) Shows the history of the development of ideas.
c) Emphasizes the empirical nature and objectivity of science.
d) Illustrates by using assumptions.
e) Shows how science proceeds by inductive and deductive reasoning.
f) Provides cause and effect relationships.
g) Discusses facts and evidence.
h) Presents the scientific method and problem solving.

Figure 3 shows that the most frequently occurring indicator in both textbook samples is "Providing cause-and-effect relationships." Meanwhile, the indicators "Describing scientists conducting experiments" and "Illustrating the use of assumptions" do not appear at all in either textbook.

The indicators "Emphasizing the empirical and objective nature of science" and "Demonstrating science through inductive and deductive reasoning" appear only in Book B, with two statements. The indicator "Discussing facts and evidence" appears only in Book A, while the indicator "Presenting the scientific method and problem-solving" appears exclusively in Book B.

Science, Technology and Society Interaction

The proper use of scientific knowledge, supported by the application of modern technology, can help society meet its daily needs (Budiarti & Suprihatin, 2017).

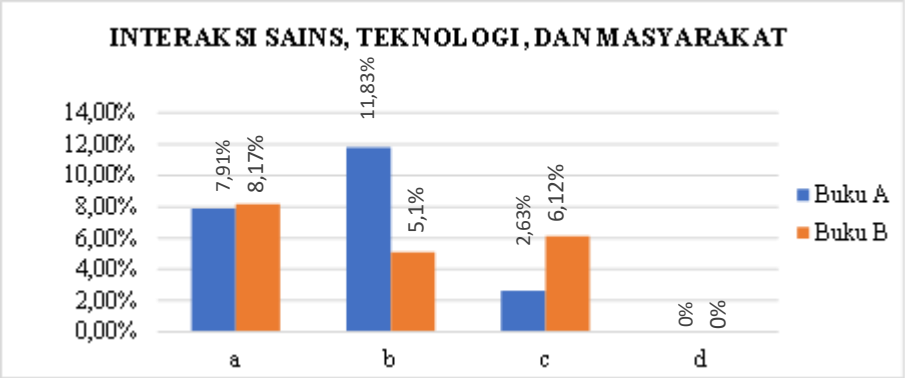

Figure 4. Occurrence of Science, Technology, and Society Interaction Indicators

Description:

a) Describe the uses of science and technology in society.
b) Emphasize the negative effects of science and technology in society.
c) Discuss social issues related to technology.
d) List occupations in science and technology.

Figure 4 shows that the most frequently occurring indicators in both textbook samples are "Describing the usefulness of science and technology in society," "Emphasizing the negative effects of science and technology on society," and "Discussing social issues related to technology." However, the indicator "Mentioning careers in the field of science and technology" does not appear in either textbook, even though it should be included to provide students with insights into career opportunities in science and technology fields.

Chemical Literacy

The research data obtained consists of statements or explanations of Green Chemistry material in Grade X chemistry textbooks, recorded in the chemical literacy indicator identification sheet. The validity of the research data was then tested by calculating the inter-rater agreement coefficient. The calculation resulted in a coefficient of 0.96, indicating an inter-rater agreement level categorized as "Very Good."

Table 3. Number and percentage of Chemical Literacy Indicator Occurrence

No.	Chemical Literacy Aspect	Book A		Book B		Avg (%)
		∑	%	∑	%	
1	content	12	37,5	29	56,86	47,18
2	Context	4	12,51	8	15,69	14,10
3	Competency	5	15,63	6	11,78	13,69
4	Attitude	11	34,37	8	15,69	25,03
	Total	**32**	**100**	**51**	**100**	**100**

Table 3 shows that the analysis of Grade X chemistry textbooks reflects chemical literacy. However, the proportion of chemical literacy categories presented is not balanced, as one category dominates specifically, the content aspect of chemical literacy.

Content Aspect

The content aspect of chemical literacy includes the fundamental principles of chemistry, which serve as a guideline for students to learn chemistry. It encompasses general concepts of chemistry and key ideas within the subject.

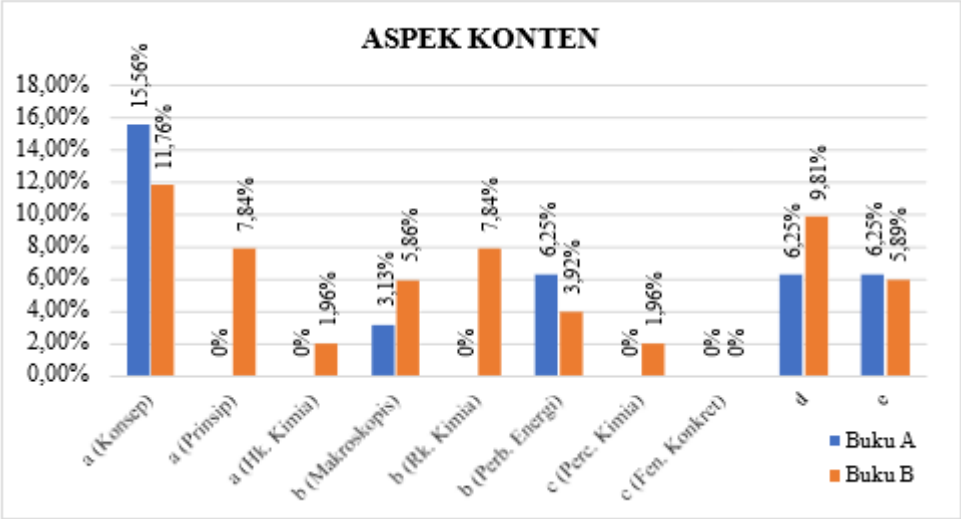

Figure 5. Occurrence of Indicators from Content Aspects

Description:

a) Present chemical concepts, principles, laws.
b) Explain macroscopic phenomena, chemical reactions, and energy changes in chemical reactions.
c) Present chemical experiments according to the subject matter, and concrete phenomena from the experiment.
d) Explain chemical materials based on microscopic representations.
e) Presenting chemical materials by paying attention to symbolic representation.

Figure 5 shows that the most frequently appearing indicator in both textbook samples is "Presenting chemical concepts, principles, and laws." The sub-indicator "Presenting chemical principles and laws" appears only in Book B. Book B includes a discussion on "Chemical reaction

equations," which covers Proust's law (indicator for presenting chemical laws) and explanations of balanced reaction equations (indicator for presenting principles).

Aspect Context

This aspect encompasses the importance of chemical knowledge in explaining everyday phenomena and applying chemical understanding in daily life.

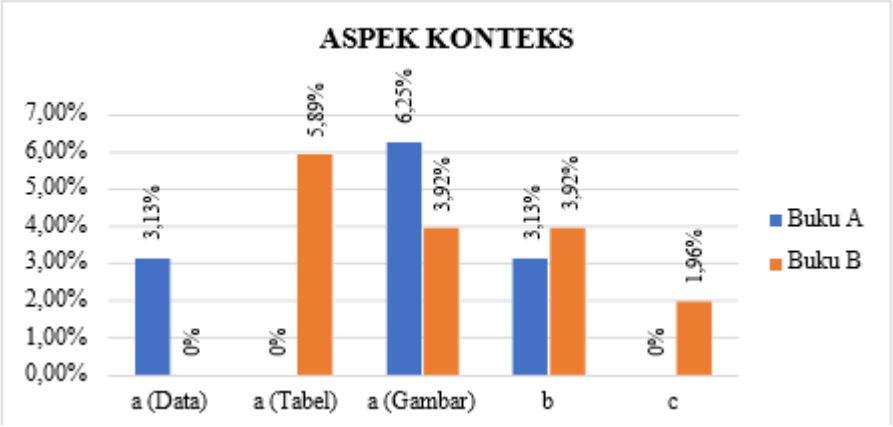

Figure 6. Occurrence of Indicators from Context Aspects

Description:

a) Present data, tables, images related to the subject matter.
b) Present the application of chemistry in everyday life.
c) Provide new findings regarding related chemical materials

The most frequently appearing indicators in both textbook samples are "Presenting data, tables, and images" and "Presenting applications of chemical knowledge." Figure 6 shows that Book B is better at broadening students' perspectives and encouraging them to learn more about the applications of chemistry in everyday life. The indicator "Providing new findings in chemistry topics" appears only in Book B, presenting new discoveries about the "Catalyst converter."

Aspect Competency

The competency aspect is an aspect that encourages students to develop students' thinking skills.

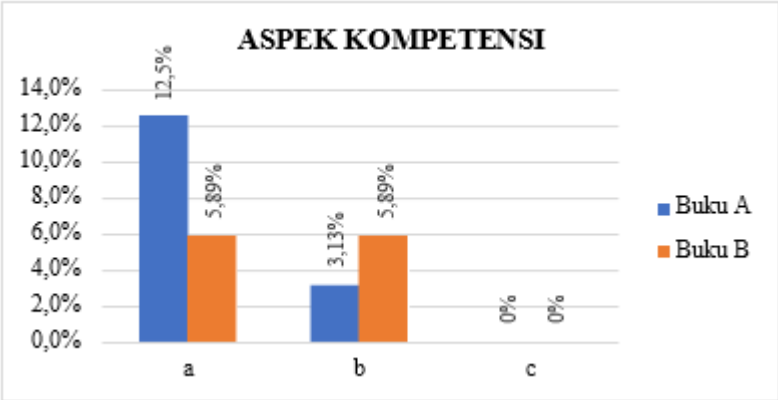

Figure 7. Occurrence of Indicators from Competency Aspects

Description :

a) Encourage learners to identify scientific issues in chemistry.
b) Present problems that can be solved with chemical knowledge.
c) Present scientific evidence in existing chemical phenomena.

The most frequently occurring indicator in both textbook samples is "Encouraging students to identify scientific issues related to chemistry." The indicator "Presenting scientific evidence in chemical phenomena" does not appear at all. Based on Figure 7, it is evident that both textbook samples have not emphasized the competence aspect. However, textbooks based on the Merdeka Curriculum should ideally place the competence aspect as one of their primary objectives.

Attitude Aspect

The attitude aspect presents a rational view of chemistry, applications of chemistry, and encourages learners to be responsible for the opinions that have been expressed.

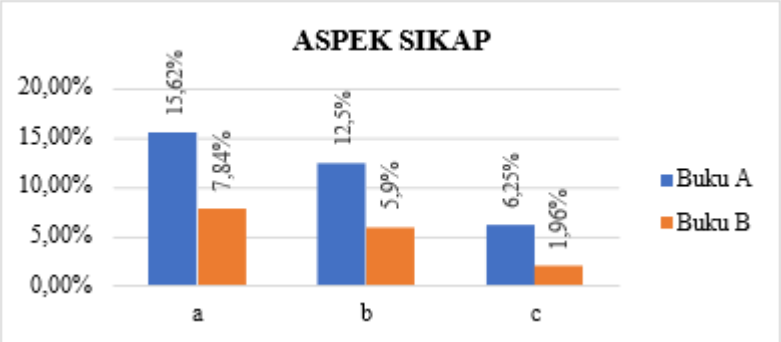

Figure 8. Occurrence of Indicators from Attitude Aspects

Description:

a) Describe the usefulness of chemistry and chemistry-based technology for society.
b) Show the negative impact of chemistry and chemical technology on society.
c) Present chemistry-based technology

The most frequently occurring indicator in both textbook samples is "Describing the usefulness of chemistry and the negative impacts of chemistry-based technology on society." The indicator "Presenting chemistry-based technology" appears most often in Book A. Book A discusses technologies such as "Biosolar 30" and "Solar panels (photovoltaics)" as solar energy sources in the context of applying green chemistry principles.

The results of the comparative analysis of scientific literacy and chemical literacy content in the two textbook samples are presented in Table 4.

Table 4. Comparison of Science Literacy and Chemical Literacy

Science Literacy category	Book A ∑	Book A %	Book B ∑	Book B %	Chemical Literacy Category	Book A ∑	Book A %	Book B ∑	Book B %
Science Knowledge	29	38,16	37	37,76	Content	12	37,5	29	56,86
Science how to investigate	15	19,73	24	24,49	Context	4	12,51	8	15,69
Science way of thinking	15	19,73	18	18,37	Competency	5	15,63	6	11,78
The interaction of science, technology and Society	17	22,37	19	19,39	Attitude	11	34,37	8	15,69
Total	**76**	**100**	**98**	**100**	**Total**	**32**	**100**	**51**	**100**

The Green Chemistry material in both textbook samples contains more scientific literacy content compared to chemical literacy. Table 4 shows that the number of scientific literacy indicators is 76 statements in Book A and 98 statements in Book B, while the number of chemical literacy indicators is 32 statements in Book A and 51 statements in Book B.

CONCLUSION

The analysis of the data and research on two Grade X high school chemistry textbooks led to the following conclusions: The presence of scientific literacy indicators in both textbook samples is well-covered and nearly balanced. The average proportions of the categories are as follows: scientific knowledge (37.96%), science as a way of investigating (22.11%), science as a way of thinking (19.05%), and the interaction of science, technology, and society (20.88%). For Book A, the proportions are 38.16%, 19.73%, 19.73%, and 22.37%, respectively, while Book B shows 37.76%, 24.49%, 18.37%, and 19.39%, respectively.

However, the presence of chemical literacy indicators in both textbooks is uneven and unbalanced. The average proportions across the content, context, competence, and attitude aspects are 47.18%, 14.10%, 13.69%, and 25.03%, respectively. For Book A, the proportions are 37.5%, 12.51%, 15.63%, and 34.37%, while Book B shows 56.86%, 15.69%, 11.78%, and 15.69%, respectively. This highlights the need for a more balanced presentation of chemical literacy indicators in both textbooks.

REFERENCE

Arohman, M., Saefudin., & Priyandoko, D. (2016). Kemampuan Literasi Sains Peserta didik pada Pembelajaran Ekosistem. Proceeding Biology Education Conference, 13(1): 90-92.

Budiarti, Y., S. Suprihatin (2017). Pengaruh model pembelajaran sain teknologi masyarakat (stm) terhadap kemampuan soft skillmahasiswa. Jurnal promosi, Vol.5. No.2(2017) 131-144.

Celik, S. (2014). Chemical Literacy Levels of Science and Mathematics Teacher Candidates. Australian Journal of Teacher Education, 39(1).

Chiappetta, E. L., Sethna, G. H., & Fillman, D. A. (1991). A quantitative analysis of high school chemistry textbooks for scientific literacy themes and expository learning aids. Journal of Research in Science Teaching, 28(10), 939–951.

Kementrian Pendidikan dan Kebudayaan. (2023). Peringkat Indonesia Pada PISA 2022. Jakarta: Tim BSKAP Kemendikbud.

Nurdini, Mustika Sari, I., & Suryana, I. (2018). Analisis Buku Ajar Fisika SMA Kelas XI Semester 1 di Kota Bandung Berdasarkan Keseimbangan Aspek Literasi Sains. Jurnal Wahana Pendidikan Fisika, 3(1), 96–103.

OECD. (2023). PISA 2022 Results Assessment and Analytical Framework: Mathematics, Financial literac, Science, Reading, and Creative Thinking Students. Paris: OECD Publishing.

Permatasari, A. (2020). PISA-500 dan Literasi Sains (Kimia). Diunduh pada Desember 2023.

Rahayu, S. (2018). Mempromosikan 21 st Keterampilan Literasi Ilmiah Abad Melalui Instruksi Kimia Inovatif. 20025(2017).

Sheldon, R. A., & Norton, M. (2020). Green Chemistry And The Plastic Pollution Challenge: Towards A Circular Economy. Green Chemistry, 22(19).

Shwartz, Y., Ben-Zvi, R., & Hofstein, A. (2006). Chemical Literacy: What Does This Mean to Scientists and School Teacher? Journal of Chemical Education, 83(10).

Sudjana, N. & Ibrahim. (2004). Penelitian dan Penilaian Pendidikan Cetakan Ketiga. Bandung: Sinar Baru Algesindo.

Wilkinson, J. (1999). A Quantitative Analysis of Physics Textbooks for Scientific Literacy Themes. Research In Science Education, 29(3).

Wirama, Tjokorda Gde Putra. (2022). Asesmen Literasi Sains Tema Kimia Hijau Pada Peserta didikKelas XII di SMAN Satu Atap Lembongan. Indonesian Journal of Educational Development. (3)1.