INSECTA Vol. 6 No. 2, 2025, pp. 122 - 135

Available online at
INSECTA
Integrative Science Education and Teaching Activity Journal
Journal homepage : https://jurnal.iainponorogo.ac.id/index.php/insecta

Article

Analysis of Visual Representations of Water Topics in Junior High School Science Textbooks: Implications for Science Literacy and Potential Misconceptions

Putri Lestari[1*], Iseu Laelasari[2]

[1,2]Universitas Islam Negeri Sunan Kudus, Indonesia

Corresponding Address: lestari010804@gmail.com

Article Info

Article history:
Received:September 12 , 2025
Accepted:October 10, 2025
Published:November 06, 2025

Keywords:

Junior high school science textbook;
Water topic visuals;
Textbook misconceptions

ABSTRACT

The low performance of Indonesian students in the PISA 2022 science assessment highlights ongoing challenges in science literacy, especially in interpreting scientific visuals. Textbooks, as the primary learning resource, play a vital role in shaping students' conceptual understanding. This study examines how water related topics are visually represented in junior high school science textbooks and explores their implications for science literacy and potential misconceptions. A descriptive qualitative method was applied using purposive sampling of nine BSE textbooks published by the Ministry of Education and Culture, covering grades VII–IX in both the 2013 and Merdeka (Indonesian independent) curricula. Visual data were classified into four categories: water, water and society, technology, and sustainability and responsibility. Content analysis was conducted with a coding instrument validated by two experts, one in water literacy and the other in science learning and the data were analyzed using the Miles and Huberman model with RStudio support for visualization. In total, 104 visuals were identified. The majority (63%) belonged to the "water" category, while "water and society" (17%), "technology" (12%), and "sustainability and responsibility" (8%) were underrepresented. Both curricula concentrated visuals in grade VII, with fewer in grades VIII and IX. Common inaccuracies included incomplete water cycle diagrams that omitted infiltration and percolation processes, potentially fostering misconceptions. These findings indicate that textbook visuals emphasize conceptual aspects of water while neglecting social, technological, and sustainability dimensions. This imbalance restricts students' opportunities to develop comprehensive science literacy. The study underscores the need for more accurate, contextual, and real world aligned textbook visuals to support curriculum goals and reduce misconceptions.

INTRODUCTION

Water is a fundamental substance that underpins almost every aspect of human life. In the field of science, water plays a central role in meeting human needs and supporting essential natural processes such as regulating Earth's temperature, facilitating photosynthesis, and dissolving compounds (Kontogeorgis et al., 2022). Therefore, cultivating students' understanding of water concepts including its physical and chemical properties, as well as the hydrological cycle from an early stage is essential for developing scientific literacy (Imaduddin & Eilks, 2024). One of the main pedagogical strategies for teaching water concepts is the use of visual representations in textbooks, which can facilitate the comprehension of scientific information (Nurafina et al., 2024). Nevertheless, the effectiveness of such visual representations is not always consistent.

Despite their potential, visual representations in textbooks often fail to translate scientific concepts into comprehensible knowledge. Studies show that many diagrams deviate from accuracy in proportion, data precision, or clarity (Angelina, 2021). In contrast, dual coding and multimodal representation theories emphasize that well-designed visuals can enhance conceptual understanding (Alma Indah & Fadilah, 2024). This gap highlights the need to evaluate not only the presence but also the quality of visuals in science textbooks.

In the 21st century, science literacy extends beyond memorizing concepts. It also includes the ability to interpret, analyze, and evaluate scientific visuals. According to (Firahma Tillah & Subekti, 2025), science literacy involves applying knowledge to identify problems, gather information, explain phenomena, and draw evidence based conclusions. Students are thus expected to engage with visual data such as charts, diagrams, and images as legitimate sources of scientific evidence (Panjaitan, 2019). Accurate visualizations can help students construct appropriate cognitive schemas (Naqiya Rabbani et al., 2023), whereas flawed or misleading visuals may generate misconceptions that are resistant to change. In this regard, the theory of visual literacy also emphasizes that interpreting scientific visuals is a crucial component of science literacy in the 21st century (Fadillah Indriyani, 2024).

The urgency of improving visual representations is evident in the Programme for International Student Assessment (PISA) 2022 results. Indonesian students scored an average of 383 in science literacy, significantly lower than the OECD average of 485 (OECD, 2023). These results highlight persistent challenges in science education, including the quality of textbooks as primary learning resources. Since textbooks remain the most widely used reference in schools, the way water-related concepts are visually represented can directly influence students' literacy outcomes. Thus, strengthening textbook visuals is an important step toward addressing the gaps reflected in Indonesia's low PISA performance.

A multitude of studies have previously indicated a degree of concern regarding the visual representation in science textbooks. As demonstrated in previous research by Aliyah and Erman, visual presentation and supporting instruments in textbooks have been found to be suboptimal in shaping students' scientific thinking skills, particularly with regard to scientific reasoning and the visual representation of complex phenomena (Aliyah & Erman, 2021). Subsequent research indicates that the categories of science literacy in science textbooks for eighth grade junior high school students under the 2013 curriculum on the material of the life organization system and the interaction of living things with the environment are not presented in a balanced manner. The most salient dimensions of this phenomenon are science as a method of inquiry and science as a mode of thinking, while the dimension of the interaction between science, technology, and society tends to be overlooked. These findings suggest that while investigative and cognitive aspects are given attention, the social context of science remains underrepresented in teaching materials. This poses a challenge in developing students' science literacy comprehensively, especially in their ability to interpret scientific information in visual forms with a social context (Hamidah et al., 2022).

Despite the prevalence of research addressing the use of visual representations in science education, there is a paucity of studies that specifically examine visual representations of water related topics in junior high school science textbooks. Studies such as Khine and Liu have conducted descriptive analyses of graphic representations in science textbooks, revealing the predominance of static visuals that may limit students' conceptual understanding. While their research provides valuable insights into textbook visuals generally, it does not focus exclusively on water related content, indicating a significant gap (Khine & Yang, 2017). Additionally, Parra- López et al. highlight the use of digital technologies to represent water usage and management, which suggests potential innovative approaches to visualizing water concepts that are yet to be fully integrated into junior high school instructional materials (Parra-López et al., 2025).

Furthermore, Singh et al. in their systematic review of industrial wastewater management emphasize the importance of accurate visual representations to overcome misconceptions about the water cycle and water quality issues (Singh et al., 2023). These studies collectively underscore the critical need for targeted research into visual representations of water in junior high school science textbooks, as such work is vital to inform the development of effective instructional materials that meet current science literacy standards and address potential student misconceptions. Furthermore, the article undertakes an evaluation of the aptitude of visual representations in relation to junior high school science learning outcomes. This evaluation is explicitly connected to the potential emergence of scientific misconceptions and is conducted through a descriptive qualitative research approach involving purposively selected science textbooks and systematic analysis of visual data. This analysis is imperative to guarantee that visual representations in textbooks are not only engaging but also straightforward to comprehend and aligned with accurate scientific concepts.

Furthermore, the presence of biased or inaccurate graphic elements in textbooks is a matter of concern. These inaccurate visualizations have the potential to shape misconceptions about natural processes that are important in everyday life life (Guerra-Reyes et al., 2024). Therefore, an analysis of the visual depictions of water themes in textbooks is imperative to assess the extent to which these visualizations facilitate students' comprehension of water concepts.

According to the provided background information, it is imperative to investigate the impact of visual representations in science textbooks on students' comprehension of scientific concepts, particularly in the context of the subject matter pertaining to water. Therefore, the research question in this study is how visual representations of water are presented in junior high school science textbooks, and what are the implications of these representations for science literacy and the potential for misconceptions among students. In accordance with the research question, the objective of this study is to analyze the visual representation of water topics in junior high school science textbooks based on existing lexicographical analysis, and to examine the implications of such visualizations on students' science literacy and the potential emergence of misconceptions.

METHODS

The present study employs a descriptive qualitative research method, with the objective of analyzing the visual representation of the topic of water in junior high school science textbooks and evaluating its implications for science literacy and potential misconceptions. Descriptive qualitative research is a research method that emphasizes natural and in-depth observation and understanding, presented descriptively, and interpreted comprehensively (Waruwu, 2024). The subjects of this study were science textbooks for seventh, eighth, and ninth grade students from the 2013 curriculum and the Merdeka curriculum. These textbooks are primarily utilized at the junior high school level and are BSE science textbooks published by the Ministry of Education and Culture.

The textbooks were selected using purposive sampling, a method of sample selection that is characterized by a specific purpose and objective (Sulistiyo, 2019). The selection was based on the consideration that BSE science textbooks published by the Ministry of Education and Culture are the most widely used in junior high schools across Indonesia and represent both the 2013 and the Merdeka curricula. However, this choice also constitutes a limitation of the study, as it excludes science textbooks from private publishers, thereby restricting the generalizability of the findings.

A total of nine textbooks were subjected to analysis, comprising six textbooks from the 2013 curriculum, with each grade level comprising two textbooks covering semesters one and two. Concurrently, a comprehensive analysis was conducted on three textbooks from the Merdeka Curriculum, encompassing grades VII, VIII, and IX. These textbooks include chapters that address the topic of water, such as the properties and states of water, the water cycle, and the role of water in ecosystems and daily life, which makes them relevant to the focus of this study.

This study used content analysis with a coding instrument for visual representation formats developed by the researcher. The instrument was validated by two experts, on in water literacy and the other in science learning and then applied to organize textbook visuals into systematic analysis tables. These data were further examined using the Miles and Huberman qualitative model to ensure that the indicators reflected theoretically valid classifications.

The instrument included operational definitions for four categories: (I) water and society (positive example visuals of water use in daily life; negative example: absence of human-water interaction), (II) technology (positive example visuals of irrigation or wastewater treatment; negative example: irrelevant or unrealistic depictions of technology), (III) sustainability and responsibility (positive example visuals of water conservation practices; negative example: ignoring environmental impacts), and (IV) water (positive example visuals of the water cycle or water states; negative example: incomplete diagrams excluding infiltration). These operational definitions ensured consistent classification across textbooks.

The data analysis technique employed in this study is the Miles and Huberman model, which consists of three stages: data condensation, data presentation, and conclusion drawing and verification (Miles et al., 2014). To assist with data organization and the creation of comparative diagrams, RStudio software was employed as an analytical tool. This enabled the visualization of trends and distributions across categories in a systematic and replicable manner.

The data, in the form of visual representations of the topic of water from junior high school science textbooks, were collected and coded based on four categories of visual representations referring to existing lexicographic analysis. These categories include water and society, technology, sustainability and responsibility, and water (Martínez-Borreguero et al., 2020). Subsequently, the data were meticulously arranged into an analysis table comprising image elements, sources, levels, learning outcomes, and categories. Subsequently, an analysis was conducted on the trends in visual representations and their implications for science literacy and the potential emergence of scientific misconceptions. The analysis results were then verified through rereading and theory based review to ensure the validity of the findings (Lungu, 2022). The present study employed data validity testing through the implementation of triangulation techniques. In the context of qualitative research, triangulation can be defined as a methodological approach aimed at assessing the validity of data through the use of external corroboration or comparison (Arianto, 2024).

Furthermore, the researchers re-examined the coded data and re-evaluated the visual representation classification categories based on science literacy indicators. This process was carried out iteratively to ensure that the data obtained met the principles of qualitative research, namely dependability and confirmability (Mulyana et al., 2024). The implementation of these two triangulation techniques and internal verification served to ensure the validity of the data in this study, thereby contributing to the development of science literacy based on visual representation in junior high school science education.

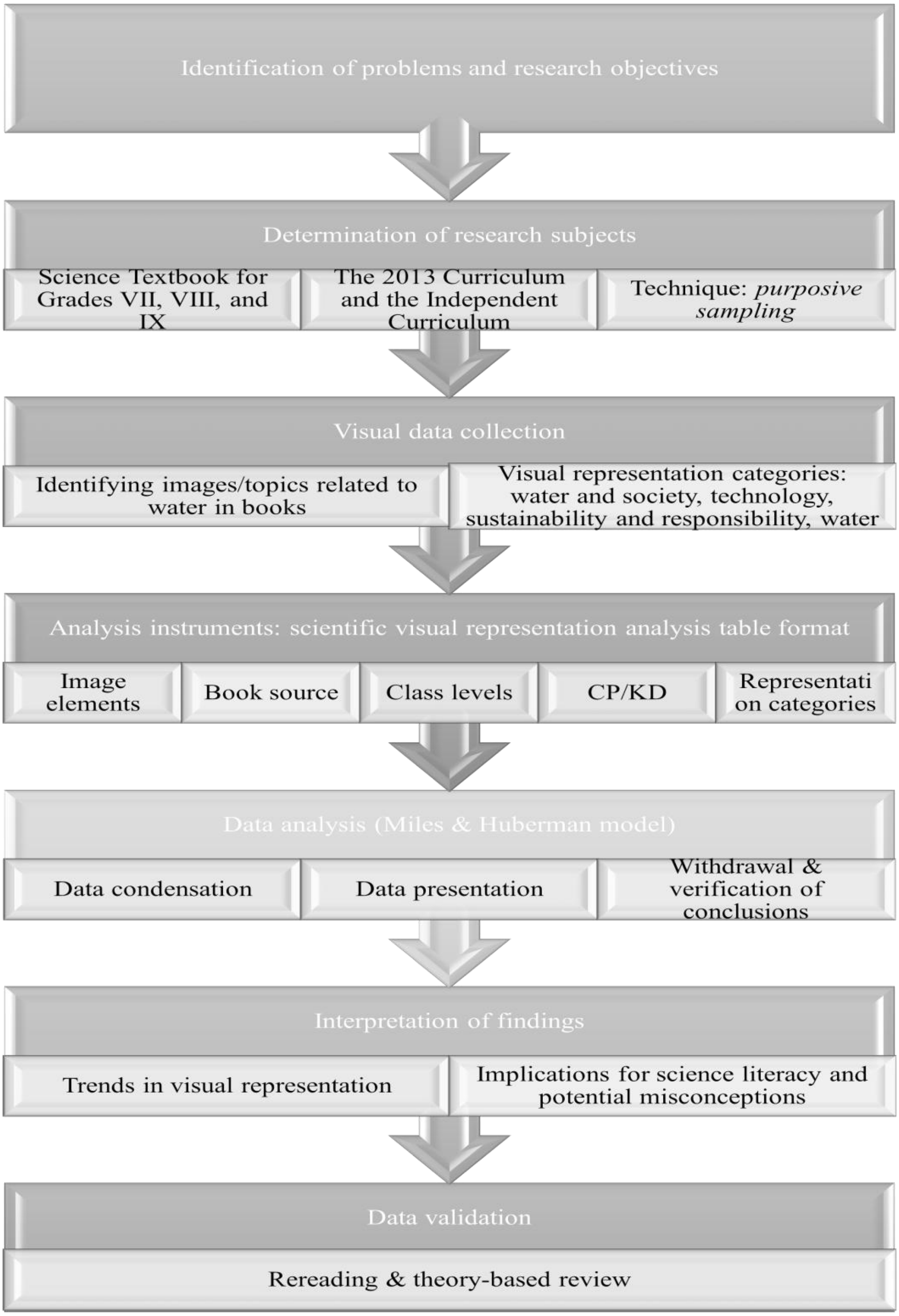

Figure 1. Research Flowchart

RESULTS AND DISCUSSION

An analysis of 104 visual representations from science textbooks aligned with both the 2013 and Merdeka curricula shows a dominance of the “water (W)” category. This finding indicates that both curricula prioritize conceptual depictions of water phenomena, while other categories such as society, technology, and sustainability remain underrepresented.

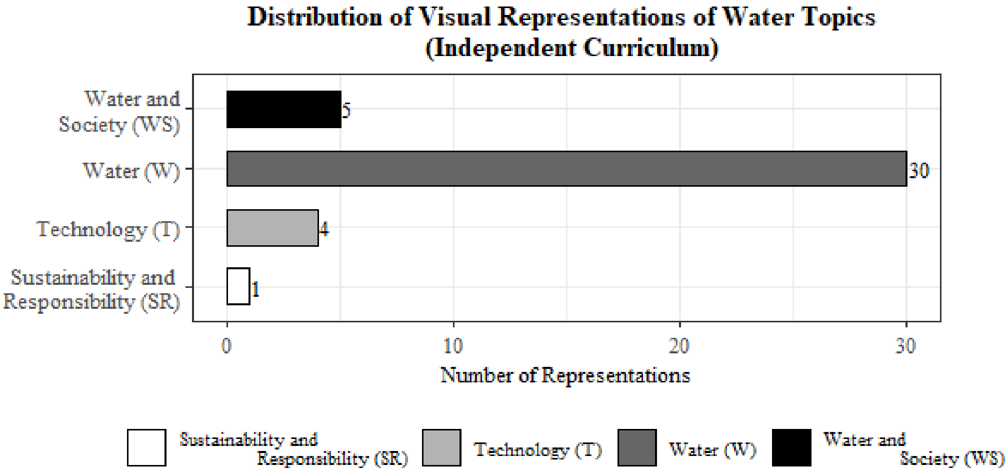

Figure 2. Distribution of visual representations of water topics based on categories (Merdeka curriculum).

Figure 2. The following study depicts the distribution of visual representations of the topic of water in Merdeka curriculum textbooks based on four existing lexicographic categories. These categories were classified as follows: category I (water and society), category II (technology), category III (sustainability and responsibility), and category IV (water). A total of 40 visual representations were identified in Merdeka curriculum textbooks for grades VII, VIII, and IX. Of the 40 representations identified, the category "water" exhibited a preponderance, with 30 images. Visualizations in this category encompass images depicting the water cycle, alterations in the state of water, the physical properties of water, and the utilization of water in experiments. Other categories were far less represented: “water and society” (5 visuals), “technology” (4), and “sustainability and responsibility” (1).

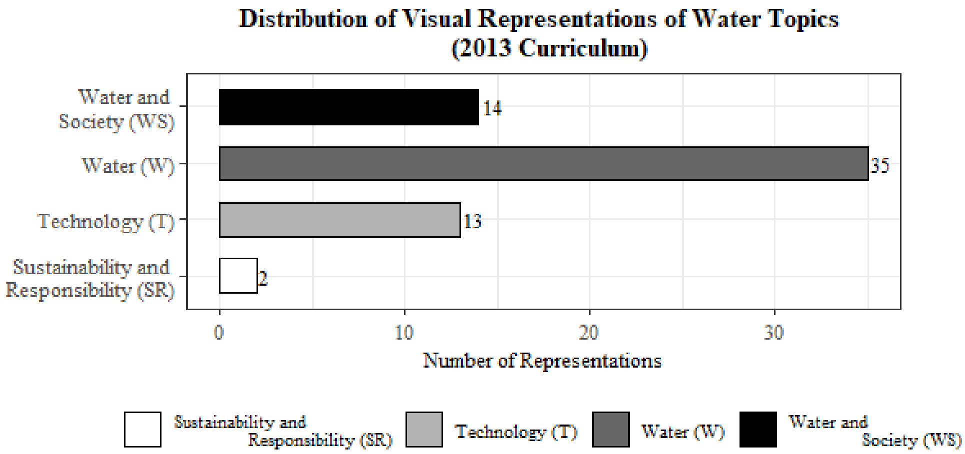

Figure 3. Distribution of visual representations of water topics based on categories (k13)

As demonstrated in Figure 3, the 2013 science textbooks also exhibit a preponderance of the category "water," which accounts for 35 of the 64 visuals. While the proportion of other visuals is marginally more balanced than in the Merdeka curriculum, the representation of the category "sustainability and responsibility" remains negligible, with a mere two visuals. The visual representation in the categories of "water and society" and "technology" is 13.

This imbalance shows that independent curriculum textbooks emphasize water mainly as a scientific concept, while neglecting its social, technological, and sustainability dimensions. Such gaps reduce opportunities to contextualize science learning in real world issues, consistent with earlier findings of limited sustainability integration (Windiyani et al., 2025). Addressing these gaps requires incorporating scientific principles into real-life contexts, which is essential for developing comprehensive science literacy (Dwi Suryani, 2021).

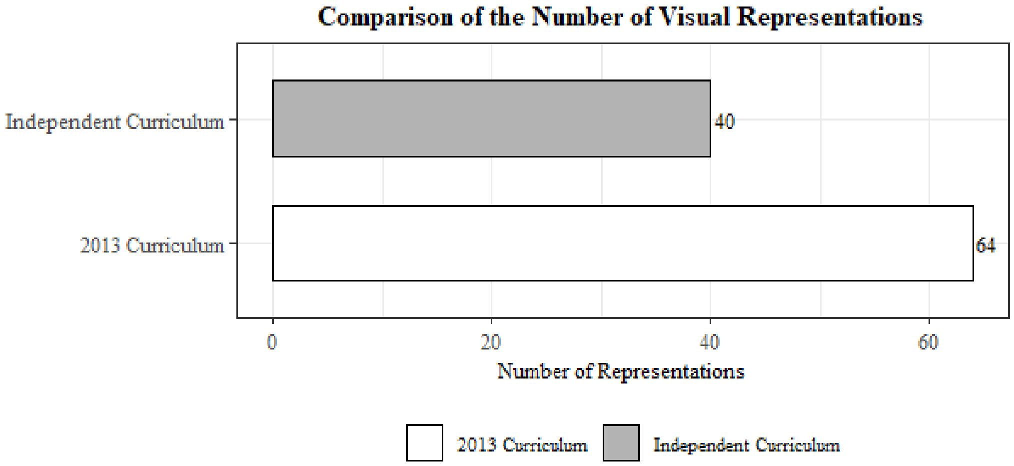

Figure 4. Comparison of the number of visual representations of the topic of water between the 2013 curriculum and the Merdeka curriculum.

Figure 4 shows that the 2013 curriculum contains more water-related visuals (64) than the Merdeka curriculum (40). However, quantity does not guarantee quality or diversity both curricula overemphasize the “water” category. This pattern is inconsistent with the Merdeka curriculum’s stated emphasis on contextual and project-based learning, and aligns with earlier findings that Indonesian science textbooks often fail to provide integrative visual contexts (Romulo et al., 2024). Indeed, the Merdeka curriculum is designed to emphasize contextual and project based learning (Safitri et al., 2022). This discrepancy suggests that textbooks have not adequately promoted the development of comprehensive science literacy.

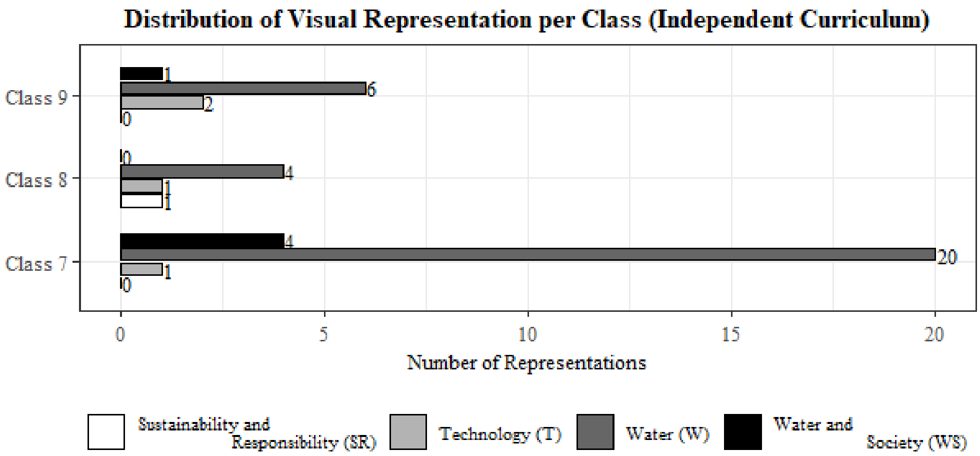

Figure 5. Distribution of visual representations of water topics based on grade level (Merdeka curriculum).

An analysis of the visual distribution in the Merdeka curriculum book reveals that grade VII exhibits the highest visual concentration, with 25 visuals. This is significantly higher than the visual concentration observed in grade VIII, which has only 6 visuals, and grade IX, which has 9 visuals. The category "water" is predominant in grade VII, comprising 20 of the total 25 visuals. Visual representations of "technology" were found to be minimal, with only one example identified. In contrast, the themes of "water and society" received greater emphasis, with four distinct visual representations observed. Notably, no visual representations of "sustainability and responsibility" were identified in the analysis. The categories "technology" and "sustainability and responsibility" emerge in grades VIII and IX, albeit in very limited numbers.

The concentration of visuals in grade VII, with a steep decline in grades VIII and IX, suggests that students receive a strong early focus on water concepts but little reinforcement later. This contradicts the principle of spiral curriculum, which emphasizes progressive deepening of concepts across levels (Rahman & Mehnaz, 2025). Similar gaps have been reported in science textbooks in other countries, where early conceptual overload without continuity hampers long-term scientific understanding (Gkintoni et al., 2025).

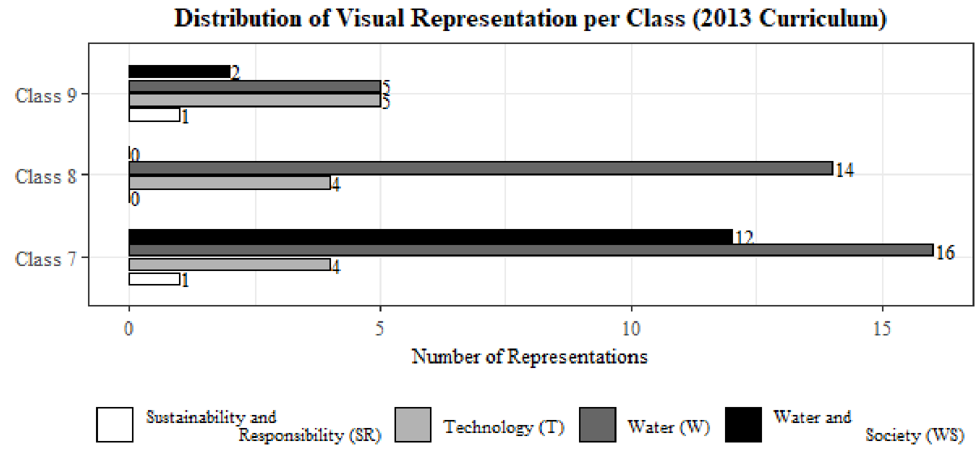

Figure 6. Distribution of visual representations of water topics based on grade level (k13).

An analysis of the distribution of visual representations in the 2013 curriculum textbooks reveals that grade VII exhibits the highest number of visual representations, with a total of 33. As indicated by the data, grade VIII contained 18 visual representations, while grade IX contained 13. The categories "water and society" and "water" exhibited a preponderance in grade VII, while the category "sustainability and responsibility" manifested once in grade VII and once in grade IX. The category "Technology" exhibits an increase in prevalence in grade IX. This distribution mirrors the Merdeka curriculum, indicating a tendency toward consolidation of material and visualization at the outset of the level. The research data show that while grade VII contains 33 visual representations across multiple categories, grades VIII and IX display a sharp decline with only 18 and 13 visuals respectively, and fewer categories represented. This decrease illustrates the absence of progressive and contextual visualization in the upper grades.

This can result in students missing the opportunity to understand the systemic and comprehensive interrelationship between water, technological dynamics, and environmental sustainability. The absence of progressive and contextual visualization continuity at the upper levels is consistent with findings that continuity in visualization is important for building deep and applicable conceptual understanding at higher levels of education (Menhard, 2024).

Implications for Science Literacy and Potential Misconceptions

The findings of the study suggest that visual depictions of water-related subjects in science textbooks for junior high school students, under both the 2013 and Merdeka curricula, are predominantly characterized by conceptual visuals classified under the category of water. The prevalence of this particular visual representation suggests a prevailing tendency among textbooks to present science as a collection of facts or abstract concepts rather than as a discipline intimately connected to society, technology, and sustainability issues. This has profound implications for the cultivation of students' comprehensive science literacy.

According to the OECD's Programme for International Student Assessment (PISA), science literacy encompasses four competencies: explaining scientific phenomena, evaluating and designing scientific investigations, interpreting data and evidence scientifically, and relating science to everyday life (Thomas, 2025) (Afina et al., 2021). The absence of visual representation of the categories "water and society" and "sustainability and responsibility" suggests that students' capacity to connect water with social and ecological contexts is not being optimally supported. The absence of visual representations that mirror real-world issues, such as the repercussions of climate change on the water cycle, wastewater treatment, and clean water crises, hinders students' capacity to cultivate the social and ethical dimensions of science literacy (Chanifah, 2021). Therefore, visualization is required that is not only conceptual but also contextualized with real-life situations and environmental issues (Sihombing et al., 2024).

Another implication is that visual representations that focus excessively on a single aspect of science tend to engender incomplete and simplistic understandings. For instance, the water cycle is depicted in junior high school science textbooks based on the 2013 curriculum and the Merdeka curriculum, which exclude processes such as runoff and infiltration. These visual representations do not demonstrate the processes of infiltration, percolation, or the role of soil and vegetation. This incomplete visualization can result in mental models that do not align with the actual functioning of natural systems. This has the potential to engender long-term misconceptions that are difficult to rectify (Putri & Kurniawati, 2025).

In the framework of dual coding theory, visualization is not merely a complementary tool; rather, it serves as the primary conduit in the process of constructing students' mental representations. In the event that visual representations in textbooks are found to be incorrect, biased, or disproportionate, students may develop inaccurate cognitive schemas from the outset. It is noteworthy that misconceptions formed from visual representations are notoriously resistant to change through verbal text or teacher explanations alone, given the holistic and simultaneous nature of visual processing in long-term memory (Bistari, 2024).

The absence of visual representation of the category of "technology" can also impede students' ability to perceive the practical application of science through technological means. The integration of visual representations, such as water treatment technology, industrial water utilization, and irrigation systems, has been demonstrated to facilitate enhanced comprehension of the interconnection between scientific principles and their practical applications in real-life scenarios. The dearth of such visual representations can result in students perceiving science as a standalone discipline devoid of real-world applications. This, in turn, can diminish their motivation and the relevance of their learning (Haryadi & Oktarisa, 2025).

The concepts of sustainability and responsibility, which function as a conduit between scientific knowledge and environmental consciousness, are seldom conceptualized. This finding suggests that the science education section of textbooks does not yet fully align with the 21st-century educational goals of integrating ecological awareness and social responsibility as part of scientific competence (Yunita & Mandasari, 2025). However, if students can comprehend the necessity of preserving water as a finite resource through collective action and environmentally sustainable technologies, they will be better prepared to cultivate scientific awareness and assume responsible citizenry.

Furthermore, the loss of opportunities to cultivate students' critical visual thinking skills is another impact to consider. Monotonous and unchallenging visual representations have been shown to engender passive reading behaviors among students when it comes to images or diagrams. Indeed, the theory of visual literacy underscores the necessity of training students to engage in active and reflective reading, interpretation, and evaluation of visual scientific information (Arneson & Offerdahl, 2018). Visual literacy constitutes a significant component of scientific literacy, as the preponderance of contemporary scientific data is presented in the form of graphs, models, or concept maps. The absence of these competencies can impede students' engagement in decision-making processes, scientific discourse, and the comprehension of scientific news media (Miller, 2021).

The results of the analysis demonstrate that conceptual visual representations devoid of contextual visualization support are most prevalent in the water category. This phenomenon has the potential to contribute to the development of scientific misconceptions among students. A thorough examination of the visual distribution yielded several forms of representation that manifest potential conceptual errors, either explicitly or implicitly. One of the most common forms is a visualization of the water cycle that does not show the processes of infiltration, percolation, and the role of soil in the water cycle. The majority of images in the existing body of research exclusively depict the processes of evaporation, condensation, and precipitation, which subsequently result in the direct flow of water into the ocean. The absence of significant processes such as natural filtration in the soil can result in the erroneous assumption that rainwater invariably re-enteres the ocean directly. However, in reality, the majority of water is absorbed by the soil, stored in aquifers, or involved in biological processes and ecosystems (Arad et al., 2023). This can disrupt students' understanding of groundwater dynamics and the importance of green space conservation in maintaining the hydrological cycle.

The analysis indicates a conspicuous absence of the category of sustainability and responsibility in textbooks, a lapse that jeopardizes the consideration of critical components of environmental responsibility and scientific ethics. The absence of visualizations, such as wastewater reuse, rainwater management, or the significance of water conservation in everyday life, can hinder students' development of an awareness that water is a finite resource necessitating judicious management. This finding aligns with the conclusions of a series of literature reviews indicating that when visual representations overlook sustainability dimensions, students tend to demonstrate technical understanding but lack sensitivity to the social and ecological impacts of human practices (Abdullahi et al., 2024).

Another potential misconception relates to biased or disproportionate visual styles. As illustrated, certain elements exhibit deficiencies, including oversized water particles, mispositioned components, and imbalanced process arrows. This discrepancy in scale contributes to the development of erroneous mental models, such as students' assumption that condensation occurs instantaneously in open space or that water molecules are visible to the naked eye (Amiruddin et al., 2024).

The dual coding theory posits that errors in visualization play a dual role in shaping misconceptions because visual information is more easily retained in students' long-term memory than text (Aryanto, 2021). In instances where the text provides a precise explanation of a concept but the accompanying visual is not accurate, the visual will inevitably exert a dominant influence on students' comprehension, making verbal explanations alone insufficient for correction (As Sa'adah et al., 2025). Visual representations that are overly conceptual may result in the formation of misconceptions and impede the cultivation of students' science literacy.

This phenomenon has the potential to impede the realization of learning objectives that necessitate students to comprehend, implement, and assess knowledge in a thorough, analytical, and contextual manner. This underscores the necessity to reevaluate the visual depictions employed in textbooks (Utamy & Rosdiana, 2023). This approach is grounded in the principles of scientific and good instructional design (Hidayah et al., 2022). The analysis conducted indicates that scientific misconceptions arising from visual representations are not merely design errors but reflect deeper pedagogical challenges in fostering students' scientific literacy, as defined by the Programme for International Student Assessment (PISA). According to the PISA framework, scientific literacy encompasses competencies such as explaining phenomena scientifically, evaluating and designing scientific investigations, and interpreting data and evidence scientifically. However, many textbook visualizations such as water cycle diagrams that omit infiltration and percolation processes, or illustrations that depict disproportionate evaporation and precipitation scales fail to support these competencies. Instead of encouraging interpretation and critical evaluation of scientific evidence, these visuals promote surface-level memorization of natural processes.

For instance, students who repeatedly encounter simplified images of the water cycle showing only evaporation, condensation, and precipitation may conclude that water always returns directly to the ocean, neglecting groundwater flow and storage. This misconception demonstrates how visualization inaccuracies can hinder the PISA indicator of interpreting data and evidence scientifically. Likewise, the absence of visuals depicting technological and societal contexts, such as water treatment systems or community water management, limits opportunities to develop the indicator of relating scientific knowledge to everyday life.

To address these visual gaps, actionable steps are required. Textbook authors should include comparative visuals that integrate water with sustainability and technology contexts, for example wastewater treatment, irrigation systems. Curriculum developers need to ensure progressive reinforcement of visual concepts across grade levels, avoiding concentration in early grades only. Teachers can be supported with supplementary resources that foster critical visual literacy. These efforts, if implemented collaboratively, will strengthen students' science literacy and align textbooks with PISA-based competencies and 21st-century education goals (Syahwati & Arif, 2022) (Ilahy et al., 2025).

It is imperative to acknowledge the limitations of this study when interpreting the findings. Initially, the data sources were constrained to science textbooks published by the Ministry of Education and Culture, designated as electronic school books (BSE). Consequently, the analysis results excluded textbooks from private publishers that are also extensively utilized in numerous schools. Secondly, the analysis of visual representation focused exclusively on the topic of water, neglecting to incorporate other subjects pertinent to the scientific ecosystem. Thirdly, the present study concentrated on visual classification without incorporating direct student comprehension tests. Consequently, future research endeavors should encompass a diverse selection of textbooks from various publishers to expand the scope of the analysis. The research could also be expanded to other science topics, such as energy or the human body. In addition, the visual analysis could be combined with student comprehension tests to empirically verify misconceptions. This would allow for the development of guidelines for the development of science literate scientific illustrations. This step is important to encourage the development of more accurate, contextual, and science-literate textbooks for the 21st century.

CONCLUSION

The analysis of junior high school science textbooks reveals that the visual depiction of water related topics remains predominantly characterized by conceptual images, devoid of social, technological, and sustainability contexts. These contexts are reflected in the categories of water and society, technology, and sustainability and responsibility. Current textbook visuals do not fully support the development of comprehensive science literacy. While visual aids simplify scientific processes, they may also generate misconceptions. Such inaccuracies can hinder students from achieving learning objectives that require holistic and critical understanding. Therefore, improvements are needed to ensure that visuals are both scientifically accurate and contextual, supporting the goals of 21st-century science education.

In addition, future research should extend the scope of analysis to a wider range of textbooks from various publishers and explore other science topics such as energy or ecosystems. Combining visual analysis with student comprehension tests is also recommended to empirically validate the relationship between visualizations and misconceptions. These directions can serve as a foundation for developing evidence based guidelines for designing scientifically literate and pedagogically effective visualizations in science textbooks.

REFERENCES

Abdullahi, A. M., Hussein, H. A., Ahmed, M. Y., Hussein, O. A., & Warsame, A. A. (2024). The impact of education for sustainable development on university students' sustainability behavior: A case study from undergraduate students in Somalia. *Frontiers in Education*, *9*, 1413687. https://doi.org/10.3389/feduc.2024.1413687

Afina, D. R., Hayati, M. N., & Fatkhurrohman, M. A. (2021). Profil Capaian Kompetensi Literasi Sains Siswa SMP Negeri Kota Tegal Menggunakan PISA. *PSEJ (Pancasakti Science Education Journal)*, *6*(1), 10–21. https://doi.org/10.24905/psej.v6i1.111

Aliyah, A., & Erman, E. (2021). Analisis Unsur-Unsur Keterampilan Proses Sains dalam Buku IPA SMP. *Jurnal Pendidikan Sains*, *9*(2). https://ejournal.unesa.ac.id/index.php/pensa/index

Alma Indah, R., & Fadilah, M. (2024). Literature Review: Pengaruh Media Pembelajaran Literasi Visual Terhadap Hasil Belajar Biologi Siswa SMA. *Biodik: Jurnal Ilmiah Pendidikan Biologi*, *10*(02). https://online-journal.unja.ac.id/biodik

Amiruddin, M. Z. B., Samsudin, A., Suhandi, A., Suliyanah, Costu, B., & Purwanto, M. G. (2024). Needs analysis of students' mental model representation through visualisation to support SDGs 4: A preliminary study. *E3S Web of Conferences*, *513*, 04005. https://doi.org/10.1051/e3sconf/202451304005

Angelina, S. (2021). *Literature Review Sistematis tentang Efektivitas Penggunaan Bahan Ajar Berbasis Multirepresentasi pada Pembelajaran IPA di SMP* [Skripsi]. UIN Sultan Syarif Kasim Riau.

Arad, I., Ziner, A., Ben Moshe, S., Weisbrod, N., & Furman, A. (2023). Improving soil aquifer treatment efficiency using air injection into the subsurface. *Hydrology and Earth System Sciences*, *27*(13), 2509–2522. https://doi.org/10.5194/hess-27-2509-2023

Arianto, B. (2024). *Triangulasi Metode Penelitian Kualitatif*. Borneo Novelty Publishing.

Arneson, J. B., & Offerdahl, E. G. (2018). Visual Literacy in Bloom: Using Bloom's Taxonomy to Support Visual Learning Skills. *CBE—Life Sciences Education*, *17*(1), ar7. https://doi.org/10.1187/cbe.17-08-0178

Aryanto, C. B. (2021). Do You Remember The Words? Dual-Coding Method on Long-Term Memory. *Jurnal Psikologi*, *19*(4), 314–322. https://doi.org/10.14710/jp.19.4.314-322

As Sa'adah, S., Wakhidah, N., Fajar Arum, W., Hidayati, S., & Indayati, T. (2025). Analisis Tingkat Pemahaman Konsep Siswa Pada Pembelajaran IPA. *Jurnal Edu-Sains*, *14*(1), 7–15. https://doi.org/10.22437/jmpmipa.v14i1.39419

Bistari, B. (2024). Mathematical Resilience and Bis-VOLKS Misconceptions in School Mathematics Learning. *JPMI (Jurnal Pendidikan Matematika Indonesia)*, *9*(1), 69. https://doi.org/10.26737/jpmi.v9i1.5453

Chanifah, F. (2021). *Pengaruh E-Modul Berbasis Problem Based Learning Terhadap Kemampuan Literasi Sains Siswa pada Materi Pemanasan Global* [Skripsi]. UIN Syarif Hidayatullah.

Dwi Cahya, A., Amanta Rahmadani, D., Wijiningrum, A., & Fajar Swasti, F. (2021). Analisis Pelatihan dan Pengembangan Sumber Daya Manusia. *YUME: Journal of Management*, *4*(2). https://doi.org/DOI: 10.37531/yume.vxix.861

Fadillah Indriyani, Z. (2024). *Analisis Kemampuan Literasi Visual Peserta Didik pada Konsep Sistem Saraf di SMAN Kabupaten Bogor* [Skripsi]. UIN Syarif Hidayatullah.

Firahma Tillah, N., & Subekti, H. (2025). Analisis Kemampuan Literasi Sains Siswa SMP Berdasarkan Indikator dan Level Literasi Sains. *Edusaintek: Jurnal Pendidikan, Sains Dan Teknologi*, *12*(1). https://doi.org/10.47668/edusaintek.v12i1.1271

Gkintoni, E., Antonopoulou, H., Sortwell, A., & Halkiopoulos, C. (2025). Challenging Cognitive Load Theory: The Role of Educational Neuroscience and Artificial Intelligence in Redefining Learning Efficacy. *Brain Sciences*, *15*(2), 203. https://doi.org/10.3390/brainsci15020203

Guerra-Reyes, F., Guerra-Davila, E., Naranjo-Toro, M., Basantes-Andrade, A., & Guevara-Betancourt, S. (2024). Misconceptions in the Learning of Natural Sciences: A Systematic Review. *Multidisciplinary Digital Publishing Institute (MDPI)*, *14*(5). https://doi.org/10.3390/educsci14050497

Hamidah, I., Ratnasari, A., & Suparjo, J. (2022). Analisis Kategori Literasi Sains pada Bahan Ajar Ilmu Pengetahuan Alam SMP/MTs Kelas VII Kurikulum 2013. *KULIDAWA*, *2*(2), 52. https://doi.org/10.31332/kd.v2i2.3094

Haryadi, R., & Oktarisa, Y. (2025). Modif (Modul Digital Flipbook) Berbasis Multi Representasi untuk Meningkatkan Literasi Sains pada Materi Gerak Lurus. *Jurnal Pena Edukasi*, *12*(1).

Hidayah, N., Yulianti, S., Puspita, L., & Haka, N. B. (2022). Analisis Kemampuan Representasi Visual Melalui Model Pembelajaran TPS. *Jurnal Ilmiah Pendidikan Biologi*, *08*(03).

Ilahy, W. Q., Subali, B., & Widiarti, N. (2025). Kajian Literatur Tren Penelitian Pengembangan Media Pembelajaran Interaktif Berbantuan Canva pada Rentang Tahun 2020-2025. *Jurnal Ilmiah Pendidikan Dasar*, *10*(1).

Imaduddin, M., & Eilks, I. (2024). A scoping review and bibliometric analysis of educational research on water literacy and water education. *Sustainable Chemistry and Pharmacy*, *42*, 101833. https://doi.org/10.1016/j.scp.2024.101833

Khine, M., & Yang, L. (2017). Descriptive Analysis of the Graphic Representations of Science Textbooks. *European Journal of STEM Education*, *2*(3). https://doi.org/10.20897/ejsteme/81285

Kontogeorgis, G. M., Holster, A., Kottaki, N., Tsochantaris, E., Topsøe, F., Poulsen, J., Bache, M., Liang, X., Blom, N. S., & Kronholm, J. (2022). Water structure, properties and some applications – A review. *Chemical Thermodynamics and Thermal Analysis*, *6*, 100053. https://doi.org/10.1016/j.ctta.2022.100053

Lungu, M. (2022). The Coding Manual for Qualitative Researchers. *American Journal of Qualitative Research*, *6*(1), 232–237. https://doi.org/10.29333/ajqr/12085

Martínez-Borreguero, G., Maestre-Jiménez, J., Mateos-Núñez, M., & Luis Naranjo-Correa, F. (2020). Water from the Perspective of Education for Sustainable Development: An Exploratory Study in the Spanish Secondary Education Curriculum. *Multidisciplinary Digital Publishing Institute (MDPI)*, *12*(7). https://doi.org/10.3390/w12071877

Menhard, M. (2024). Dampak Virtual Reality Terhadap Keterlibatan Mahasiswa dan Hasil Belajar di Perguruan Tinggi. *Jurnal Cahaya Mandalika (JCM)*, *5*(2). https://www.ojs.cahayamandalika.com/index.php/jcm/article/view/3072

Miles, M. B., Huberman, A. M., & Saldaña, J. (2014). *Qualitative data analysis: A methods sourcebook* (Edition 3). Sage.

Miller, E. M. (2021). The Impact of Visual Literacy in Secondary Science Education. *Spark Repository*.

Mulyana, A., Vidiati, C., Agung Danahramanto, P., Agussalim, A., Apriani, W., Fiansi, F., Fitra, F., Ari Aryawati, N. P., Adi Noer Ridha, N., Astria Milasari, L., Fernando Siagian, A., & Margareta Martono, S. (2024). *Metode Penelitian Kualitatif*. Widina Media Utama.

Naqiya Rabbani, I., Aditya, N., Salsabila, N., Lunaadhara Isri, T., & Dwi Farisandy, E. (2023). Pengaruh Metode Dual-Coding Terhadap Long-Term Memory Mahasiswa. *Jurnal Psikologi Universitas Muhammadiyah Lampung*, *5*(1).

Nurafina, E., Roshayanti, F., & Anas Dzakiy, M. (2024). Nature of Model pada Buku Ajar IPA sebagai Terjemahan Representasi Eksplanasi Ilmiah Menjadi Eksplanasi Pedagogi. *Jurnal Inovasi Pembelajaran BIologi*, *5*(1). https://journal.unesa.ac.id/index.php/jipb

OECD. (2023). *PISA 2022 Results (Volume I): The State of Learning and Equity in Education*. OECD Publishing. https://doi.org/10.1787/53f23881-en

Panjaitan, L. A. (2019). *Pengembangan Literasi Sains di Sekolah*. GUEPEDIA. https://books.google.co.id/books?id=dHn8DwAAQBAJ

Parra-López, C., Ben Abdallah, S., Garcia-Garcia, G., Hassoun, A., Trollman, H., Jagtap, S., Gupta, S., Aït-Kaddour, A., Makmuang, S., & Carmona-Torres, C. (2025). Digital technologies for water use and management in agriculture: Recent applications and future outlook. *Agricultural Water Management*, *309*, 109347. https://doi.org/10.1016/j.agwat.2025.109347

Putri, A. D., & Kurniawati, W. (2025). Analisis Miskonsepsi Melalui Tes Diagnostik Two-Tier Pada Materi Tumbuhan Kelas IV SD. *Borobudur Educational Review*, *05*(01). https://doi.org/DOI: https://doi.org/10.31603/bedr.13318

Rahman, P., & Mehnaz, S. (2025). The Implementation of Spiral Progression Approach in Mathematics Education in the Second District of Ilocos Sur. *SSRN Electronic Journal*, *7*(2). https://doi.org/10.2139/ssrn.5054029

Romulo, C., Venkataraman, B., Caplow, S., Ajgaonkar, S., Allen, C. R., Anandhi, A., Anderson, S. W., Azzarello, C. B., Brundiers, K., Blavascunas, E., Dauer, J. M., Druckenbrod, D. L., Fairchild, E., Horne, L. R., Lee, K., Mwale, M., Mischler, J., Pappo, E., Patel, N. S., … Vincent, S. G. (2024). Implementing interdisciplinary sustainability education with the food-energy-water (FEW) nexus. *Humanities and Social Sciences Communications*, *11*(1), 928. https://doi.org/10.1057/s41599-024-03332-7

Safitri, A., Wulandari, D., & Herlambang, Y. T. (2022). Proyek Penguatan Profil Pelajar Pancasila: Sebuah Orientasi Baru Pendidikan dalam Meningkatkan Karakter Siswa Indonesia. *Jurnal Basicedu*, *6*(4), 7076–7086. https://doi.org/10.31004/basicedu.v6i4.3274

Sihombing, R. A., Muslim, M., Rahman, T., & Karimi, A. (2024). Literature Study Of The E-Book Based On Education For Sustainable Development (ESD) As The Main Solution To Improving Sustainability Awareness. *INSECTA: Integrative Science Education and Teaching Activity Journal*, *5*(1), 108–120. https://doi.org/10.21154/insecta.v5i1.8616

Singh, B. J., Chakraborty, A., & Sehgal, R. (2023). A systematic review of industrial wastewater management: Evaluating challenges and enablers. *Journal of Environmental Management*, *348*, 119230. https://doi.org/10.1016/j.jenvman.2023.119230

Sulistiyo, U. (2019). *Buku Ajar Metode Penelitian Kualitatif*. PT. Salim Media Indonesia.

Syahwati, F., & Arif, S. (2022). Analysis Of The Effect Of Scientific Literacy And Questioning Ability On Science Learning Outcomes. *INSECTA: Integrative Science Education and Teaching Activity Journal*, *3*(2), 150–157. https://doi.org/10.21154/insecta.v3i2.5127

Thomas, M. (2025). *PISA 2025 SCIENCE FRAMEWORK (DRAFT)*.

Utamy, V. G., & Rosdiana, L. (2023). Analysis Of Students' Misconception Profile On Human Respiratory System Material Using Four-Tier Diagnostic Test. *INSECTA: Integrative Science Education and Teaching Activity Journal*, *4*(2), 124–137. https://doi.org/10.21154/insecta.v4i2.6929

Waruwu, M. (2024). Pendekatan Penelitian Kualitatif: Konsep, Prosedur, Kelebihan dan Peran di Bidang Pendidikan. *Afeksi: Jurnal Penelitian dan Evaluasi Pendidikan*, *5*(2), 198–211. https://doi.org/10.59698/afeksi.v5i2.236

Windiyani, T., Setiawan, B., Sofyan, D., A. Gani, R., & Iasha, V. (2025). *Kurikulum CRT Berbasis ESD Teori dan Implementasinya di Sekolah Dasar*. PT. Pena Persada Kerta Utama.

Yunita, L., & Mandasari, N. (2025). Pendidikan Sains Berorientasi Keterampilan Abad 21 dalam Konteks Pendidikan Tinggi: Review. *Panthera : Jurnal Ilmiah Pendidikan Sains dan Terapan*, *5*(1), 40–49. https://doi.org/10.36312/panthera.v5i1.334