FROM AWARENESS TO ACTION: A SYSTEMATIC LITERATURE REVIEW OF TEACHING MATERIALS BASED ON EDUCATION FOR SUSTAINABLE DEVELOPMENT (ESD)

Rizky Agassy Sihombing[1*], Muslim[2], Taufik Rahman[3]

[1]Master Program on Science Education, Faculty of Mathematics and Science Education, Universitas Pendidikan Indonesia

[2]Department of Physics Education, Faculty of Mathematics and Science Education, Universitas Pendidikan Indonesia

[3]Department of Biology Education, Faculty of Mathematics and Science Education, Universitas Pendidikan Indonesia

Corresponding author's email : rizkyagassy@upi.edu

Abstract

Education for Sustainable Development (ESD) is crucial for equipping learners with the skills and knowledge needed to address global sustainability challenges. This research employs a Systematic Literature Review (SLR) methodology to evaluate the effectiveness of ESD-based teaching materials across various educational levels. Utilizing databases such as Google Scholar, SINTA, and Scopus, the study reviews articles focusing on the integration of ESD in formal education. The findings indicate that ESD-based materials significantly enhance students' critical thinking skills, sustainability awareness, and problem-solving abilities. These materials are deemed valid and practical by both experts and students, and they effectively facilitate the understanding and application of scientific principles to real-world problems. The study underscores the importance of incorporating ESD into educational curricula to foster a generation equipped to tackle environmental and societal challenges. Additionally, the use of digital tools and e-platforms proves effective in promoting sustainability education. Overall, the integration of ESD in education is vital for promoting sustainable development and improving the quality of education across primary, secondary, and higher education levels, particularly in disaster-prone regions like Indonesia.

INTRODUCTION

Education plays a pivotal role in advancing the success of Industry 5.0. There are several ways to provide education, including formal, non-formal, and informal learning (Al-Emran & Al-Sharafi, 2022; Khairunisa & Sundawa, 2023). Formal learning takes place through structured programs in educational institutions, adult training centers, or workplaces and typically results in recognized qualifications or certificates. In contrast, non-formal learning includes educational activities that are not formally assessed and do not lead to certification (Jain, 2022). Informal learning occurs in everyday activities related to work, family, or leisure, without a formal structure.

Education has undergone numerous innovations and developments over time, adapting to the demands and needs of the era. These innovations include the adoption of new pedagogical theories, improved approaches, innovative teaching methods, effective teaching techniques, advanced learning aids, changes in learning processes, and even changes in institutional structures. Implementing these innovations has significantly transformed teaching and learning activities, positively impacting student learning.

One of the subjects taught in formal education is natural sciences. Natural sciences promote an interactive learning process, focusing on understanding concepts rather than mere memorization. This field encompasses extensive knowledge derived from observations and investigations, explaining the details, causes, and mechanisms behind various phenomena (Manurung et al., 2021; Panggabean et al., 2023). Integrating comprehensive science education aligns with the United Nations' Sustainable Development Goal (SDG) 4, which aims to ensure inclusive and quality education for all, fostering a deeper understanding of scientific principles crucial for sustainable development across diverse communities. Additionally, a solid understanding of science contributes to other SDGs, such as SDG 3 (Good Health and Well-being), SDG 6 (Clean Water and Sanitation), and SDG 7 (Affordable and Clean Energy), highlighting its extensive role in addressing global challenges and promoting sustainable practices (Maryanti et al., 2022; Ramadhan, 2023).

The Sustainable Development Goals (SDGs) also include climate change in their agenda. Sustainable Development is defined as development that meets current needs without compromising the

ability of future generations to meet their own needs (UNESCO, 2017). The concept of sustainability involves balancing social, economic, and environmental dimensions, maintaining equilibrium in life amid natural limitations (Novidsa et al., 2020). Integrating SDGs into education creates the concept of Education for Sustainable Development, aiming to develop individuals' competencies to reflect on their actions considering social, cultural, economic, and environmental impacts from both local and global perspectives (UNESCO, 2017).

Sustainable education emphasizes the ability of individuals or groups to consider natural and social dimensions in social, economic, and political decision-making processes, ensuring that current needs are met without compromising future needs (Ermenc & Niemczyk, 2022). Individuals should be empowered to act sustainably in complex situations, which may require them to take new directions, and to participate in socio-political processes, driving their communities toward sustainable development.

People who feel strongly about the environment often show their concern through active participation in protecting and preserving it. Currently, human activities have caused significant environmental degradation, including increased waste production, air pollution, deforestation, and related issues like more frequent environmental incidents (Septian et al., 2016). An effective approach to improving environmental conditions involves embedding sustainability awareness deeply within educational frameworks. This strategy aims to foster a broader understanding and commitment to sustainable behaviors among students and society at large.

Educators' capacity to enhance student engagement while minimizing disruptions is crucial for establishing a secure and effective learning environment (Octavia et al., 2022). The creativity of teachers significantly contributes to achieving educational objectives (Sihombing et al., 2022; Simatupang et al., 2023). Employing suitable teaching tools is a practical approach for educators to elucidate intricate scientific concepts (Sihombing et al., 2023). Integrating technological resources in education, particularly through e-books, has proven effective in improving students' comprehension of subjects (Haleem et al., 2022). E-books represent a digital evolution of traditional books accessible on various devices, offering students convenient access to information (Santoso et al., 2018). They enable direct reading on screens, replacing paper and offering features like search functions, page navigation, bookmarks, and annotation tools (Sihombing & Hasruddin, 2024). Leveraging information and communication technology (ICT) in educational innovation involves developing novel teaching materials that incorporate the Sustainable Development Goals (SDGs) (Sihombing et al., 2023).

The education system has undergone significant changes since the COVID-19 pandemic, one of which is the increased use of technology to support education, developed by technology experts. Technology has helped overcome the limitations of implementing learning during the pandemic. Even now, technological advancements continue to support ESD-based learning. Post-COVID-19, the Indonesian government is striving to implement policies that ensure the success of quality education in the country. Not only the government but also teachers, lecturers, and researchers are contributing to achieving the SDGs, particularly in education. Teachers transfer knowledge directly to students and implement ESD-based learning in practice. Lecturers and researchers continue to develop, research, study, and evaluate the implementation of ESD, particularly in higher education institutions. This study aims to examine research in Indonesia on the theme of Education for Sustainable Development (ESD) across various educational levels. In light of these concerns, a systematic literature review was undertaken to investigate appropriate educational tools that could effectively raise the sustainability among junior high school students.

RESEARCH METHODS

The research employs a Systematic Literature Review (SLR) methodology, which is designed to gather, synthesize, and evaluate pertinent evidence from various published sources (Mengist et al., 2020). SLR involves sourcing data from various databases that are chosen based on specific research questions and keywords. As a form of secondary study, a systematic review can be instrumental in preparing research to address formulated problems through several specific questions (Huang, 2019). The SLR strategy implemented in this study adheres to the guidelines for conducting systematic literature reviews in the context of software (Dos Santos, 2018). The SLR framework comprises three key stages: Planning the Review, Briefing the Review, and Reporting the Review (Dos Santos, 2018), as illustrated in Figure 1.
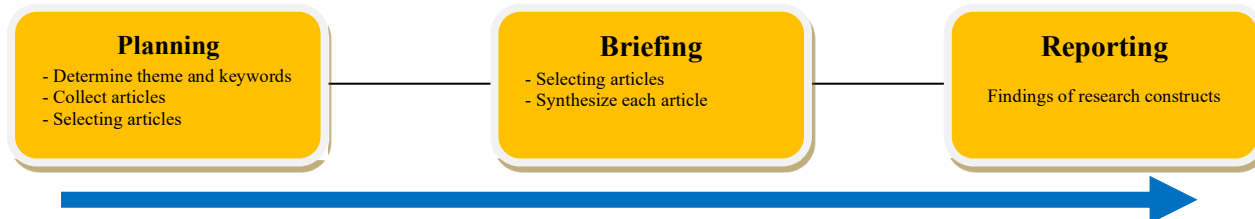
Figure 1. Steps of SLR

Phase I: Planning the Review

In the planning review phase, several activities are carried out, including identifying need factors, formulating research questions, and devising search strategies. This phase also involves developing reviews of protocols used and reviewing the methodology for the discussion of the article (Dos Santos, 2018). The initial research strategy, an initial mapping study, helps determine the strategy's accuracy. The systematic literature review (SLR) is based on previous research reviews, aiming to identify relevant literature for SLR research questions. The strategy identifies key studies, including key search terms and resources used. The approach to identifying terms involves breaking down the question items into parts, listing synonyms, abbreviations, and alternative spellings, and considering the subject headings used in databases and journal sources. Resources for the search include electronic search engines, journals, conference proceedings, digital libraries, and literature (Dos Santos, 2018).

Phase II: Briefing the Review

The briefing review phase includes several key activities: developing search strategies for data sources, selecting literature studies, assessing study quality, extracting and monitoring data, and synthesizing data (Dos Santos, 2018). This study utilizes the SLR method to evaluate all research related to the predetermined research questions established during the planning stage. The following subsections will provide a more detailed explanation of this briefing review.

Database source

Five database sources were utilized to identify literature consistent with the research questions: Google Scholar, SINTA, and Scopus. These databases were chosen as the main reference sources due to their credibility and comprehensive repositories. These primary sources were used to search for published journals and each assigned a code from J1 to J10.

Selection criteria (Inclusive & Exclusive Criteria)

The selection of pertinent literature is structured based on inclusion and exclusion criteria related to teaching materials, Education for Sustainable Development (ESD), and their respective categories. Various search methods are employed to address the previously identified research questions. This study identified several keywords, including 'Teaching Materials based on ESD,' 'ESD in Learning,' and 'ESD Implementation.'

Assessment Quality

The quality assessment is considered a crucial step in evaluating the quality of the selected literature. Quality assessment includes question items aimed at evaluating the extent of bias in the articles as well as internal and external factors of validity (Dos Santos, 2018). The articles used for the SLR research are presented in Table 1.

Table 1. The articles utilized for the SLR research

Code	Author	Journal	Ranking	Title
J1	(Badiah et al., 2024)	Edufisika: Jurnal Pendidikan Fisika	SINTA 5	Development of Integrated Education for Sustainable Development Digital Teaching Materials on Renewable Energy to Facilitate Students' Critical Thinking Abilities
J2	(Setyowati et al., 2022)	Jurnal IPA dan Pembelajaran IPA	SINTA 3	The Development of Science Teaching Materials Based on the PjBL-STEM Model and ESD Approach on Environmental Pollution Materials
J3	(Insani et al., 2023)	Pendas : Jurnal Ilmiah Pendidikan Dasar	SINTA 4	Interactive E-Module Learning Tools Based on Education for Sustainable Development on the Topic of Herbal Plant Conservation in Elementary Schools
J4	(Putri et al., 2024)	Jurnal Pendidikan Sains Indonesia (Indonesian	SINTA 2	Developing Global Warming Module Based on Education for Sustainable Development to

Code	Author	Journal	Ranking	Title
		Journal of Science Education)		Increase Middle School Students' Understanding and Sustainability Awareness
J5	(Aji et al., 2022)	Qalamuna - Jurnal Pendidikan, Sosial, dan Agama	SINTA 2	Development of E-Module Flipbook on Science Learning to Support Sustainable Development Goals (SDGs) For Elementary School Students
J6	(Budiati et al., 2022)	Jurnal Pendidikan MIPA	SINTA 2	Teaching Students about Education for Sustainable Development through E-module of Indonesian Traditional Fermented Food
J7	(Chin et al., 2019)	EURASIA Journal of Mathematics, Science and Technology Education	Q2	Promoting Education for Sustainable Development in Teacher Education integrating Blended Learning and Digital Tools: An Evaluation with Exemplary Cases
J8	(Widodo et al., 2023)	BIOSFER: Jurnal Tadris Biologi	SINTA 3	Development of Integrated Interactive Modules Education for Sustainable Development (ESD) Global Warming Material Junior High School Muhammadiyah Pekanbaru
J9	(Pradipta et al., 2021)	IJORER : International Journal of Recent Educational Research	SINTA 3	The Effectiveness of Science Learning Tools Based on Education Sustainable Development (ESD) to Improve Problem-Solving Skills
J10	(Hanifah et al., 2024)	INKUIRI: Jurnal Pendidikan IPA	SINTA 4	Development of E-Encyclopedia Based on Education for Sustainable Development on the Topic of Interaction between Living Organisms and Their Environment for Grade VII

Phase III: Reporting Review

The 'Reporting' phase is a phase in which there are findings of research constructs that are reported systematically, as the results of the reporting study

RESULTS AND DISCUSSION

This study employs a literature review methodology focusing on keywords such as ESD (Education for Sustainable Development) and Teaching Materials based on ESD. The key phases include planning, briefing, and reporting. Google Scholar, SINTA, and Scopus are utilized as databases to gather relevant articles. Selected articles undergo review based on participant characteristics, sample size, research methodologies, data collection methods, and research findings. The outcomes of this review are presented in Table 2.

Table 2. Article Analysis Results

Code	Education	Samples	Method	Data Collection	Finding
J1	Senior high school	27	Research and Development (R&D)	Validation instrument	Content expert validation, media expert validation, and student acceptance of the teaching materials were rated as highly suitable.
J2	Junior high school	Not mentioned	Research and Development (R&D)	Validation instrument	Based on validation results, the critical thinking skills assessment was deemed very feasible, and the sustainability consciousness assessment was also found to be highly feasible. The research findings indicate that the developed teaching materials are valid and suitable for use.
J3	Elementary school	20	Research and Development (R&D)	Literature study, observation, interviews, and validation instrument	The e-modules were assessed as highly feasible by experts in material and learning media, with positive student feedback supporting their suitability for educational use. Thus, these ESD-based interactive e-modules are recommended as effective educational tools.
J4	Junior high school	304	Research and Development	Observation, interviews, and	The validation tests confirmed high validity for both media and

Code	Education	Samples	Method	Data Collection	Finding
			(R&D)	validation instrument	materials. While the control group showed low N-gain results, the experimental group had moderate results. Effect size tests indicated high criteria for both groups in the post-test. Overall, the study suggests that the developed modules effectively enhance students' understanding and awareness of sustainability.
J5	Elementary school	10	Research and Development (R&D)	Interview and validation instrument	Material experts rated the e-module highly suitable, while linguistic assessment found it very adequate. Media evaluation categorized the science e-module as very feasible. Teachers rated its practicality, and students found it very practical after testing.
J6	Junior high school	4	Research and Development (R&D)	Interview and validation instrument	The data analysis shows that the ESD e-module's mapping and media validation received positive ratings, with experts providing actionable suggestions for improvement. Consequently, the e-module is deemed suitable for implementation at various scales.
J7	Elementary school	Not mentioned	Qualitative	Observations, interviews, documentary analysis, and survey instrument	The utilization of e-platforms and digital tools has proven effective in facilitating the sharing, exchange, and dissemination of information both before, during, and after events.
J8	Junior high school	35	Research and Development (R&D)	Interview and validation instrument	The interactive modules were found feasible and very practical based on expert validations and user feedback, indicating high effectiveness and engagement.
J9	Junior high school	16	Research and Development (R&D)	Validation instrument and tests	Students improved problem-solving skills using ESD-based learning, applying fluid pressure principles (Archimedes' Law and Bernoulli's Law) to address the Lapindo mud phenomenon ecologically, economically, and socially within the community.
J10	Junior high school	30	Research and Development (R&D)	Validation and readability instrument	The developed e-encyclopedia received an overall feasibility validation score categorized as very feasible. Specifically, the content aspect, presentation and graphics, and language clarity were highly rated. The readability test also resulted in an excellent score.

Based on Table 2, the participants in the research on teaching materials based on Education for Sustainable Development (ESD) are varied, encompassing senior high school students, junior high school students, and elementary school students. The sample sizes in these studies range from 4 to 304 participants. The research methods utilized include Research and Development (R&D), qualitative approaches, and mixed methods. Data collection techniques are adapted to the research method employed and encompass a wide array of tools such as interviews, observations, questionnaires, validation instruments, documentary analysis, pre-test and post-test assessments, and readability tests.

The findings from these studies indicate that the teaching materials based on ESD received high ratings in terms of content and media feasibility. They were shown to significantly improve students' critical

thinking skills and raise their awareness about sustainability issues. Moreover, these materials enhanced students' problem-solving abilities by allowing them to apply scientific principles to real-world problems effectively. The research also underscored the practicality and suitability of these teaching materials, as validated by both experts and students. Additionally, the use of e-platforms and digital tools proved to be effective in facilitating the sharing, exchange, and dissemination of information before, during, and after educational events.

Overall, the studies demonstrate that ESD-based teaching materials are not only valid and practical but also highly effective educational tools. They are beneficial across various educational levels and contexts, supporting a diverse range of students in enhancing their understanding of sustainability and applying their knowledge to solve real-life problems. The integration of these materials into educational curricula can thus play a crucial role in promoting sustainable development education and fostering a generation of learners equipped to address environmental and societal challenges.

Education for Sustainable Development (ESD) needs to be taught to students in schools. ESD can be integrated into the curriculum through various means, including teaching media, learning materials, learning models, learning approaches, and projects. Using ESD-based teaching materials particularly those focused on can enhance students' scientific literacy and sustainability awareness (Sihombing et al., 2024) and environmental literacy (Wilujeng et al., 2019). However, research by Ekamilasari et al. (2021) indicates that ESD only marginally improves students' critical thinking skills, placing them in the low category. In contrast, the study by Annisa et al. (2024) found that ESD-based worksheets can significantly enhance students' critical thinking abilities and sustainability awareness.

ESD skills greatly improve the quality of education in primary, secondary, and high schools (Mogren et al., 2019; Abera, 2023; Aslam et al., 2024). Incorporating sustainable content into the curriculum and using ESD pedagogy enhances teaching and learning by developing skills, perspectives, and values necessary for sustainable societies. This approach enhances conceptual understanding and problem-solving abilities related to environmental issues through science education. To optimize the ESD program, it is crucial to develop ESD content knowledge, which is considered essential in practice (Hudson, 2014; Su et al., 2023) and should be prioritized in education to meet the needs of sustainable professional development (Ling, 2016; Boeve-de Pauw et al., 2022). Although UNESCO introduced ESD in 2005, its integration into science education programs in higher education has not been adequately addressed (Filho, 2018). Implementing ESD in Indonesian education is particularly important due to the country's vulnerability to natural disasters caused by geological and geographical factors. ESD is expected to strengthen community resilience in adapting to geographical changes.

CONCLUSION AND SUGGESTION

A. Conclusion

This study provides a comprehensive analysis of the utilization of systematic literature review (SLR) methodology to evaluate research on Education for Sustainable Development (ESD) and its integration into teaching materials. The findings reveal that ESD-based teaching materials significantly enhance students' critical thinking, problem-solving skills, and sustainability awareness across various educational levels. The use of digital tools and e-platforms further supports the effective dissemination and engagement with these materials. The integration of ESD into the curriculum through various teaching materials and methods is essential for promoting sustainable development education. The findings underscore the need for a robust ESD framework in educational curricula to equip students with the necessary skills to address environmental and societal challenges.

B. Suggestion

To enhance the effectiveness of ESD-based teaching materials, future studies should cover diverse educational levels and contexts. Incorporating interactive digital tools can engage students better. Investing in educators' professional development and integrating ESD into national curricula, especially in vulnerable regions, will build resilience and awareness. Longitudinal studies can assess long-term impacts, and collaboration between institutions, policymakers, and researchers is essential for developing comprehensive ESD frameworks. Implementing these suggestions will improve ESD materials, fostering a generation ready to address sustainable development challenges.

REFERENCES

Abera, H. G. (2023). The Role of Education in Achieving the Sustainable Development Goals (SDGs): A Global Evidence Based Research Article. *International Journal of Social Science and Education Research Studies*, *03*(01), 67–81. https://doi.org/10.55677/ijssers/v03i1y2023-09

Aji, S. D., Yasa, A. D., Dewi, P. K., Kumala, F. N., & Putri, A. N. (2022). Development of E-Module Flipbook on Science Learning to Support Sustainable Development Goals (SDGs) for Elementary School Students. *QALAMUNA: Jurnal Pendidikan, Sosial, Dan Agama*, *14*(2), 895–906. https://doi.org/10.37680/qalamuna.v14i2.3705

Al-Emran, M., & Al-Sharafi, M. A. (2022). Revolutionizing education with Industry 5.0: Challenges and future research agendas. *International Journal of Information Technology and Language Studies (IJITLS)*, 6(3), 1-5.

Annisa, D. P., Kaniawati, I., Eliyawati, E., Program, S. E., Mathematics, F., Education, N. S., & Indonesia, U. P. (2024). *STEM ESD-Based Learning with " Arduino Uno-Based Trash Can " to Improve Students ' Critical Thinking Skills and Sustainable Awareness in Learning Environmental Pollution*. *10*(1), 115–145. https://doi.org/10.30870/jppi.v10i1.24008

Aslam, D. F., Khoiri, N., Saefan, J., & Saptaningrum, E. (2024). *Improving the Attitudes and Creative Thinking Skills of Senior High School Students Using an ESD-Enhanced STEM Approach*. https://doi.org/10.20527/bipf.v12i2.18510

Badiah, S., Saefullah, A., & Antarnusa, G. (2024). Development of Integrated Education for Sustainable Development Digital Teaching Materials on Renewable Energy To Facilitate Students' Critical Thinking Abilities. *EduFisika: Jurnal Pendidikan Fisika*, *9*(1), 63–73. https://doi.org/10.59052/edufisika.v9i1.32225

Boeve-de Pauw, J., Olsson, D., Berglund, T., & Gericke, N. (2022). Teachers' ESD self-efficacy and practices: a longitudinal study on the impact of teacher professional development. *Environmental Education Research*, *28*(6), 867–885. https://doi.org/10.1080/13504622.2022.2042206

Budiarti, A. N. S. L., Hernani, H., & Amprasto, A. (2022). Teaching Students about Education for Sustainable Development through E-module of Indonesian Traditional Fermented Food. *Jurnal Pendidikan MIPA*, *23*(2), 540–553. https://doi.org/10.23960/jpmipa/v23i2.pp540-553

Chin, C. K., Munip, H., Miyadera, R., Thoe, N. K., Ch'ng, Y. S., & Promsing, N. (2019). Promoting Education for Sustainable Development in teacher education integrating blended learning and digital tools: An evaluation with exemplary cases. *Eurasia Journal of Mathematics, Science and Technology Education*, *15*(1), 1–17. https://doi.org/10.29333/ejmste/99513

Dos Santos, O. W., Bittencourt, I. I., Isotani, S., Dermeval, D., Brandão Marques, L., & Frango Silveira, I. (2018). Flow Theory to Promote Learning in Educational Systems: Is it Really Relevant? *Revista Brasileira de Informática Na Educação*, *26*(02), 29. https://doi.org/10.5753/rbie.2018.26.02.29

Ekamilasari, E., Permanasari, A., & Pursitasari, I. D. (2021). Critical thinking skills and sustainability awareness for the implementation of education for sustainable development. *Journal of Science Education Research*, *5*(1), 46-53. https://doi.org/10.21831/jser.v5i1.41753

Ermenc, K. S., & Niemczyk, E. K. (2022). Education for Sustainable Development. *Sodobna Pedagogika/Journal of Contemporary Educational Studies*, *73*(2), 146–149. https://doi.org/10.21300/21.4.2020.2

Febrizal, F., Hernani, H., & Mudzakir, A. (2023). Systematic Literature Review: Peran Pembelajaran Kimia Terhadap Keberlanjutan Dalam Konteks Education for Sustainable Development (Esd). *Quantum: Jurnal Inovasi Pendidikan Sains*, *14*(2), 238. https://doi.org/10.20527/quantum.v14i2.15963

Haleem, A., Javaid, M., Qadri, M. A., & Suman, R. (2022). Understanding the role of digital technologies in education: A review. *Sustainable Operations and Computers,* *3*(1), 275-285. https://doi.org/10.1016/j.susoc.2022.05.004

Hanifah, A. N., & Purnamasari, S. (2024). *Pengembangan E-Ensiklopedia Berbasis Education for Sustainable Development Pada Materi Interaksi Makhluk Hidup dengan Lingkungannya Kelas VII*. *13*(1), 99–105. https://doi.org/10.20961/inkuiri.v13i1.79495

Huang, S. Y., Chiu, A. A., & Chao, P. C. (2019). Critical success factors in implementing enterprise resource planning systems for sustainable corporations. *Sustainability,* *11*(6785). https://doi.org/10.3390/su11236785

Hudson P. (2016). Understanding preservice teachers' development of pedagogical knowledge practices when co-teaching primary science to peers. *Journal of Science and Mathematics in Southeast Asia*, *37*(1), 44-66.

Insani, A. M., Hamdu, G., Putri, A. R., Universitas, P., & Indonesia, P. (2023). 3 1,2,3. *Jurnal Ilmiah Pendidikan Dasar*, *08*(September), 5476–5490.

Jain, J. (2022). *Non-formal and informal learning: A global perspective*. Delhi: Vidya Books.

Khairunisa, W., & Sundawa, D. (2023). The urgency of digital literacy in developing character education for youth in Society 5.0. In *Proceedings International Seminar Tulungagung University*, 125-143.

Lim, C. K., Haufiku, M. S., Tan, K. L., Farid Ahmed, M., & Ng, T. F. (2022). Systematic Review of Education Sustainable Development in Higher Education Institutions. *Sustainability (Switzerland)*, *14*(20), 1–22. https://doi.org/10.3390/su142013241

Ling, H. P. (2016). Science teaching experiences in informal settings: one way to enrich the preparation program for preservice science teachers. *Universal Journal of Educational Research*, *4*(5), 1214-1222. https://dx.doi.org/10.13189/ujer.2016.040535.

Manurung, G. A., Simanjuntak, L.A., & Sihombing, R. A. (2021). Misconceptions on The Concept of Photosythesis and Plant Respiration for Class VIII at SMP Negeri 27 Medan in Science Learning. *Indonesian Science Education Research (ISER)*, *3*(2), 12-19.

Mardian, V. (2023). How Is Esd (Education For Sustainable Development) Implemented After Covid-19 In Indonesia To Realize Sdg's? *Physics and Science Education Journal (PSEJ)*, *3*, 126–133. https://doi.org/10.30631/psej.v3i3.2116

Maryanti, R., Rahayu, N. I., Muktiarni, M., Al Husaeni, D. F., Hufad, A., Sunardi, S., & Nandiyanto, A. B. D. (2022). Sustainable Development Goals (SDGs) in science education: Definition, literature review, and bibliometric analysis. *Journal of Engineering Science and Technology, Special Issue on ICMScE2022*, 161-181.

Mengist, W., Soromessa, T., & Legese, G. (2019). Method for conducting systematic literature review and meta-analysis for environmental science research. *MethodsX, 7*, 100777. https://doi.org/10.1016/j.mex.2019.100777

Mogren, A., Gericke, N., & Scherp, H. A. (2018). Whole school approaches to education for sustainable development: a model that links to school improvement. *Environmental Education Research, 24*(4), 508-531. https://doi.org/10.1080/13504622.2018.1455074

Novidsa, I., Purwianingsih, W., & Riandi. (2020). Exploring knowledge of prospective biology teacher about Education for Sustainable Development (ESD). *JPBI (Jurnal Pendidikan Biologi Indonesia)*, *6*(2), 317-326. https://doi.org/10.22219/jpbi.v6i2.12212

Octavia, S. C., Sihombing, R.A., Destine, K. T., & Hutagalung, J. F. (2022). Analysis of Obstacles on Limited Face-To-Face Learning During the Covid-19 Pandemic Junior High School in Medan. *Tarbiyah: Jurnal Ilmiah Kependidikan*, *11*(1), 18-28.

Panggabean, F. T. M., Simanjuntak, L. A., Sihombing, R. A., Octavia, S. C., Tambunan, J. B. (2023). Analysis of 7th-Grade Students' Misconceptions of Acid-Base. *J-PEK (Jurnal Pembelajaran Kimia)*, *8*(1), 1-7.

Pradipta, D. D., Madlazim., & Hariyono, E. (2021). The Effectiveness of Science Learning Tools Based on Education Sustainable Development (ESD) to Improve Problem-Solving Skills. *IJORER : International Journal of Recent Educational Research*, *2*(3), 342–353. https://doi.org/10.46245/ijorer.v2i3.113

Putri, S. T., Fardhani, I., Mulyati, Y., Kurniawan, B. R., & Putri, A. A. (2024). Developing Global Warming Module Based on Education for Sustainable Development to Increase Middle School Students' Understanding and Sustainability Awareness. *Jurnal Pendidikan Sains Indonesia*, *12*(2), 247–263. https://doi.org/10.24815/jpsi.v12i2.33679

Ramadhan, M. N. P. (2023). The role of SDG 4: Quality education on the internationalization of Indonesia's education. *Hasanuddin Journal of Strategic and International Studies, 1*(2), 39-51. https://doi.org/10.20956/hjsis.v1i2.27442

Santoso, T. N. B., Siswandari., & Sawiji, H. (2018). The Effectiveness of Ebook Versus Printed Books in The Rural Schools in Indonesia at The Modern Learning Era. *International Journal of Educational Research Review*, *3*(4), 77-84

Septiani, E. (2020). Education for Sustainable Development (ESD) Berbasis Perubahan Iklim dalam Pendidikan IPS. *Prosiding Seminar Nasional FISIP UNNES*, 16–28. https://proceeding.unnes.ac.id/psnf/article/view/2912

Setyowati, Y., Kaniawati, I., Sriyati, S., Nurlaelah, E., & Hernani, H. (2022). The Development of Science Teaching Materials Based on the PjBL-STEM Model and ESD Approach on Environmental Pollution Materials. *Jurnal IPA & Pembelajaran IPA*, *6*(1), 45–53. https://doi.org/10.24815/jipi.v6i1.23571

Sihombing, R. A., & Hasruddin, H. (2024). Development of E-Book STEM-Based on Human Digestive System Material Based on Scientific Literacy. *Jurnal Pendidikan Matematika dan IPA*, *15*(2), 182-197.

Sihombing, R. A., Manurung, G. A., & Simanjuntak, L. A. (2022). Analysis Implementation of Technological Pedagogical Content Knowledge by Science Teachers Through Distance Learning at Junior High School In Medan. *Jurnal Pendidikan Matematika dan IPA*, *13*(2), 214-230.

Sihombing, R. A., Muslim, T. R., 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, 5*(1), 108-118.

Sihombing, R. A., Muslim., & Rahman, T. (2023). Effective Classroom Management During the Limited Face-To-Face Learning Period in Junior High School Medan. *Jurnal Manajemen Pendidikan: Jurnal Ilmiah Administrasi, Manajemen dan Kepemimpinan Pendidikan*, 5(2), 1-16

Sihombing, R. A., Muslim., & Rahman, T. (2023). The Development of Interactive AudioVisual-Based Media Using VideoScribe to Reduce Misconceptions Electrical Potential and ECG Material. *Tarbiyah: Jurnal Ilmiah Kependidikan*, *12*(2), 69-80

Simatupang, H., Siregar, E. H., Sihombing, R. A., & Tanjung, M. Y. (2023). Profile of Technology Pedagogical Content Knowledge-21 (TPACK21) on Pre-Service Science Teacher in Microteaching Course. *Sciendo*, *2022*, 764-771.

Siregar, H. M. (2023). Pendidikan Untuk Pembangunan Berkelanjutan Di Pembelajaran Matematika Dalam Meningkatkan Soft Skills Peserta Didik. *Nabla Dewantara : J.Pendidik.Matematika*, *8*(1), 37–44. https://doi.org/10.51517/nabla.v8i1.251

Su, C. S., Díaz-Levicoy, D., Vásquez, C., & Hsu, C. C. (2023). Sustainable Development Education for Training and Service Teachers Teaching Mathematics: A Systematic Review. *Sustainability (Switzerland)*, *15*(10). https://doi.org/10.3390/su15108435

Thoriq, A., & Mahmudah, F. N. (2023). Education for Sustainable Development (Esd): a Systematic Literature Review on Curriculum Development Strategy Design. *European Journal of Education Studies*, *10*(5), 201–223. https://doi.org/10.46827/ejes.v10i5.4803

UNESCO. (2017). *A Guide for ensuring inclusion and equity in education*. The United Nations Educational, Scientific and Cultural Organization. https://unesdoc.unesco.org/ark:/48223/pf0000248254

Widodo, H., Purwanto, H., Sholihat, N., Jehloh, N., & Suryanti. (2023). Pengembangan Modul Interaktif Terintegrasi Education for Sustainable Development (ESD) Materi Pemanasan Global SMP Muhammadiyah Pekanbaru. *Biosfer: Jurnal Tadris Biologi, 14*(2), 141-148. https://doi.org/10.24042/biosfer.v14i2.18328

Wilujeng, I., Dwandaru, W. S. B., & Rauf, R. A. B. A. (2019). The effectiveness of education for environmental sustainable development to enhance environmental literacy in science education: A case study of hydropower. *Jurnal Pendidikan IPA Indonesia*, *8*(4), 521–528. https://doi.org/10.15294/jpii.v8i4.19 948