JIMP (Jurnal Inovasi dan Manajemen Pendidikan)
Vol. 5 No. 2, Desember 2025, pp. 175~185
e-ISSN 2807-3231
DOI: 10.12928/jimp.v5i2.15271

Integrating Sustainable Development Goals into Contextual Physics Education: Evidence from Instructional Strategies on Climate Action and Quality Education

Arif Malik Khairi [1*], Dwi Sulisworo [2]
[1] Ahmad Dahlan University, Indonesia;
[2] Ahmad Dahlan University, Indonesia;
[1] 2408041014@webmail.uad.ac.id; [2] dwi.sulisworo@uad.ac.id;
[*] 2408041014@webmail.uad.ac.id

Received: *Revised:* *Accepted:*

KEYWORDS

Contextual Physics Education,
Sustainable Development Goals (SDGs),
Climate Action,
Quality Education,
Problem-Based Learning

ABSTRACT

Ten empirical studies on contextual physics education were reviewed to examine instructional strategies for integrating sustainability and the Sustainable Development Goals (SDGs) across educational levels. The studies involved six senior high school contexts, two junior high school contexts, one university-level implementation, and one multi-level review, employing approaches such as guided inquiry, Contextual Teaching and Learning (CTL), problem-based learning, and research-based module development. Although only one study explicitly addressed SDG 13 (Climate Action), most studies implicitly supported SDG 4 (Quality Education) through the integration of renewable energy issues, environmental awareness, and local wisdom within physics learning. The findings demonstrate that contextual approaches yield significant educational benefits, including higher environmental awareness (normalized gain of 0.71 in the experimental group compared to 0.56 in the control group), large cognitive effect sizes reaching 2.34, and student satisfaction levels up to 96.77%. Additional outcomes include improved conceptual understanding, enhanced scientific literacy, strengthened creative thinking skills, and increased student participation. Overall, this review confirms that contextual physics education is an effective pedagogical approach for linking physics concepts with sustainability issues while simultaneously fostering essential competencies needed to address global challenges aligned with the SDGs.

Introduction

The increasing complexity of global challenges such as climate change, energy sustainability, and environmental degradation has intensified the demand for educational approaches that extend beyond the transmission of factual knowledge toward the development of higher-order thinking skills, environmental awareness, and social responsibility. In physics education, this shift encourages learning designs that connect abstract concepts with real-world phenomena and societal issues, enabling students to understand physics as a meaningful and applicable discipline rather than a collection of formulas (Bao & Koenig, 2019; Bruner, 1996; Dewey, 1938). Within this context, education is increasingly expected to contribute to global agendas, particularly the Sustainable Development Goals (SDGs), which emphasize the role of education in addressing sustainability challenges through transformative learning (Salmoiraghi et al., 2025; Wang, 2024).

In response to these demands, contextual physics education has emerged as an important pedagogical approach. Contextual learning situates physics concepts within authentic contexts—such as renewable energy, environmental problems, climate change, and local wisdom—so that students can bridge theory and practice while developing conceptual understanding and scientific literacy (Çoker et al., 2010; Usmeldi, 2016; Zulhaini et al., 2016). Recent studies also indicate that contextual and problem-oriented physics learning can foster sustainability awareness and support Education for Sustainable Development (ESD) by encouraging students to reflect on the environmental and social implications of scientific knowledge (Fathurohman et al., 2025; Prayogi & Verawati, 2024).

Over the past decade, empirical research on contextual physics education has expanded through the application of guided inquiry, Contextual Teaching and Learning (CTL), problem-based learning, and the development of contextual learning modules or media. These approaches have been shown to improve conceptual understanding, scientific literacy, creative thinking, and student engagement across junior high school, senior high school, and higher education levels (Asyhari & Hartati, 2015; Liliawati, 2011; Putri et al., 2019; Suhandi, 2003). Moreover, several recent studies explicitly link contextual physics learning with sustainability themes aligned with SDG 4 (Quality Education) and SDG 13 (Climate Action), demonstrating positive impacts on environmental awareness, learning motivation, and student attitudes toward sustainability (Hartati & Hariyono, 2020; Wati et al., 2024).

Despite this growing body of literature, important limitations remain evident. Many studies investigate contextual physics learning in isolated instructional settings and emphasize specific teaching models or learning outcomes without systematically examining how these approaches align with the SDG framework. In many cases, sustainability is embedded implicitly rather than explicitly articulated in relation to specific SDGs, particularly SDG 13, which limits the visibility and conceptual strength of sustainability-oriented physics education (Andini & Siswanto, 2025; Fahrudin & Maryam, 2022). Furthermore, existing reviews tend to focus on particular instructional models—such as problem-based learning or ethnoscience—without providing an integrated synthesis that compares instructional strategies, SDG integration, and educational outcomes across educational levels (Arroco, 2021; Ayu et al., 2024).

Based on this state of the art, the main research gap lies in the absence of a focused synthesis that systematically maps contextual physics education strategies to SDG integration and associated learning outcomes across diverse educational contexts. Addressing this gap is essential to strengthen the theoretical foundation of contextual physics education and to clarify its contribution to sustainability-oriented learning within the SDG framework.

Accordingly, this study addresses the problem of how contextual physics education has been implemented in relation to sustainability and the SDGs, and what educational outcomes have been reported in empirical research. The purpose of this study is to synthesize empirical research on contextual physics education in order to (1) identify dominant instructional strategies, (2) analyze the extent and form of SDG integration—particularly SDG 4 and SDG 13—and (3) examine reported learning outcomes across cognitive, affective, and skills-based domains. The results of this review are expected to provide a structured reference for future research, instructional design, and educational policy related to physics education and sustainable development.

Method

This study employed a semi-systematic literature review approach to synthesize empirical research on contextual physics education integrated with sustainability and the Sustainable Development Goals (SDGs). A semi-systematic review was selected because this study aims not only to summarize existing findings but also to compare instructional strategies, forms of SDG integration, and educational outcomes across diverse educational contexts without applying full meta-analytic procedures (Arroco, 2021; Ayu et al., 2024).

The literature search was conducted using Elicit AI, a semantic academic search platform that indexes more than 138 million scholarly publications from databases such as Semantic Scholar and OpenAlex. The search query "Penerapan Pendidikan Fisika Kontekstual Berbasis Sustainable Development Goals (SDGs)" was employed to identify studies addressing contextual physics education in relation to sustainability frameworks. Based on semantic relevance ranking, 50 publications were initially retrieved as the preliminary dataset.

A screening process was then applied using predefined inclusion criteria: (1) the study focused on physics education; (2) the instructional approach was contextual or context-based; (3) sustainability or SDG-related themes were explicitly or implicitly embedded; (4) empirical data on learning outcomes were reported; and (5) the study involved students in formal or informal educational settings. Studies were excluded if they were purely theoretical, lacked empirical data, or did not provide sufficient methodological detail. Through this screening process, 10 studies were selected for in-depth analysis. The final selection was based on relevance to the research objectives, methodological clarity, representation of diverse instructional strategies, and availability of full-text access. This number was considered sufficient to capture dominant implementation patterns while maintaining analytical depth and coherence.

Data extraction was conducted using a structured coding framework integrated within the Elicit platform. Each selected study was analyzed according to six analytical categories: (1) educational level and learning context; (2) instructional strategy or contextual approach; (3) form and extent of SDG integration; (4) research design and methodological characteristics; (5) learning outcomes measured; and (6) sustainability-related competencies addressed. To enhance data reliability, the extracted information was cross-checked across studies and compared thematically to ensure consistency of interpretation (Fahrudin & Maryam, 2022).

The data analysis followed a thematic and comparative narrative approach, focusing on identifying recurring instructional strategies, patterns of SDG integration, and similarities or differences in reported educational outcomes. Rather than aggregating effect sizes statistically, this study emphasizes conceptual synthesis to address the identified research gap and to clarify how contextual physics education contributes to sustainability-oriented learning aligned with SDG 4 (Quality Education) and SDG 13 (Climate Action) (Salmoiraghi et al., 2025; Wang, 2024).

Table 1. Characteristics of Selected Studies on Contextual Physics Education

No	Study	Educational Level	Contextual Approach	SDG Integration	Research Design
1	(Hartati & Hariyono, 2020)	Senior high school	Guided inquiry	Explicit: SDG 13	Quasi-experimental
2	(Putri et al., 2019)	Senior high school	Contextual learning	Implicit: SDG 7, 13	Experimental
3	(Utami et al., 2017)	University	STEM-A with local wisdom	Implicit: SDG 4, 13	Quasi-experimental
4	(Suhandi, 2003)	Junior high school	CTL	Implicit: SDG 4, 13	Experimental
5	(Sulfiah & Sulisworo, 2016)	Junior high school	Contextual comics	Not explicit	R&D
6	(Fahrudin & Maryam, 2022)	Various levels	Ethnoscience-based	Implicit: SDG 4	Systematic review
7	(Usmeldi, 2016)	Senior high school	Research-based module	Implicit: SDG 4, 13	R&D
8	(Zulhaini et al., 2016)	Senior high school	Contextual module	Implicit: SDG 4	R&D
9	(Asyhari & Hartati, 2015)	Senior high school	Guided inquiry	Implicit: SDG 4	R&D
10	(Liliawati, 2011)	Senior high school	Problem-based learning	Implicit: SDG 4	Experimental

Table 1 summarizes the characteristics of the selected studies, including educational level, instructional strategies, SDG integration, and research design. The diversity of contexts and approaches represented in the table ensures that the synthesis captures a broad perspective on how contextual physics education is implemented in relation to sustainability, thereby providing a robust basis for the comparative analysis presented in the Results and Discussion sections.

Results and Discussion

1. Overview of Contextual Physics Education Studies

Contextual physics education in the reviewed studies is implemented across diverse educational levels and instructional settings, indicating that it functions as a flexible pedagogical framework rather than a single fixed teaching model. As revealed by the synthesis, contextual approaches are most frequently applied at the senior high school level, where students are cognitively prepared to engage with abstract reasoning and real-world problem contexts. However, the inclusion of junior high school and university-level studies demonstrates that contextual physics education can be adapted to different learner characteristics and curricular demands without losing its core pedagogical principles.

Across all educational levels, contextual physics education consistently emphasizes the integration of physics concepts with authentic real-world contexts, such as environmental issues, renewable energy, and local wisdom. This shared characteristic supports constructivist and experiential learning theories, which argue that meaningful learning occurs when students actively connect new knowledge with prior experiences and socially relevant contexts. Therefore, contextualization serves not only as an instructional strategy but also as a conceptual bridge between physics content and sustainability-oriented learning.

Table 2 summarizes the instructional strategies, educational levels, and learning focus of the reviewed studies, providing an overview of how contextual physics education is implemented across different contexts.

Table 2. Instructional Strategies in Contextual Physics Education

Study	Educational Level	Instructional Strategy	Key Learning Focus
(Hartati & Hariyono, 2020)	Senior high school	Guided inquiry	Climate action, environmental awareness
(Putri et al., 2019)	Senior high school	Contextual learning	Renewable energy concepts
(Utami et al., 2017)	University	STEM-A with local wisdom	Cultural context & sustainability
(Suhandi, 2003)	Junior high school	CTL	Application of physics in daily life
(Sulfiah & Sulisworo, 2016)	Junior high school	Contextual comics	Conceptual understanding & engagement
(Fahrudin & Maryam, 2022)	Multi-level	Ethnoscience-based review	Cultural relevance in physics

Study	Educational Level	Instructional Strategy	Key Learning Focus
(Usmeldi, 2016)	Senior high school	Research-based module	Scientific literacy
(Zulhaini et al., 2016)	Senior high school	Contextual module	Conceptual understanding
(Asyhari & Hartati, 2015)	Senior high school	Guided inquiry	Character education

Table 2 shows that guided inquiry and problem-based learning dominate contextual physics education, particularly at the senior high school level. This dominance suggests that contextualization is most effective when students actively engage in inquiry and problem-solving rather than passive content consumption.

2. Instructional Strategies and Their Comparative Effectiveness

A comparative analysis of the instructional strategies presented in Table 2 indicates that guided inquiry and problem-based learning dominate contextual physics education research. Guided inquiry approaches combine structured exploration with teacher scaffolding, enabling students to develop conceptual understanding while managing cognitive load. This balance is particularly effective when physics learning is integrated with sustainability-related topics that require both conceptual accuracy and contextual awareness.

In contrast, problem-based learning places greater emphasis on student autonomy and collaborative problem solving. This approach has been shown to significantly enhance creative thinking and problem-solving skills, as students are required to analyze real-world problems, propose solutions, and reflect on their reasoning processes. Contextual Teaching and Learning (CTL) further complements these approaches by emphasizing reflection and experiential learning cycles, reinforcing students' ability to apply physics concepts to everyday situations.

Development-oriented strategies, such as contextual modules and comics, play a supportive role by increasing engagement and conceptual accessibility, particularly for younger learners. However, comparative synthesis suggests that instructional strategies emphasizing active inquiry and problem solving tend to produce stronger higher-order cognitive and skills-based outcomes than approaches relying primarily on content presentation.

3. Integration of Sustainability and Sustainable Development Goals (SDGs)

The extent and form of sustainability integration in contextual physics education are systematically illustrated in Table 3. The table shows that explicit alignment with the Sustainable Development Goals (SDGs), particularly SDG 13 (Climate Action), remains limited. Most studies integrate sustainability implicitly through learning topics such as renewable energy, environmental awareness, and local wisdom, rather than explicitly framing instruction within SDG targets.

Although implicit integration is sufficient to generate positive learning outcomes, the lack of explicit SDG framing may reduce students' awareness of the global relevance of physics learning. Explicitly linking physics concepts to SDG targets has the potential to strengthen Education for Sustainable Development (ESD) by helping students recognize physics as a tool for addressing global sustainability challenges, rather than merely an academic subject.

Table 3 presents the form of SDG integration and sustainability themes addressed in each reviewed study.

Table 3. Integration of Sustainability and SDGs in Contextual Physics Education

Study	SDG Alignment	Sustainability Theme	Integration Type
(Hartati & Hariyono, 2020)	SDG 13	Climate change	Explicit
(Putri et al., 2019)	SDG 7, SDG 13	Renewable energy	Implicit
(Utami et al., 2017)	SDG 4, SDG 13	Local wisdom & conservation	Implicit
(Suhandi, 2003)	SDG 4, SDG 13	Environmental awareness	Implicit
(Sulfiah & Sulisworo, 2016)	–	Contextual understanding	Not explicit
(Fahrudin & Maryam, 2022)	SDG 4	Ethnoscience & culture	Implicit
(Usmeldi, 2016)	SDG 4, SDG 13	Scientific literacy	Implicit
(Zulhaini et al., 2016)	SDG 4	Concept mastery	Implicit
(Asyhari & Hartati, 2015)	SDG 4	Character education	Implicit
(Liliawati, 2011)	SDG 4	Creative thinking	Implicit

Table 3 indicates that explicit SDG integration remains limited. Most studies embed sustainability implicitly, which partially explains the identified research gap regarding the lack of systematic SDG-oriented instructional frameworks in contextual physics education.

4. Educational Outcomes Across Learning Domains

The educational outcomes reported across the reviewed studies demonstrate consistent positive effects of contextual physics education on cognitive, affective, and skills-based learning domains. Cognitively, students show significant improvements in conceptual understanding and scientific literacy, as indicated by high normalized gains and large effect sizes. These findings suggest that contextualization facilitates deeper conceptual processing by enabling students to relate abstract physics principles to meaningful real-world phenomena.

In the affective domain, contextual physics education fosters increased motivation, positive learning attitudes, and heightened environmental awareness. These outcomes are particularly important in sustainability-oriented education, as affective engagement often precedes long-term behavioral change. In terms of skills development, inquiry-based and problem-based contextual approaches contribute to the enhancement of creative thinking, problem-solving abilities, and collaboration skills, which are central to twenty-first-century competency frameworks.

Table 4 summarizes the learning outcomes reported in the reviewed studies, highlighting the consistency of positive impacts across learning domains.

Table 4. Educational Outcomes of Contextual Physics Education

Study	Outcomes Measured	Key Results
(Hartati & Hariyono, 2020)	Environmental awareness	n-gain 0.71 (exp) vs 0.56 (control)
(Putri et al., 2019)	Cognitive achievement	Effect size d = 2.34
(Utami et al., 2017)	Conceptual understanding	Medium gain
(Suhandi, 2003)	Concept application	n-gain 0.64 vs 0.21
(Sulfiah & Sulisworo, 2016)	Media suitability	Positive student response
(Fahrudin & Maryam, 2022)	Scientific literacy	Positive qualitative impact
(Usmeldi, 2016)	Scientific literacy	>85% achievement
(Zulhaini et al., 2016)	Concept mastery & satisfaction	96.77% satisfaction
(Asyhari & Hartati, 2015)	Cognitive, affective, psychomotor	Improvement across domains
(Liliawati, 2011)	Creative thinking	Higher gains than traditional

Table 4 confirms that contextual physics education consistently improves learning outcomes across domains. Notably, large cognitive gains and high student satisfaction reinforce the effectiveness of contextual approaches in supporting SDG 4 (Quality Education), while improvements in environmental awareness align with SDG 13 (Climate Action).

5. Cross-Study Synthesis and Contribution to the Research Gap

To address the research gap identified in this review, a cross-study synthesis was conducted by integrating instructional strategies, SDG alignment, and educational outcomes. This synthesis reveals that while contextual physics education is widely implemented and empirically effective, its contribution to SDG-oriented learning remains conceptually underdeveloped due to the predominance of implicit sustainability integration.

Table 5 presents an analytical mapping that synthesizes key patterns across the reviewed studies, directly linking instructional strategies, sustainability integration, and educational implications.

Table 5. Cross-Study Synthesis of Contextual Physics Education

Dimension	Dominant Pattern	Educational Implication
Instructional strategy	Guided inquiry & problem-based learning	Stronger cognitive and skills-based outcomes
SDG integration	Mostly implicit	Sustainability learning present but under-articulated
Learning outcomes	Consistently positive across domains	Supports SDG 4 (Quality Education)
Sustainability focus	Environmental awareness & renewable energy	Indirect contribution to SDG 13
Research limitation	Fragmented designs & reporting	Need for explicit SDG-based frameworks

Table 5 demonstrates that while contextual physics education is empirically effective, its contribution to SDG-oriented learning remains conceptually underdeveloped. This synthesis clarifies the originality of the present review by systematically linking instructional strategies, sustainability integration, and educational outcomes—an aspect that has not been comprehensively addressed in previous studies.

6. Implications for Theory and Practice

Taken together, the findings presented in Tables 2–5 reinforce the alignment of contextual physics education with constructivist and experiential learning theories. From a practical perspective, the results suggest that physics educators should intentionally design contextual learning experiences that explicitly connect physics concepts with sustainability issues and SDG targets. For future research, greater emphasis should be placed on explicit SDG-based instructional designs, standardized outcome measurement, and transparent methodological reporting to strengthen the contribution of contextual physics education to sustainable development.

Conclusion

This review demonstrates that contextual physics education is an effective and flexible pedagogical framework for enhancing learning quality and supporting sustainability-oriented education. Across diverse educational levels and instructional contexts, contextual approaches—particularly guided inquiry, problem-based learning, and Contextual Teaching and Learning—consistently improve students' conceptual understanding, scientific literacy, creative thinking, and learning engagement. These findings confirm the strong contribution of contextual physics education to SDG 4 (Quality Education) by promoting meaningful, student-centered, and competency-based learning.

In relation to sustainability, the review reveals that contextual physics education contributes to SDG 13 (Climate Action) primarily through the integration of environmental issues, renewable energy, and local wisdom into physics learning. However, this contribution is predominantly implicit, with only a limited number of studies explicitly aligning instructional design with SDG frameworks. This finding addresses the identified research gap by showing that while contextual physics education already supports sustainability learning in practice, its theoretical and conceptual linkage to the SDGs remains underdeveloped.

The main contribution of this study lies in its systematic synthesis of instructional strategies, forms of SDG integration, and educational outcomes across empirical studies. By mapping these dimensions simultaneously, this review provides a clearer understanding of how contextual physics education can function as a strategic vehicle for Education for Sustainable Development (ESD). The synthesis highlights the need to move beyond isolated implementations toward more explicit and intentional SDG-oriented instructional frameworks in physics education.

Despite these contributions, this study has several limitations. The review is limited to a relatively small number of studies and relies on narrative synthesis rather than quantitative meta-analysis, which restricts the generalizability of effect sizes across contexts. Additionally, variations in research design and outcome measurement across the reviewed studies limit direct comparison. Future research should address these limitations by employing larger datasets, standardized evaluation instruments, and explicit SDG-based instructional designs.

In conclusion, contextual physics education holds strong potential not only to improve physics learning outcomes but also to support sustainability-oriented competencies aligned with global development goals. To maximize this potential, future research and instructional practice should emphasize explicit SDG integration, rigorous evaluation, and innovative contextual learning designs that position physics education as an active contributor to sustainable development.

Reference

Andini, E. R., & Siswanto, J. (2025). Citizen Science in Science-Physics Class: Building Contextual Climate Change Literacy. *Lontar Physics Today*, *4*(3), 136–141. https://doi.org/10.26877/lpt.v4i3.25078

Arroco, S. (2021). Educational Outcomes from Learning Physics Through Guided Inquiry. *Bicol University R & D Journal*, *24*(2), 39.

Asyhari, A., & Hartati, R. (2015). Implementasi Pembelajaran Fisika SMA Berbasis Inkuiri Terbimbing Terintegrasi Pendidikan Karakter untuk Meningkatkan Hasil Belajar Siswa pada Materi Cahaya dan Optika. *Jurnal Ilmiah Pendidikan Fisika Al-Biruni*, *4*(1). https://doi.org/10.24042/jipfalbiruni.v4i1.79

Ayu, H. Di., Chusniyah, D. A., Kurniawati, M. P., Purwanti, P. F., Lukitawanti, S. D., & Putri, A. N. (2024). Problem-based learning (PBL) as an effective solution to enhance understanding of physics concepts: A systematic literature review. *Journal of Environment and Sustainability Education*, *2*, 86–105. https://doi.org/10.62672/joease.v2i2.29

Bao, L., & Koenig, K. (2019). Physics education research for 21st century learning. *Disciplinary and Interdisciplinary Science Education Research*, *1*(1), 2. https://doi.org/10.1186/s43031-019-0007-8

Bruner, J. (1996). *The culture of education*. Harvard University Press.

Çoker, B., Çatlioğlu, H., & Birgin, O. (2010). Conceptions of students about renewable energy sources: A need to teach based on contextual approaches. *Procedia - Social and Behavioral Sciences*, *2*(2), 1488–1492. https://doi.org/10.1016/j.sbspro.2010.03.223

Dewey, J. (1938). *Experience and education*. Macmillan.

Fahrudin, A., & Maryam, E. (2022). Review Analisis Pendidikan Fisika Berbasis Etnosains, Budaya, dan Kearifan Lokal di Indonesia. *Jurnal Riset Rumpun Matematika Dan Ilmu Pengetahuan Alam*, *1*(1), 12–24. https://doi.org/10.55606/jurrimipa.v1i1.126

Fathurohman, A., Susiloningsih, E., Kistiono, Kurdiati, L. A., Agustina, I., & Luciana, L. (2025). Exploring the ESD-Integrated Physics E-Modules Needs of Cultivating High School Students' Sustainability Awareness about Global Warming in Wetland Ecosystems. *SPEKTRA Jurnal Kajian Pendidikan Sains*, *11*, 200–209. https://doi.org/10.32699/spektra.v11i2.8227

Hartati, M., & Hariyono, E. (2020). Efektivitas Pembelajaran Fisika Terintegrasi dengan Aksi Iklim pada Prinsip SDGs (Sustainable Development Goals) dalam Meningkatkan Karakter Peduli Lingkungan. *IPF: Inovasi Pendidikan Fisika*, *09*(03), 349–355.

Liliawati, W. (2011). Pembekalan Keterampilan Berpikir Kreatif Siswa SMA melalui Pembelajaran Fisika Berbasis Masalah. *Jurnal Pengajaran MIPA*, *16*(2), 93–98. https://doi.org/10.18269/jpmipa.v16i2.36016

Prayogi, S., & Verawati, N. N. S. P. (2024). Physics Learning Technology for Sustainable Development Goals (SDGs): A Literature Study. *International Journal of Ethnoscience and Technology in Education*, *1*(2), 155–191. https://doi.org/10.33394/ijete.v1i2.12316

Putri, K. D., Suyanto, E., & Nyeneng, I. D. P. (2019). Pengaruh Penerapan Model Pembelajaran Kontekstual dalam Pembelajaran Fisika terhadap Hasil Belajar Siswa pada Materi Energi Terbarukan. *Titian Ilmu: Jurnal Ilmiah Multi Sciences*, *11*(2), 87–93. https://doi.org/10.30599/jti.v11i2.474

Salmoiraghi, A., Zamboni, A., Toffaletti, S., Di Mauro, M., Malgieri, M., Fiorello, C., Onorato, P., & Oss, S. (2025). Core of Sustainability Education: Bridging Theory and Practice in Teaching Climate Science to Future Mathematics and Physics Teachers. *Sustainability*, *17*(11), 1–31. https://doi.org/10.3390/su17115120

Suhandi, A. (2003). Penerapan Model Pembelajaran Kontekstual untuk Meningkatkan Kemampuan Mengaplikasikan Konsep Fisika dalam Konteks Kehidupan Nyata. *Jurnal Pengajaran MIPA*, *4*(2).

Sulfiah, U., & Sulisworo, D. (2016). Pengembangan Media Pembelajaran Kontekstual Menggunakan Komik Fisika untuk Peserta Didik SMP/MTs Kelas VII pada Pokok Bahasan Kalor. *Berkala Fisika Indonesia*, *8*(2), 31–37.

Usmeldi. (2016). The Development of a Research-Based Physics Learning Model with a Scientific Approach to Develop Students' Scientific Processing Skills. *Jurnal Pendidikan IPA Indonesia*, *5*, 134–139. https://doi.org/10.15294/jpii.v5i1.5802

Utami, I. S., Septiyanto, R. F., Wibowo, F. C., & Suryana, A. (2017). Pengembangan STEM-A (Science, Technology, Engineering, Mathematic and Animation) Berbasis Kearifan Lokal dalam Pembelajaran Fisika. *Jurnal Ilmiah Pendidikan Fisika Al-Biruni*, *6*(1), 67–73. https://doi.org/10.24042/jpifalbiruni.v6i1.1581

Wang, L. (2024). Exploring the integration of physics education and sustainable development education: resource utilization and environmental awareness cultivation. *Region - Educational Research and Reviews*, *6*(5), 99. https://doi.org/10.32629/rerr.v6i5.2148

Wati, A. W., Sari, D. P., Sulaeman, N. F., Syam, M., & Saparini, S. (2024). Integrating SDGs in Climate Change Education: Insights from Pre-Service Physics Teachers. *Jurnal Eksakta Pendidikan (JEP)*, *8*(2), 86–98. https://doi.org/10.24036/jep/vol8-iss2/890

Zulhaini, Halim, A., & Mursal. (2016). Pengembangan Modul Fisika Kontekstual Hukum Newton untuk Meningkatkan Pemahaman Konsep Fisika Siswa di MAN Model Banda Aceh. *Jurnal Pendidikan Sains Indonesia*, *4*, 180–190.