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BiBibliometric Trends of Environmental-STREAM in Science Education

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Abstract - *The integration of environmental issues and religious aspects in science learning is essential to foster student responsibility holistically. The development of the integration of these issues has not been well mapped. This study presents a bibliometric analysis to evaluate the global publication trends of Environmental-STEM, STEAM, and STREAM in science education. The Publish or Perish application is used as a source for the Google Scholar database as well as VOSviewer for keyword mapping (co-word analysis), a comprehensive screening of 499 articles in the 2015–2025 range. Based on the strict PRISMA protocol, 125 articles were obtained that met the final eligibility criteria for analysis. The results of the analysis show that interdisciplinary publications had soared in 2020. Research that explicitly integrates environmental aspects as well as religious aspects in the framework of STREAM called Environmental-STREAM (E-STREAM) has not been found in network visualization. This crucial research gap confirms the novelty of this study which emphasizes the urgency of E-STREAM as a distinctive aspect-based learning framework. Practically, this research contributes in the form of a conceptual roadmap for educators and curriculum developers to design contextual science learning that bridges science literacy, creativity, and environmental responsibility rooted in the spiritual-ethical side.*

Keywords: *Bibliometric Analysis; Science Education; VOTE; STEAM; STREAM*

1. Introduction

Global environmental challenges such as climate change, biodiversity loss, and environmental degradation are increasingly critical issues and require immediate and long-term solutions [1]. These conditions not only threaten ecological systems, but also affect human life and sustainable development around the world. In response, the United Nations (UN) has emphasized the role of education in achieving the Sustainable Development Goals (SDGs), particularly through quality education that promotes environmental literacy, responsibility, and sustainable decision-making [2], [3], [4]. Environmental literacy is seen as one of the important solutions in equipping students to understand, maintain, and make responsible decisions for the environment [5]. Environmental literacy includes four main dimensions, namely environmental knowledge (cognitive), attitude towards the environment, cognitive skills, and responsible behavior towards the environment [6]. As a result, science education is increasingly positioned as a strategic domain to foster students' awareness, competence, and ethical responsibility towards environmental sustainability [7], [8]. The latest international frameworks in science education, including the International Student Assessment Programme (PISA), explicitly highlight environmental competence as an essential component of science literacy [7], [8].

This global urgency is in stark contrast to the reality of science learning at the classroom level in developing countries such as Indonesia. Although the Independent Curriculum formally mandates the utilization of local socio-environmental issues for contextual deep learning, empirical data show that Indonesian students continue to struggle with very low environmental literacy and a weak sense of ecological responsibility [9], [10]. These findings are reinforced by those who report that the implementation of environmental literacy in Indonesian schools is still not running optimally. Revealed that students' environmental awareness is still a problem that affects their understanding and behavior towards the environment. This condition shows that the mastery of the concept of the environment has not been fully internalized into real attitudes and actions in daily life [11], [12]. Science learning in regional schools often still uses a learning approach that tends to be theoretical and less contextual, so students environmental awareness tends to be low. Students' high mastery of scientific knowledge is not necessarily followed by attitudes and behaviors that support the environment in real terms [13], [14]. There is an urgent need to reform instructional design in science classrooms in Indonesia by implementing a holistic interdisciplinary framework that can bridge the gap between scientific knowledge and ecological action in the real world.

To bridge this gap, modern science education has evolved from rigid, content-oriented teaching to an interdisciplinary approach. Environmental education is increasingly dominated by the use of STEM (*Science, Technology, Engineering, and Mathematics*) approaches [15]. STEM can be integrated with environmental issues through E-STEM (Environmental-STEM) [16], which combines science learning with the basic principles of ecological sustainability to stimulate real-world problem-solving [17]. Furthermore, E-STEM evolved into E-STEAM by integrating the Arts aspect to foster innovation, design thinking, and creative communication while addressing complex environmental degradation [18], [19].

A critical examination of these earlier frameworks reveals significant conceptual limitations. Previous research on STEM, E-STEM, and STEAM has largely limited its focus to the cognitive dimension, technical problem-solving skills, and technological innovation [20]. For example, standard E-STEM models usually stop at the boundaries of carbon emission calculations, engineering water purification prototypes, or developing environmental monitoring applications [21]. While these technical competencies are invaluable, they routinely ignore the ethical, emotional, and spiritual values that serve as fundamental drivers for deep-rooted and sustainable change in human behavior over the long term [22]. Technical knowledge alone does not guarantee the existence of ecological empathy; A student may understand the science of global warming very well, but still lack the moral conviction to act.

In the Indonesian context, this missing link is very problematic. The main goal of Indonesia's national education explicitly relies on the development of students who are not only intellectually competent, but also have faith, fear God Almighty, and have noble character. This unique educational philosophy provides a strategic entry point for ecotheology, a perspective that frames environmental conservation not just as a secular task of a technical nature, but as a deep moral and spiritual obligation to the Creator [23]. In this context, the STREAM (Science, Technology, Religion, Engineering, Arts, and Mathematics) framework naturally emerges as a comprehensive solution, as it inherently accommodates religious and ethical dimensions. By combining sustainability education with this aspect of religion called Environmental-STREAM (E-STREAM), educators can theoretically foster science literacy as well as spiritual environmental responsibility at the same time.

Despite the enormous conceptual potential of E-STREAM, its systematic integration into mainstream science education is not yet established. To date, local conceptual works in Indonesia have occasionally discussed ecotheology, but these discussions are still confined to isolated religious studies classes, completely cut off from rigorous scientific explanations in physics or biology classes. On the other hand, various bibliometric studies have been conducted to map the development of the integration of environmental education in science learning. The integration of Education for Sustainable Development (ESD) and STEM in the period 2015–2025 shows an increasing trend that supports interdisciplinary, contextual, and sustainability-oriented learning and opens up various research opportunities in the future.

Bibliometric analysis and mapping of STEAM, environmental, and science education research in the period 2013–2020 which shows significant development of research themes as well as indicating opportunities for further exploration. Previous bibliometric studies in the field of science education have developed comprehensively, but they remain tightly bound within the boundaries of conventional STEM or STEAM [24]. There has been no macro-level bibliometric investigation that explicitly targets, tracks, or maps global research trends, publication trajectories, and interrelated keyword structures at the intersection of environmental issues, religious values, and integrated science frameworks. This study directly addresses such critical research gaps and establishes its novelty as the first comprehensive bibliometric analysis that maps the macro-evolution of the emerging Environmental-STEM, STEAM, and E-STREAM domains over the past decade (2015-2025). Using publish or perish software to access data from Google Scholar and using VOSviewer for advanced co-word mapping, the study provides a crucial conceptual roadmap.

This study aims to conduct a bibliometric analysis of research on Environmental-STEM, STEAM, and STREAM in the context of science education published between 2015 and 2025. Specifically, this study aims to: (1) examine publication trends and growth patterns in Environmental-STEM, STEAM, and STREAM research; (2) identify dominant research themes and keyword groups related to environmental and interdisciplinary science education; and (3) explore the extent to which environmental and religious dimensions have been integrated within the STREAM framework.

2. Methods

This study uses bibliometric analysis methods to map the structural and dynamic evolution of interdisciplinary science education research. The main focus is on the Environmental-STEM, STEAM, and STREAM frameworks. The research workflow (Figure 1) is structured into four different stages based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, including: First, Identification. Second, screening. Third, eligibility. Fourth, inclusion [25].

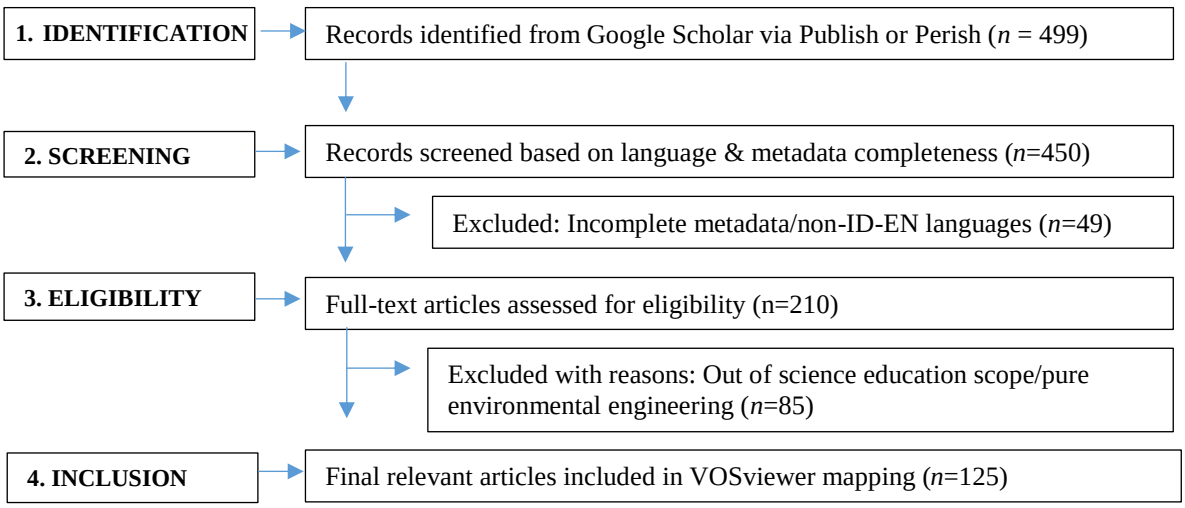

Figure 1. Document Screening Flow Diagram Based on the PRISMA 2020 Protocol

2.1. Data Sources and Search Strategies

Literature search using the Publish or Perish (PoP) application. Google Scholar was chosen as the primary database because it has a much wider and more inclusive coverage of regional publications, proceedings, as well as local experiments in developing countries when compared to restrictive databases such as Scopus or the Web of Science [26]. The E-STREAM framework is very contextual and newly developed, the use of Google Scholar minimizes the risk of loss of grey literature which is the initial foundation of this research novelty [27]. The search strategy is limited to the period 2015–2025 by a decade. Keyword combinations include: (1) "Environmental-STEM", (2) "Environmental-STEAM", and (3) "Environmental" and "STREAM". This initial auto-search collected 499 metadata records.

2.2. Screening Procedures and Inclusion Criteria

Based on the PRISMA protocol in the Identification step, 499 initial documents were obtained that were strictly screened. At the screening stage, duplicate articles, incomplete texts, and documents outside English and Indonesian were obtained, which were issued as many as 49 documents and left 450 articles. At the eligibility stage, an in-depth evaluation of abstracts and full texts was conducted on 210 relevant documents. The inclusion criteria set are: (1) published in 2015–2025, (2) being in the realm of science education, and (3) focusing on interdisciplinary approaches (STEM/STEAM/STREAM) related to environmental or sustainability issues. Articles with the theme of pure environmental engineering or pure religious ecotheology without a scientific pedagogical context were excluded from the dataset of 85 documents. The inclusion process obtained 125 final articles that were worthy of analysis.

2.3. Data Analysis and Bibliometric Mapping

The metadata of the final 125 articles is exported in RIS format and then imported into the VOSviewer application version 1.6.20 [28]. The analysis is centered on co-word analysis to map the relationship between concepts and trends in historical publications. The minimum appearance threshold for keywords is set 5 times. The software then generates network visualizations, overlays, and density to accurately detect research gaps around the E-STREAM framework.

2.4. Research Validation and Limitations

Validation of the mapping results is done by manually applying a thesaurus file in VOSviewer to unify variations of similar keyword spellings (e.g., "STEM" and "STEM education") and to clean up common terms that are not informative. The limitations of this study lie in the variation in the peer-review standards on Google Scholar as well as the reliance on specific query strings that allow for missed alternative terms.

3. Results and Discussions

Based on data obtained through Publish or Perish from the Google Scholar database for the period 2015–2025, the trend of publications themed around environmental integration in the framework of STEM, STEAM, and STREAM shows dynamic fluctuations. The volume of publications has been gradually increasing since 2015 and reached its peak in 2020. After that, the number of publications tended to stabilize in the 2021–2022 period before finally declining at the end of the observation period (2024–2025) shows on Figure 2.

Figure 2. Research Distribution from 2015-2025

Conceptually, the surge in publications that peaked in 2020 reflects the massive global academic response to the launch of the UN Sustainable Development Goals (SDGs) agenda and the growing international demand to integrate climate change education into school science curricula (UNESCO, 2020). This trend is in line with the argument of Li et al. (2020) [20] who stated that the last decade has been a phase of expansion in which interdisciplinary approaches such as STEM and STEAM are widely adopted to solve real-world problems, including environmental degradation. The downward trend at the end of the period (2024–2025) does not necessarily indicate a decrease in interest in environmental issues. Global researchers are beginning to realize the limitations of a purely technical interdisciplinary approach, thus triggering a shift in research focus from just quantitative mapping to the search for new frameworks that are more holistic and value-based [1], [2].

3.1. Keyword Cluster Analysis and Research Gap Strengthening

The network visualization generated by VOSviewer divided the keyword mapping (co-word analysis) of 125 selected articles into several main clusters that represented the focus of previous research. The dominant clusters are centered on the terms "environmental education", "STEM education", "STEAM", "sustainability", and "design thinking" (Figure 3).

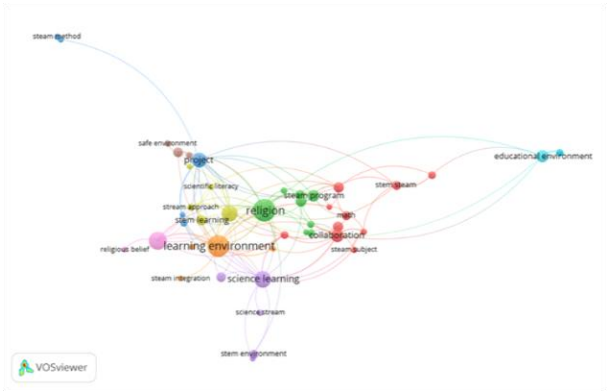

Figure 3. Network Visualization Cluster Keywords Research Interdisciplinary Science Environmental Education

Bibliometric visualization on Figure 3 shows a close relationship between environmental education, sustainability, environmental literacy, and STEM/STEAM approaches. The appearance of the keyword religion in the research network indicates that the religious aspect has begun to receive attention in the study of environmental education. Analysis of intercluster connectivity shows that research that integrates environmental education, STEM/STEAM approaches, and religious or spiritual values simultaneously is still relatively limited. These findings lead to opportunities for the development of an E-STREAM approach that connects environmental literacy, STEM competencies, and religious or spiritual values in an integrated learning framework to form responsible sustainable behavior.As a concrete example, in the literature on E-STEM, the main focus of research generally revolves around the effectiveness of project-based learning (PjBL) to create wastewater filtration tools or calculate the carbon footprint of schools [21]. In the E-STEAM cluster, the addition Arts elements is mostly only used to increase students' visual creativity in communicating waste recycling campaigns or designing digital posters about global warming [19].

The limitations of this previous literature are empirically shown by the total absence of interconnection between the keywords "religion" or "spiritual values" and the "environmental education" cluster in the VOSviewer map. Research that explicitly integrates ethical-religious and science-environmental aspects into a single E-STREAM instructional model has not been found in this decade.

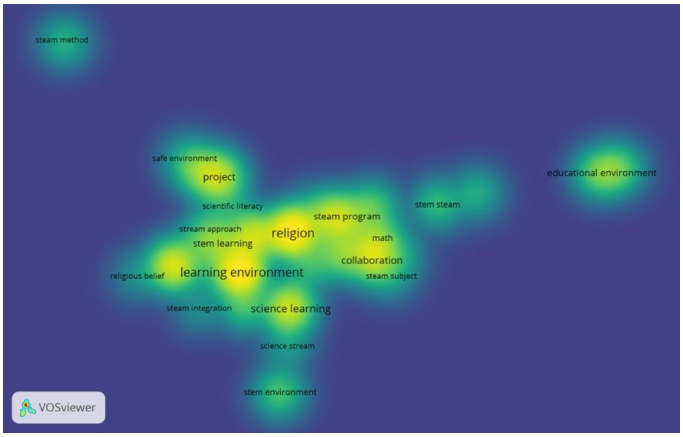

Figure 4. Density Visualization

The mapping results (Figure 4) show that the research network is still dominated by STEM and STEAM approaches, which is characterized by the emergence of several key keywords such as *learning environment*, *science learning*, *steam program*, *project*, and *collaboration* as a large node and is in a central position in the network visualization. The dominance of these nodes shows that the focus of science education research during the observation period is more directed towards the development of STEAM-integrated science learning through project-based and collaborative approaches, as well as strengthening the learning environment that supports active learning processes. These findings are in line with the results of previous bibliometric studies which stated that STEAM is the most developed and widely used approach in science education because it is considered effective in improving students' science literacy, creativity, and 21st century skills [29], [30]. Network visualization also shows that the learning environment has a very central role in research networks [30]. The connection of this term with various other keywords, such as *project*, *collaboration*, and *science learning*, shows that the learning environment is an important foundation in the implementation of STEM and STEAM learning. A conducive learning environment allows students to actively engage in the process of inquiry, experimentation, and real problem-solving through project-based learning. Supports the view that the success of integrated science learning is not only determined by the content or approach of the curriculum, but also by the quality of the learning environment that includes physical, social, and psychological aspects [28], [31]. The central position *of the learning environment* in the bibliometric network indicates that the development of STEAM-based science education is highly dependent on the creation of a learning ecosystem that supports collaboration, creativity, and active involvement of students.

Meanwhile, the results of the analysis show that terms that specifically represent the integration of the environment (environmental) and religion (religion) in the STREAM framework still appear with relatively small node sizes and have limited relevance compared to the term STEAM. This condition indicates that the research that explicitly develops the E-STREAM approach in science education is still relatively small and has not become mainstream in science education studies. Some research shows that environmental aspects are beginning to be widely integrated in STEAM learning, especially in the context of environmental education and sustainability, but these integrations generally still focus on science and technology aspects without involving the dimension of moral or religious values systemicallyatis [32], [33]. To strengthen the conceptual analysis of the mapping of the previous literature while emphasizing the novelty of this research, Table 1 presents a synthesis of empirical implementation as well as the main findings of several key literature related to the E-STEM and E-STEAM approaches.

Table 1. Study on the Implementation of E-STEM and E-STEAM in Science Learning

References	Findings
Sihombing *et al*. (2024)	Literature review on STEM-ESD (Education Sustainaiblity Development) integration through project learning, integration of STEM modules using sustainable development principles, inquiry methods in Indonesian education can improve sustainable awareness and critical thinking skills. The importance of policy reforms that emphasize interdisciplinary approaches, improved teacher training, and a comprehensive curriculum in integrating STEM and sustainable development [34].
Alkair *et al*. (2023)	The development of programs that combine Environmental-STEM with collaborative problem solving can encourage students to be actively collaborative and provide their skills in overcoming environmental problems through project design [35].
Artika & Rosemary (2023)	Students participating in the focus discussion group have low environmental awareness on the impact of climate change, less wise in the use of electricity and transportation, and low in waste management. The gap in the implementation of E-STEM in the national curriculum. Students should be introduced to the connection of nature through daily life problems through E-STEM so that they can be adaptable and resilient in facing climate change. Thus, the implementation of environment-based STEM learning can make students interested in learning science and provide a positive outlook on STEM disciplines [36].
Demir & Kose (2022)	STEM activities in nature in nature in the experimental group had a positive influence on students' environmental attitudes and STEM career interests. Increase students' perception of the field of engineering. The motivation level of students is high during STEM activities in nature and teachers benefit from STEM activities in nature [21].
Koculu & Girgin (2022)	E-STEM can improve student perception, process design, understand the ideas of various disciplines and their integration, and more meaningful learning on environmental issues. E-STEM is an effective and innovative way to inspire people to implement what they learn to solve complex environmental problems [37].
Helvaci (2021)	E-STEM can increase environmental knowledge, environmental awareness in prospective teachers and provide positive opinions during the learning process. It is necessary to implement E-STEM for prospective teachers in science courses [38].
Syahmani *et al*. (2021)	The results of the bibliometric analysis on the STEAM approach to improve environmental education and waste management literacy show that research publications on "Environmental Literacy", "STEAM", and "waste management" in the last 51 years are still rare. STEAM can be considered to develop students' environmental literacy in the theme of waste management [32].
Yıldırım (2021)	Case study to identify the opinions of prospective teachers through a STEM-integrated environmental education program (STEM-IEEP). (STEM-IEEP). The STEM-IEEP program can increase the environmental awareness of prospective teachers, develop a positive attitude and find solutions to environmental problems. The integration of the environment with STEM can develop 21st century skills, professional skills and contribute to technological advancement [39].
Helvaci & Helvaci (2019)	E-STEM provides positive statements from students regarding the environment, especially regarding the theme of recycling and the application of the use of various disciplines at the same time. Increased confidence, creativity of students in expressing ideas like an engineer. The importance of developing studies on E-STEM and arts aspects that can be done together with E-STEM [40].
Kaya & Elster (2019)	Education stakeholders should think critically in integrating STEM concepts in science teaching. The concept of the environment is integrated into the STEM pedagogical content knowledge framework (PCK) for teacher professional development. The need to pay attention to environmental literacy to help conserve natural resources. Environmental literacy is a key concept in science education. Environmental education must be an important part of teacher education. The environmental perspective in teacher education can be integrated through E+STEM+PCK [16].

The results of the literature review show that the integration *of Science, Technology, Engineering, and Mathematics* (STEM) with environmental aspects, often referred to as *Education for Sustainable Development* (ESD), plays an important role in science learning through *Project-Based Learning* (PjBL). The PjBL model provides students with the opportunity to learn technical concepts while facing complex real problems, such as climate change, energy crisis, and various other environmental issues [41], [42]. A literature review also shows that the integration of sustainable development principles and environmental aspects into STEM approaches increases students' sensitivity to the ecological impacts of various technological innovations [35], [43]. This approach trains students' critical thinking skills in analyzing and solving environmental problems around them. The approach increases students' career interest in STEM fields, develops creativity and design skills, and introduces the engineering profession to students [44].

The results of bibliometric analysis and literature review show that research that integrates environmental literacy, STEAM approaches, and environmental issues, especially waste management, is still limited [32]. This condition opens up opportunities to develop E-STEM and E-STEAM approaches that are integrated with religious aspects through the concept of *ecotheology* [45]. The integration encourages students to connect environmental literacy with religious values. In the Islamic perspective, the concept of *caliph fil ardh* affirms that humans have the responsibility to manage and prosper the earth (Q.S. Al-Baqarah, 2: 30), while Q.S. Al-A'raf 7: 56 prohibits humans from doing damage on the earth [45]. The integration of religious values in environmental learning has the potential to strengthen students' motivation to understand and maintain environmental sustainability through the internalization of moral and spiritual values that emphasize human responsibility to nature [46].

3.2. Pedagogical Implications and Research Directions of E-STREAM

These bibliometric findings have profound pedagogical implications for the future of science education, especially in a country with strong religious-cultural characteristics such as Indonesia. The absence of a global E-STREAM model in the scientific literature is an opportunity as well as an urgency for local educators to pioneer science curriculum reform based on spiritual-ethical values. Practically, the science curriculum must no longer separate the laws of nature (biology/chemistry) from the moral responsibility of man as a caliph or *stewardship* mandated by religious values [23]. Future pedagogical implementations of E-STREAM can be designed through the integration of ecotheology concepts into problem-based learning models or contextual projects, such as the integration of PjBL-ESD (*Project Based Learning - Education for Sustainable Development*) [42]. For example, when students study the topic of water pollution, they are not only taught the chemical aspects (pH levels and pollutants) and engineering aspects (making STEM-based water filters), but also invited to reflect on religious values regarding the purity of water, the prohibition of doing damage to the earth, and the spiritual responsibility to preserve natural resources for future generations. This approach ensures that the science literacy students acquire in the classroom transforms into ecological empathy that encourages pro-environmental actions consistently and voluntarily in daily life [47], [48].

As future research directions, the macro roadmap resulting from bibliometric analysis paves the way for new empirical research. Further research is needed that focuses on: (1) the development of valid and practical E-STREAM-based learning tools (such as E-Modules or RPPs); (2) testing the effectiveness of the E-STREAM model in simultaneously improving students' environmental literacy and religious character through experimental methods in the classroom; and (3) exploration of the perception and readiness of science teachers in integrating religious values into interdisciplinary scientific materials. The research gaps found in this bibliometric study can be immediately filled with empirical evidence that contributes significantly to the development of sustainable science education at the local and international levels.

4. Conclusions

This bibliometric study makes a significant theoretical contribution by mapping the landscape of global publications on the integration of environmental issues in interdisciplinary science education (STEM, STEAM, STREAM) for the period 2015–2025. Key findings reveal that despite the surge in publications following the UN SDGs agenda, academic discourse is still stuck on purely technical-cognitive boundaries. The crucial contribution of this research is empirical proof of the existence of a fundamental research gap, where there has not been a systematic integration between aspects of environmental sustainability and religious moral values in a single Environmental-STREAM (e-STREAM) framework. The discovery of this research gap emphasizes the novelty of this study as well as an epistemological critique that contemporary environmental education is losing its affective-spirituality dimension, which is actually the main moral anchor of human beings in manifesting sustainable pro-environmental behavior. While providing a comprehensive macro roadmap, the limitations of this study lie in the use of a single Google Scholar database via Publish or Perish that has heterogeneous peer-review standards, as well as the risk of missing alternative terminology due to reliance on specific query strings. As future research directions to fill these gaps, research should be directed to: (1) research and development (R&D) of E-STREAM-based learning tools to test their effectiveness on students' environmental literacy and religious character; (2) reconstruction of the science curriculum that is able to bridge pure science material with ecotheology in harmony; and (3) the implementation of the teacher professional development program to improve the readiness and pedagogical competence to the a new research with the same of scopes and biology school laboratory activity.

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