Eco-Friendly Pedagogies For STEM Education: A Review

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Abstract

Higher education institutions typically employ teaching methods that are demands of successful learning in a society that is always learning. Throughout history, changing people's awareness, concerns, and attitudes through education has proven an effective strategy for combating social, economic, and sustainable development challenges. The study analyzes the secondary literature from the Scopus, Springer Link, and Google Scholar databases. For this, the articles were selected using keywords, and the range was from 2015 to 2023. For this purpose, N=292 research articles were analyzed by following inclusion and exclusion criteria. The Prisma flow chart (Liberati et al., 2014) was implemented to objectively scrutinize the papers from the source. The study results reveal that there is dearth of use of ecofriendly pedagogies for skills and competencies development. Skills should be developed among young learners with the help of eco-friendly teaching approaches for science, technology, engineering, and mathematics (STEM) by implementing project-based learning, field trips, and the use of 3R-based activities for sustainability, nurturing young minds, empowering

entrepreneurs, and working collectively for sustainable future. It is recommended that teachers, policymakers, management, and government bodies should implement the polices to ensure teaching and learning should be based on the ideology of the amalgamation of environmental protection, social justice, and economic vitality to build communities that are not only sustainable for the present but also for future generations.

Key Words: Eco-friendly, Teaching, Learning, Sustainable Development, Pedagogies.

Introduction

To foster educational excellence and shrink opportunity gaps by imparting knowledge, entrepreneurship skills, language competencies, and soft skills to produce marketable young graduates for the socioeconomic development of Pakistan (Lashari & Umrani, 2023), there is a dire need to revisit the teaching criteria that can contribute to the productivity of the learners in Science, Technology, Engineering, and Mathematics (STEM) education. Eco-friendly teaching pedagogies aim to minimize their adverse effects on the environment while simultaneously fostering environmental sustainability and consciousness in the classroom (Kelley & Knowles, 2016).

The earth's biological, chemical, and geological cycles are under enormous pressure in the age of the Anthropocene (Steffen et al., 2007) due to human-caused resource misuse and usage at a scale never seen before (Barnosky & Hadly, 2016). Resolving complicated environmental and conservation challenges requires more than just conducting pertinent, high-quality scientific research and communicating the results to decision-makers (Knight et al., 2019; Lemos et al., 2018; Toomey et al., 2017). Throughout history, changing people's awareness, concerns, and attitudes through environmental education has proven to be an effective strategy for combating environmental degradation (Khan, Lashari & Iqbal, 2022). We need environments that work together to enhance and complement social, political, and economic contexts

through the practical application and understanding of research findings.

Given the escalating environmental concerns and the pressing imperative for sustainable development, the education domain has experienced a fundamental transformation in its approach, which now integrates eco-friendly practices (Hernández-Barco et al., 2021). The change, as mentioned above, is especially evident within the realm of STEM (Science, Technology, Engineering, and Mathematics) education, as educators are actively investigating novel instructional approaches that not only augment scholarly acquisition but also cultivate a profound commitment to ecological stewardship among students (Cebrián & Junyent, 2023). This paper examines the developing field of environmentally conscious teaching methods in the context of STEM education. It investigates the many approaches, advantages, and obstacles to incorporating sustainability principles into the educational process.

Problem Statement

The growing international apprehension regarding the preservation of the environment calls for a thorough evaluation of educational methodologies to cultivate environmentally conscious principles, specifically within the STEM (Science, Technology, Engineering, Arts, and Mathematics) education framework. The need to incorporate STEM education to cultivate critical thinking and creativity is generally recognized (Zeidler, 2016). However, an urgent need is to examine and adopt efficacious, environmentally friendly pedagogical approaches within educational settings. Academic practices frequently lack a unified system to include environmental awareness in STEM disciplines (Alam, 2021). This deficiency can impede the cultivation of a cohort capable of effectively tackling urgent ecological issues. This study aims to identify gaps in current eco-friendly teaching methods for STEM education, investigate novel approaches, and suggest recommendations that enhance students' environmental consciousness, accountability, and sustainable behaviors. This research contributes to the overarching objective of

preparing a future awarded generation that values ecological stewardship and academic achievement.

Scope of the study

The amount of plastic waste entering the oceans (The Guardian, 2020), the current rates of deforestation (RTL Today, 2021), the dangerous effects of climate change (Insurance Journal, 2021; The New York Times, 2021), and the flooding in Pakistan (Waseem & Rana, 2023; Bhamani, 2022) are notable examples of how this degradation has become more noticeable in recent years. The necessity for environmental education for sustainable growth has increased due to this circumstance. Education should raise people's knowledge, change future generations' behavior regarding severe ecological conditions, arouse human concern, and motivate them to change their habits and behaviors. In this regard, the study will contribute to teaching eco-friendly methods for a sustainable future in Pakistan.

The present study aims to explore eco-friendly teaching approaches for STEM (Science, Technology, Engineering, and Mathematics) education. It seeks to thoroughly examine the existing state of environmental integration within STEM disciplines. The research will investigate current pedagogical strategies, curriculum structures, and educational policies to assess how environmentally sustainable principles are integrated. Furthermore, the study will examine educators' obstacles when incorporating environmentally conscious pedagogical approaches in science, technology, engineering, and mathematics (STEM).

In addition, the research will investigate the effects of environmentally conscious instructional approaches on academic achievements, cognitive growth, and attitudes about ecological sustainability among students. Emphasis will be placed on interdisciplinary methodologies, the integration of technology, and novel pedagogical strategies that promise to reshape conventional STEM education into a framework for nurturing environmentally conscious and ecologically literate individuals.

The amalgamation of Eco-friendly and STEM Education

STEM education has experienced a surge in recognition due to its multidisciplinary methodology, which promotes the development of critical thinking, problem-solving abilities, and creativity in learners. Nevertheless, in light of global environmental challenges such as climate change, pollution, and resource depletion, educators progressively acknowledge the necessity of including ecological awareness in STEM curricula (Sırakaya & Sırakaya,2022). The convergence of environmentally sustainable practices with STEM education presents a distinct prospect for nurturing a cohort of environmentally aware persons with the requisite knowledge and competencies to tackle intricate global issues.

Eco-Friendly Pedagogies

The primary focus of this discourse revolves around examining critical pedagogical approaches that promote environmental sustainability within the realm of education. This study examines a range of environmentally conscious teaching methodologies that educators are implementing to integrate STEM education with objectives related to sustainability. The pedagogical approaches encompass project-based learning centered around environmental themes, experiential activities prioritizing ecological principles, and augmented reality (A.R.) use of green technologies in the classroom setting (Pimthong & Williams, 2018). Furthermore, the impact of outdoor and nature-based educational experiences on cultivating a more profound bond between students and the natural environment generates a heightened sense of duty toward preserving the domain (Moore & Smith, 2014).

Method & Procedure

Bibliometric Analysis

The study used bibliometrics to analyze educational paradigms like eco-friendly pedagogies trends and impacts on learning outcomes. This emerging theme in education is studied using the bibliometric methodology to analyze scholarly publications and academic collaborations in the relevant literature. Bibliometric analysis of eco-friendly

pedagogies examines many academic databases and archives to find themes, significant authors, and trends.

Bibliometric analysis encompasses several methodologies, such as historical analysis, keyword analysis, citation analysis, institution analysis, and content analysis. A historical study was undertaken to construct a chronological research framework on the trends of eco-friendly pedagogies for sustainability globally from 2015 to 2023. The objective of keyword analysis is to ascertain the specific terms various researchers employ in their scholarly investigations. A network comprising the most often occurring keywords was built using Google Scholar, Scopus, SpringerLink, Elsevier, and Willey Online.

Thematic Analysis

The study used thematic analysis for the analysis of the available literature. It is a qualitative way of analyzing data that involves systematically identifying, managing, and interpreting patterns of themes within a dataset (Braun & Clarke, 2012). The objective of the analysis is to ensure the investigation's objectivity and results and to conduct the research to avoid vagueness, abstraction, conceptual difficulty, and excessive complexity. The PRISMA framework was employed to carry out a theme analysis. Researchers extensively utilize the PRISMA framework as a highly dependable approach for conducting systematic literature reviews.

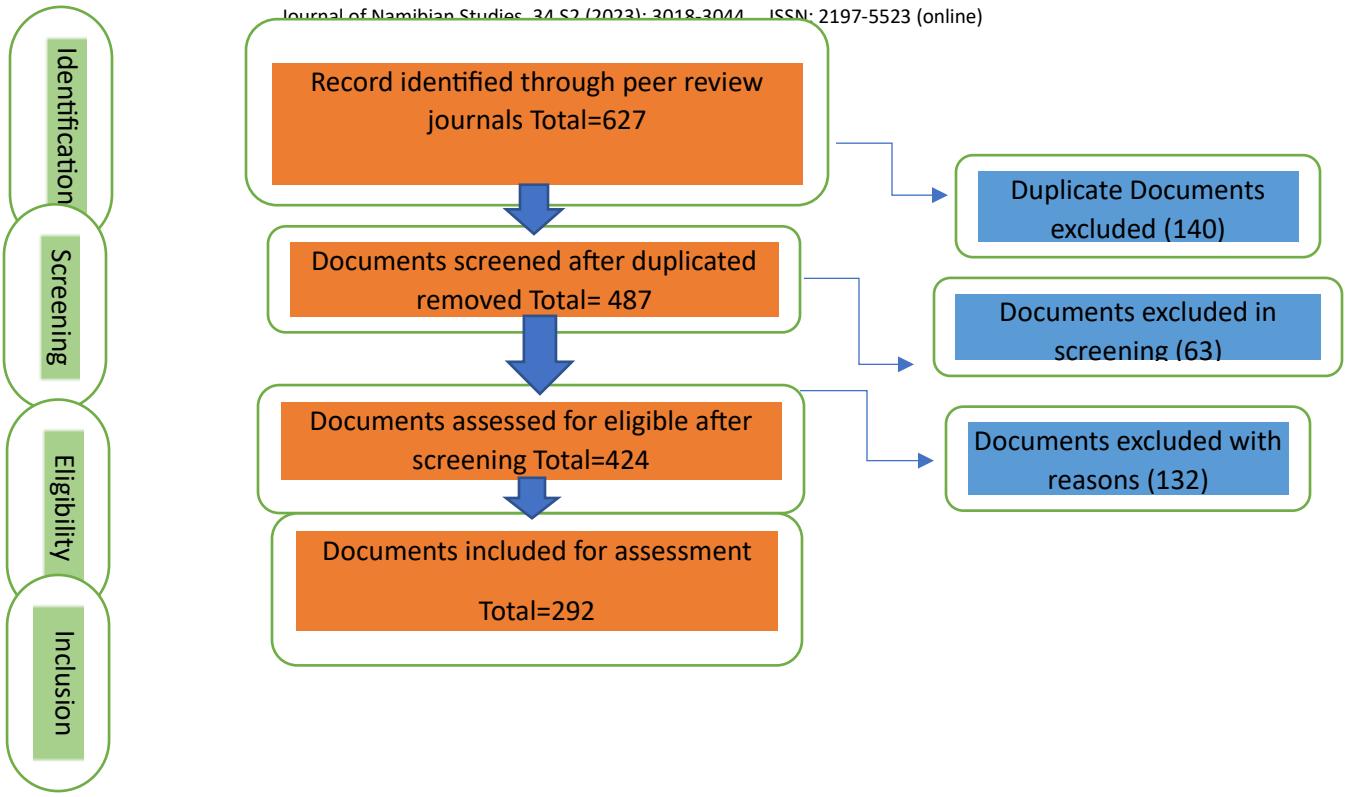

Fig 1. PRISMA flow chart (adapted from Liberati et al., 2014).

The study uses a Prisma flowchart to scrutinize the papers in the context. The search for relevant literature by adopting the robust technique to ensure the objectivity of the research and to find and analyze the literature pertinent to confirm the validity of the results.

Results and Discussion

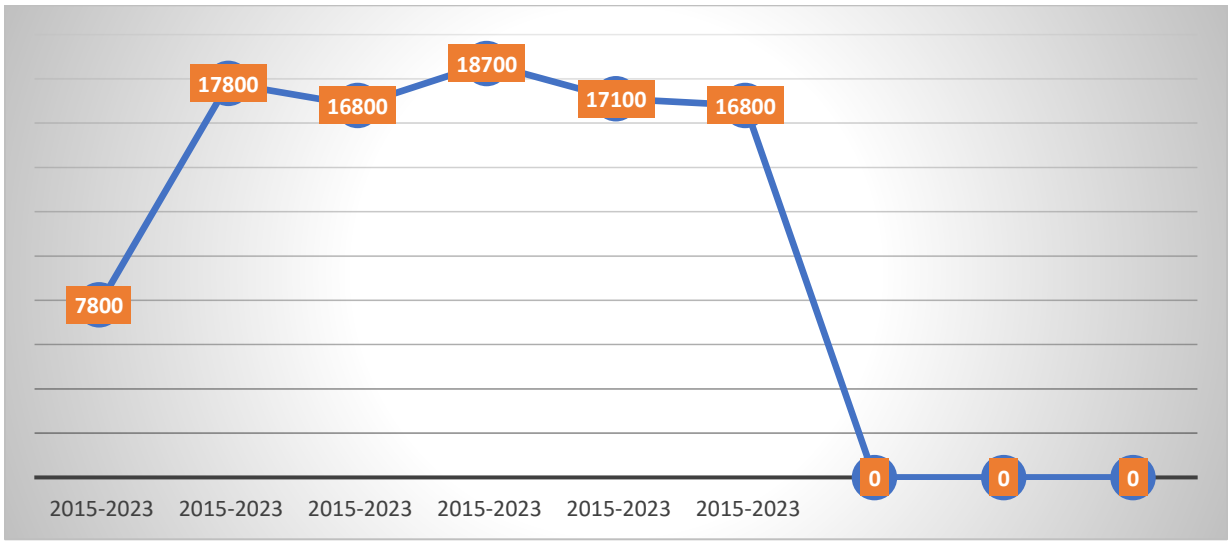

Fig 1. Google Scholar Data Set from 2015 to 2023

The graph shows the eco-friendly pedagogies-based search research data increases year-wise. A good surge has developed from the year 2015 to 2023.

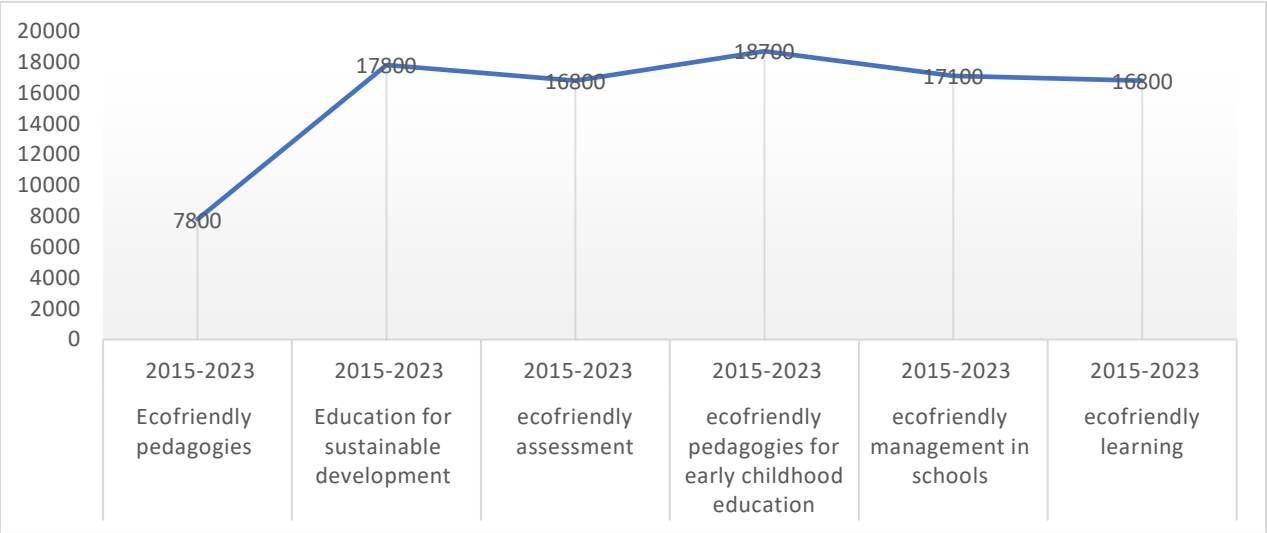

Figure 2. Themes-based search on Google Scholar

The search results from 2015-2023 on Google Scholar indicate that ecofriendly pedagogies-based themes are at the minimum level while education for sustainable development and ecofriendly pedagogies for early childhood education are at the highest level of 18700 without extracting the data set.

Discussion

Outdoor Learning

Using outdoor learning is increasingly acknowledged as an environmentally conscious pedagogical approach that augments scholastic achievement and cultivates a more profound affinity with the natural world (Zeidler, 2021). According to existing research, extending education beyond the confines of conventional classroom environments to outdoor settings offers learners distinct prospects for interacting with the natural world, fostering a heightened feeling of responsibility towards the environment (Bilton, 2010). This strategy follows sustainability and environmental consciousness since it effectively mitigates the carbon emissions linked to conventional educational infrastructure and promotes a more sustainable way of living. The studies

have demonstrated that engaging in educational activities in outdoor settings has been associated with higher cognitive abilities, heightened levels of creativity, and improved aptitude for resolving complex problems (Lewis & Poole, 2017). Moreover, including pupils in natural environments cultivates a heightened feeling of accountability toward the environment (Wan, Jiang & Zhan, 2021). Integrating outdoor learning into the curriculum is a promising pathway for fostering individuals (Ardoin et al., 2018) with academic proficiency and a dedication to preserving the environment.

Energy Efficiency

Numerous studies continuously emphasize the importance of energy-efficient systems in educational environments, specifically classroom heating, air conditioning, and lighting (Successful STEM Education, 2013). Using energy-efficient technology within these systems reduces operational expenses and contributes substantially to environmental preservation through the mitigation of carbon emissions (Isoda et al., 2017). Research indicates that fostering knowledge and understanding among students regarding the need to conserve energy plays a crucial role in promoting sustainable practices inside educational establishments (Zendler, Seitz, & Klaudt, 2018). Promoting the utilization of natural light among students and pushing for the mindful use of artificial lighting and electronic gadgets during inactivity can significantly contribute to energy conservation (González-Gómez, & Jeong, 2022). This strategy aligns with more comprehensive initiatives to foster environmentally sustainable behaviors and cultivate a sense of ecological accountability among the youth.

Reduce, Recycle, Reuse

The significance of imparting the principles of waste reduction, Reuse, and recycling to children as a vital component of environmental education is repeatedly emphasized in research (Yuksel, 2021). Research findings suggest that an early introduction to these principles cultivates a heightened awareness of ecological responsibility and a long-term dedication to adopting sustainable practices (Sulistyowati, Ananda, & Hudha, 2021). Educators can influence children's behavior and attitudes

about consumption and disposal by prioritizing waste reduction.

Implementing practical measures, such as providing recycling bins within educational settings and promoting students' utilization of recyclable containers and bottles, has had favorable results (Buana, 2016). Children's active engagement in waste sorting and recycling leads to increased consciousness regarding the environmental consequences associated with their decision-making (Saki et al., 2011). Engaging kids in transporting recyclable containers and bottles to school not only fosters individual accountability but also stimulates discussions around sustainable behaviors within the household. The correlation between the educational institution and the home strengthens the significance of waste management as a collaborative endeavor, expanding its influence beyond the confines of the academic setting (Faridy & Rohendi, 2021).

Existing research provides evidence of implementing practical strategies, such as introducing recycling bins and promoting the habit of bringing recyclable materials among students, as efficacious approaches to educating youngsters about waste reduction and recycling (Rudiyanto, 2021). These tactics foster the cultivation of an environmentally conscious generation and facilitate the formation of enduring habits that uphold sustainability principles.

Sustainable Materials

The utility of sustainable resources is paramount in cultivating an environmentally conscious educational setting within classroom environments (Howard et al., 2019). Numerous studies continually underscore the environmental ramifications of conventional teaching materials, underscoring the necessity of migrating towards sustainable alternatives(Urválková & Surynková, 2021; Siming, Asad, & Lashari, 2015). Using environmentally sustainable materials, such as recycled paper, biodegradable stationery, and non-toxic supplies, diminishes the ecological impact linked to the creation and disposal of educational resources (Siming, Asad, & Lashari, 2015). Additionally, this practice establishes a model for conscientious consumption within the student population. Integrating sustainable

materials into educational methodologies can holistically enhance the comprehension of environmental matters and foster a sense of responsibility toward the environment(Urválková. & Surynková, 2021). Furthermore, teachers should utilize these resources to develop interactive and experiential educational opportunities that prioritize the fundamental concepts of sustainability. Educational institutions can assume a pivotal role in exemplifying environmentally conscious behavior and fostering a dedication to sustainability in future generations by embracing a research-oriented methodology for material selection and promoting the utilization of sustainable resources.

Digital Learning

Utilizing online learning platforms and digital resources in education presents an evidence-based approach to effectively diminish paper use and foster ecological sustainability (Clark & Mayer, 2023; Lashari & Umrani, 2023). According to existing research, the utilization of e-books and digital textbooks has been found to result in significant reductions in paper consumption, hence mitigating the environmental consequences typically connected with conventional print materials (Adarkwah, 2021; Lashari et al., 2023b; Fayaz et al., 2023). By promoting online platforms for accessing course information, educators contribute positively towards reducing deforestation, reducing carbon footprints, and creating engaging and dynamic learning experiences (Adarkwah, 2021).

Research indicates that online homework submission is an additional means to enhance these endeavors (Mooman & Lashari, 2023). Transitioning from conventional paper-based assignments to digital submissions optimizes the assessment procedure and reduces reliance on paper resources (Abou-Khalil et al., 2021). Highlighting the advantages of digital submissions can catalyze students to adopt technology for educational objectives while engaging in environmental preservation. Furthermore, the incorporation of online learning tools not only offers ecological benefits but also aligns with the ever-changing digital environment, equipping students with the necessary

skills to meet the technological requirements of the future (Lashari et al., 2023a). The adoption of digital learning in educational institutions globally is becoming more prevalent (Lashari & Umrani, 2023). This trend highlights the strategic utilization of online platforms as a viable and progressive method. This strategy not only addresses the issue of paper waste reduction but also provides students with crucial digital competencies necessary for success in the modern day.

Planting Gardens and Composting

Instruct children in growing their food by starting a school garden. One way to teach kids about the advantages of minimizing food waste is through composting. Incorporating environmentally conscious pedagogical approaches, such as implementing garden cultivation and composting practices, can substantially enhance students' comprehensive and sustainable educational experience (Samejo, Lashari & Mahar, 2023). The cultivation of school gardens offers pupils a practical and immersive educational experience that fosters a connection between them and the environment. This activity enables individuals to observe the complete life cycle of plants, thus promoting comprehension of the relevance of biodiversity, the role played by pollinators, and the importance of maintaining healthy soil. In addition to its ecological advantages, gardening has the potential to foster physical activity, teamwork, and a sense of responsibility among students as they engage in the maintenance and nurturing of plants.

Implementing environmentally conscious teaching strategies can cultivate a lasting dedication to sustainable behaviors among students, thereby equipping them with the knowledge and ability to make well-informed decisions that positively impact the environment and promote overall planetary wellbeing.

Conservation Techniques

Implementing environmentally conscious teaching methods prioritizing preserving energy and water resources is pivotal in cultivating ecological consciousness among young learners (Fischer & Barth, 2015). By integrating sustainability

principles into the curriculum, teachers can develop a heightened sense of responsibility and environmental awareness among young learners. The teaching approaches must encompass academic information and actively involve students in practical activities that effectively illustrate the consequences of their actions on the environment (Camp & Fraser, 2012). Highlighting the need to conserve energy and water in households reinforces these ideas (Jacobson, McDuff, & Monroe, 2015), hence promoting the adoption of environmentally conscious behaviors among youngsters in their everyday routines. Teachers should integrate interactive instructional methods, practical experiments, and tangible instances from everyday life to effectively demonstrate (Kaye et al., 2015) the correlation between individual behaviors and their corresponding environmental impacts.

Field Trips

Eco-friendly pedagogical approaches contain a comprehensive framework for education that facilitates the transmission of knowledge and cultivates a heightened awareness of environmental stewardship among students. Incorporating field trips into the school curriculum represents a potent strategy for augmenting the eco-friendly approach (Stevenson et al., 2019). Instead of limiting education to the confines of a traditional classroom setting, field trips allow children to interact directly with the natural world (Schneiderhan-Opel & Bogner, 2021), cultivating a profound bond with the environment. These excursions offer distinctive chances for experiential learning, allowing students to witness natural systems, biodiversity, and sustainable practices in operation.

An educational excursion of significant influence could encompass visits to environmentally conscious establishments, such as organic farms, renewable energy installations, or recycling centers (Moteea, 2022). These excursions provide students with tangible instances of sustainable practices and technologies (Putz, Treiblmaier, & Pfoser, 2018), fostering a critical thinking mindset (Heras, Medir, & Salazar, 2020) on their environmental impact.

Furthermore, an environmentally conscious pedagogical approach entails the reduction of the ecological impact associated with educational endeavors (Amado, 2022). This may involve selecting materials with minimal waste generation, promoting energy-efficient practices, and encouraging environmentally friendly transportation alternatives for field excursions (Sánchez-Fuster, Miralles-Martínez, & Serrano-Pastor, 2023). Educational institutions, via the implementation of such practices, contribute significantly to the cognitive development of their pupils and the fostering of environmental awareness.

Environmental Education

Integrating environmental concerns into the curriculum, encompassing subjects such as climate change, pollution, biodiversity, and sustainable development, constitutes an essential aspect of environmental education. According to Sauvé (1992), six major principles of environmental education trends are aligned with teaching, learning, and curriculum design.

Environment as nature ... to be appreciated, respected, preserved

Comprehending and actively interacting with the natural world requires an experiential methodology that explores the complexity of the mechanisms behind natural phenomena. This perspective emphasizes the importance of firsthand interactions and direct experiences in understanding the intricate network of biological processes (Regan, 2017). The acquisition of theoretical information alone is insufficient in cultivating a clear idea connection and deep respect for the natural world. By immersing oneself in the natural environment, carefully examining its intricate patterns, and actively experiencing its inherent rhythms, individuals can acquire profound insights beyond mere comprehension derived from textbooks (Vilkka, 2021). This experiential methodology enhances our understanding and fosters an excellent appreciation for the intricate equilibrium inherent throughout ecosystems (Brady, 2019). This phenomenon enables individuals to view nature not merely as an abstract concept but as a dynamic and linked actuality. By actively participating in this close interaction, individuals

are more aptly prepared to make well-informed decisions and actively participate in sustainable practices, thereby playing a role in the conservation and balance of the natural environment.

Environment as a resource ... to be managed

The environment is an essential and limited asset that supports life. Researchers and environmental scientists emphasize the imperative of effectively managing the environment to safeguard its sustainability and promote the well-being of current and future generations (Salman et al., 2023). Environmental management includes the meticulous and conscientious use of natural resources, the conservation of biodiversity, and the amelioration of anthropogenic effects such as pollution and climate change (Brady, 2019). By thoroughly comprehending the surrounding ecosystem and making well-informed choices, society can guarantee the appropriate management of this unique resource, benefiting both present and future generations.

Environment as a problem ... to be solved.

Within the field of education, there is an increasingly acknowledged need to integrate environmental challenges as issues that must be addressed within the frameworks of teaching and learning. Educators are progressively incorporating these tangible issues into the academic curriculum in light of the intricate environmental challenges our global community faces, like climate change, biodiversity depletion, and pollution. This strategy aims to provide students with the essential skills of critical thinking, scientific knowledge, and problem-solving capabilities required to tackle environmental concerns effectively. In addition, the integration of ecological problem-solving into educational curricula cultivates a collective consciousness of environmental stewardship, thereby motivating students to assume the roles of knowledgeable and accountable individuals((Rehman, Lashari & Abbas, 2023) who actively contribute to the promotion and implementation of sustainable practices (Fletcher, 2015).

Environment as a "place to live"... to know and learn about, to plan for, to take care of

Within the field of education, there is an increasingly recognized notion that the educational setting should not merely be perceived as a passive backdrop for learning but instead, as an active and dynamic "habitat" - a physical space that is deeply understood, utilized for learning purposes, strategically planned for, and responsibly maintained (Vilka, 2021). The significance of cultivating a sense of connection and stewardship towards the natural world is underscored in scholarly investigations on environmental education(Simming, Asad & Lashari, 2015; Shutaleva et al., 2020). Educators strive to comprehensively comprehend the ecosystems in which students reside by integrating the environment as a focal point in the pedagogical process. This approach promotes the development of environmental literacy (Samejo, Lashari & Mahar, 2023), which empowers individuals to make well-informed choices and actively engage in the sustainable governance of their environment. Employing practical learning, field visits, and community engagement, students can investigate their immediate surroundings, recognize environmental concerns, and formulate approaches for preserving natural resources and promoting sustainable lifestyles (Rehman, Lashari & Abbas, 2023). Current research examines pedagogical strategies that are effective in education and explores the effects of incorporating the environment as a "habitat" within educational frameworks (Shutaleva, Nikonova, Savchenko, & Martyushev, 2020). The objective is to foster a generation that understands the interdependencies between human and natural systems and is motivated to contribute to their environment's welfare actively.

Environment as the biosphere ... in which we all live together into the future

Within the field of education, there is an increasing focus on integrating the environmental idea of the biosphere into instructional practices and educational experiences. The significance of perceiving the environment as more than a collection of separate ecosystems but rather as a cohesive and interrelated biosphere in which all forms of life cohabit is emphasized by research (Shutaleva, Nikonova, Savchenko, & Martyushev, 2020). Educators acknowledge the importance of cultivating a comprehensive comprehension

of the intricate interconnectedness of life on earth, which includes ecosystems, biodiversity, and the complicated equilibrium of natural phenomena. By integrating the biosphere as a focal point in educational instruction (Rehman, Lashari & Abbas, 2023), students acquire a deeper understanding of the intricate interdependencies between living creatures and their surroundings, cultivating a heightened ecological consciousness (Erhabor & Don, 2016). This method fosters a proactive mindset, urging pupils to contemplate the long-term viability of human endeavors about the whole ecological system. Ongoing research endeavors aim to investigate efficacious instructional strategies (Rehman, Lashari & Abbas, 2023), curriculum development, and the consequences of integrating the biosphere concept into educational practices (Hoang & Kato, 2016). The overarching objective is to equip forthcoming generations with the knowledge and skills necessary to assume the role of conscientious custodians of the earth, fully aware of their responsibility to preserve the well-being and coherence of the biosphere for future generations.

Environment as a community project ... in which to get involved

Participating in environmental education as a communal endeavor presents a comprehensive method of acquiring knowledge beyond conventional classroom settings. This study highlights the need to incorporate ecological subjects into community-based educational programs (Samejo, Lashari & Mahar, 2023). By cultivating a symbiotic relationship between education and the environment, individuals acquire scholarly information and deeply comprehend their responsibility in safeguarding the earth (Ahmed, Lashari, & Golo, 2023). The community functions as a dynamic educational setting wherein individuals can engage actively in practical endeavors, such as community gardens, waste reduction initiatives, or local conservation undertakings (Lashari et al., 2023). This method fosters a sense of responsibility towards the environment and promotes a dedication to implementing sustainable practices within the community. Numerous studies continuously demonstrate that experiential learning within a community context has been found to augment

understanding and memory retention, hence offering a more comprehensive educational encounter (Wahid, Ghazi & Lashari, 2023). Therefore, integrating environmental education within community initiatives serves as a driving force for empowering individuals and communities alike, fostering the development of knowledgeable citizens committed to preserving the environment for posterity.

Green Building Design

The integration of environmentally conscious design ideas can be observed in the construction or renovation of educational facilities, sometimes called green building design. Topics such as energy-efficient windows, insulation, and renewable energy sources can be explored in educational settings with students.

Green building design has become crucial in promoting environmentally sustainable teaching and learning settings, substantially impacting the educational sector(Simming, Asad & Lashari 2015). Incorporating sustainable practices in building design has a wide-ranging impact that extends beyond structural considerations, embracing the entirety of the educational experience. Green buildings significantly enhance the indoor environment's quality, thereby fostering students' well-being and productivity. The learning environment is enhanced by improved air quality, abundant natural light, and efficient temperature regulation.

Furthermore, incorporating renewable energy sources and energy-efficient systems in green buildings follows environmental preservation objectives, as it reduces carbon footprints and minimizes resource utilization. These sustainable characteristics provide concrete illustrations for students, strengthening their commitment to ecological responsibility and cultivating a culture of environmental stewardship. In addition, green building designs frequently include water-saving technologies, thereby fostering water conservation and imparting knowledge to students regarding the significance of conscientious water utilization.

Furthermore, incorporating green building solutions can function as educational instruments in their own right. Educational institutions that embrace sustainable designs

can integrate the fundamental principles of environmental sustainability into their academic programs, allowing students to engage in practical, experiential learning and gain exposure to tangible instances of sustainability in action. The comprehensive approach to education encompasses not only the dissemination of theoretical information but also the cultivation of a practical comprehension of the interdependencies between the constructed environment and the natural ecosystem.

The influence of green building design on creating environmentally conscious teaching and learning environments is significant. By strongly emphasizing sustainability within educational infrastructure, institutions can make significant contributions to global environmental conservation initiatives while simultaneously fostering the development of a generation of ecologically aware and responsible individuals. Incorporating green construction principles into educational environments is a driving force for promoting positive transformation, enabling a future in which ecological consciousness is essential to the educational journey.

Project Based Learning

Project-based learning can effectively involve students in experiential and practical learning encounters centered around environmental concerns (Fayaz et al., 2023). Examples of such activities include the development and execution of recycling initiatives, the undertaking of ecological research endeavors, and the creation of public awareness campaigns.

Eco-Clubs

Promote the establishment of eco-clubs or environmental action organizations within the educational institution. These groups can undertake projects and initiatives to promote sustainability within the campus environment.

Eco-Clubs are crucial in advocating and implementing environmentally conscious pedagogical approaches within STEM (Science, Technology, Engineering, Arts, and Mathematics) education inside educational institutions.

These student-led clubs aim to include environmental sustainability into the curriculum to foster a cohort of environmentally sensitive persons. An essential approach entails integrating real-world environmental challenges into STEM (Science, Technology, Engineering, Arts, and Mathematics) education, enabling students to engage in critical thinking and problem-solving while exploring potential solutions. For example, scientific and technological lessons can effectively incorporate programs focusing on renewable energy, waste reduction, and biodiversity conservation.

In addition, Eco-Clubs emphasize using practical, experiencing methods to facilitate learning, specifically about eco-friendly practices. Students have the opportunity to actively participate in worthwhile endeavors such as the creation of recycled art, the development of sustainable technological solutions, or the involvement in ecological field trips. These activities aim to cultivate a more profound comprehension of environmental issues among students. This strategy facilitates knowledge acquisition among students and develops a sense of accountability and guardianship toward the environment.

Conclusion

Integrating environmentally conscious teaching methodologies in STEM education yields many advantages, encompassing increased student involvement and enthusiasm and fostering a commitment to environmental responsibility. Nevertheless, this review undertakes a critical analysis of the difficulties linked to the implementation of these pedagogical approaches. These issues encompass the necessity for adequate teacher training, resource limitations, and the possibility of encountering resistance to change within conventional educational systems.

This review culminates by delineating prospective directions for future research and development within eco-friendly teaching pedagogies for STEM education as the area evolves. Further, there is an enormous research gap in several areas, including exploring breakthrough technologies, forming best practices, and formulating legislative proposals to encourage integrating eco-friendly ideas into STEM education.

This paper aims to contribute to the ongoing academic discussion on the convergence of environmentally conscious teaching methodologies and STEM (Science, Technology, Engineering, and Mathematics) education. Through a comprehensive comprehension of the present state of affairs, obstacles, and potential prospects, persons in the field of education, policymakers, and researchers can together strive towards cultivating a cohort of environmentally aware individuals who possess the necessary skills to tackle the intricate difficulties of the contemporary period.

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