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EFFECTIVENESS OF AN EDUCATIONAL UNIT IN READING FOR DEVELOPING SUSTAINABILITY CONCEPTS THROUGH GREEN EDUCATION PRINCIPLES IN EARLY CHILDHOOD

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ABSTRACT

Objectives: This study aims to evaluate the effectiveness of an educational unit in reading for developing sustainability concepts through green education principles in early childhood. Specifically, it investigates how the proposed unit enhances students' sustainability concepts in three areas: environmental, economic, and social sustainability. It is hoped that the objectives of this study will be in line with the fourth goal of the Sustainable Development Goals, which is quality education (SDG 4).

Theoretical Framework: The study is grounded in green education principles, which emphasize integrating sustainability concepts into early childhood education. This framework aims to foster critical thinking, environmental awareness, and responsible behavior. A conceptual framework was developed to align reading activities with the sustainability dimensions.

Method: A quasi-experimental research design with a single-group pretest-posttest approach was used. The sample consisted of 30 male third-grade students from Al-Hufuf's Tenth Primary School in Al-Ahsa, Saudi Arabia, selected through simple random sampling. An educational unit based on green education principles was developed, incorporating targeted sustainability concepts. A sustainability concepts test was administered before and after the intervention.

Results and Discussion: The results revealed statistically significant differences between pretest and posttest scores, demonstrating the effectiveness of the proposed unit in improving students' sustainability concepts. The Blake Effectiveness Coefficient confirmed the educational impact.

Research Implications: This study underscores the importance of incorporating sustainability education into early childhood curricula. It shows that well-designed educational units can effectively enhance sustainability concepts, helping foster a generation capable of responsible decision-making for a sustainable future.

Originality/Value: This study contributes to green education research by providing empirical evidence of the effectiveness of a reading-based educational unit in improving sustainability concepts in early childhood. It highlights the value of integrating sustainability principles into educational activities.

Keywords: quality education (SDG 4), green education, sustainability concepts, early childhood education, reading activities, Sustainable Development Goals (SDG).

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1 INTRODUCTION AND THEORETICAL FRAMEWORK

Green Education plays a crucial role in fostering sustainability through well-designed educational curricula. By incorporating eco-friendly practices and sustainable development principles into various subjects, these curricula equip students with the necessary skills to address environmental challenges (Utari *et al.*, 2024). Such educational programs cultivate critical thinking and problem-solving abilities, empowering students to adopt sustainable behaviors and contribute to a more resilient future (Gaweł *et al.*, 2024).

Education for sustainability can be integrated into curricula across all educational levels, from early childhood to university, serving as a crucial tool for fostering environmental awareness and promoting sustainability concepts among students (Davis & Elliott, 2023). In early childhood, targeted activities focusing on nurturing a love for nature and its preservation can lay the foundation for environmental understanding. As students advance through their education, sustainability education can be incorporated into various subjects, including science, geography, and mathematics, thereby deepening their comprehension of environmental challenges and solutions (Gal, 2023).

Green Education represents a modern educational paradigm that integrates two fundamental dimensions: environmental awareness and sustainable development. These intertwined elements aim to cultivate a generation capable of addressing environmental challenges while promoting sustainable practices. The core objective of Green Education is to enhance students' environmental consciousness and simultaneously foster their intellectual and social skills. By engaging in eco-friendly activities, students contribute to creating a healthier, more sustainable environment that aligns with global sustainability goals (Kwilinski *et al.*, 2023).

At its heart, Green Education is a transformative process aimed at equipping young individuals with the knowledge and tools to identify and solve

pressing environmental issues. This approach instills a proactive mindset toward environmental stewardship, empowering students to devise solutions that prevent the escalation of environmental crises. Educational institutions play a pivotal role in this process by embedding environmental science and sustainability topics into primary and secondary school curricula (Robayo-Acuña *et al.*, 2023).

Green Education extends beyond traditional classroom instruction, encompassing diverse programs and initiatives that prioritize environmental sustainability. These initiatives range from promoting renewable energy usage and waste reduction strategies to fostering water conservation and sustainable agricultural practices. Moreover, sectors like transportation and construction are increasingly incorporating green practices into their educational and training modules, emphasizing the importance of integrating sustainability into all aspects of life (Salazar *et al.*, 2024).

In essence, Green Education serves as a catalyst for societal change, aiming to create a generation of environmentally responsible citizens. Through its comprehensive approach, it not only addresses current environmental challenges but also lays the foundation for a more sustainable future. By fostering a culture of environmental responsibility, Green Education ensures that future leaders are equipped with the knowledge and skills necessary to build a resilient and sustainable world (Yin *et al.*, 2024).

In light of the above, it can be pointed out that the education system plays a crucial role in fostering awareness of sustainability among young students, particularly in early childhood and primary education, by incorporating green education into the curriculum. Through the integration of environmental principles, children not only learn the importance of conserving natural resources but also internalize the values of sustainability, applying them to their everyday lives. This foundational education enables them to understand the interconnectedness of humans and the environment, empowering them to make responsible decisions that benefit the planet. Furthermore, it lays the groundwork for continued environmental education in later stages, sharpening their critical thinking skills and preparing them to actively contribute to sustainable development.

In this context, a study by Yadav *et al*. (2022) emphasized the urgent need for a robust environmental education (EE) system to address environmental degradation, which has been exacerbated by factors such as industrialization, population growth, and increased demand for luxury goods. The authors highlighted that the lack of proper education and awareness regarding environmental issues has significantly contributed to the depletion of natural resources. The study stressed that sustainable development relies on raising public awareness, especially among students, researchers, policymakers, and communities, to enhance environmental security. Furthermore, it pointed out that successful environmental education programs are built on public participation and localized, sector-specific approaches to policy and planning.

A study by Uralovich *et al*. (2023) highlighted that environmental education is a key factor in achieving environmental sustainability and sustainable development. The study emphasized that humanity's negative impact on nature has disrupted the ecological balance, and relying solely on technology or legislation is insufficient to address these issues. Instead, it pointed out that raising environmental awareness and fostering a culture of environmental preservation through education are crucial for mitigating adverse effects and achieving the Sustainable Development Goals.

Vesterinen and Ratinen (2024) conducted a systematic literature review to explore sustainability competences in primary school education. Their study focused on identifying key sustainability competences, such as systems thinking, futures thinking, values thinking, collaboration, and action-oriented competence. The authors found that systems thinking and collaboration were the most frequently studied competences, while futures thinking received less attention. The review highlighted that fostering sustainability competences in primary school involves promoting dialogue, collaboration, and imagination among students, alongside active participation in environmental initiatives. This underscores the importance of integrating sustainability competences into primary education to equip students with the skills necessary for addressing global challenges.

Dube *et al*. (2023) highlight the importance of creating sustainable learning environments by adopting a posthuman and borderless curriculum. This approach, they argue, is crucial for addressing global challenges such as pandemics, and environmental crises. The authors emphasize that a borderless curriculum enables educators and students to think collaboratively and innovatively, fostering resilience and adaptability in the face of disruption. By integrating this model, the educational system can remain flexible and responsive to unforeseen challenges, ensuring continuity and relevance in teaching and learning practices. This perspective aligns with the broader goal of sustainability in education, where adaptation and cooperation are key to overcoming global issues.

Zguir *et al*. (2021) discussed the importance of embedding Education for Sustainable Development (ESD) and the values of the Sustainable Development Goals (SDGs) into curricula, emphasizing its role in shaping future generations' sustainability mindset. The authors reviewed various educational systems from countries like Singapore, New Zealand, and Qatar, illustrating how sustainability values are embedded in their curricula. They concluded that while progress has been made, there is still a need for more holistic and coordinated efforts to effectively incorporate sustainability education across educational systems, particularly in Qatar, to foster higher-order thinking and environmental mindfulness among students.

Sustainability is a multifaceted concept that emphasizes meeting the needs of the present without compromising the ability of future generations to meet their own needs. This principle lies at the heart of Green Education, as it seeks to cultivate a deep understanding among students of the delicate balance between human activity and the natural environment. By embedding sustainability concepts within educational frameworks, Green Education empowers learners to adopt a forward-thinking mindset, ensuring that economic development, environmental stewardship, and social well-being are pursued in harmony (Ekselsa *et al*., 2023).

Central to the idea of sustainability are its three interconnected pillars: economic, environmental, and social. These pillars, often described as "profit, planet, and people," underscore the need for a holistic approach to

development. Educational curricula designed around these principles help students understand the importance of integrating sustainable practices into various sectors, such as energy, agriculture, and industry. This comprehensive approach ensures that students can critically evaluate how their actions impact not only the environment but also economic stability and societal well-being (Carmen-Valentina *et al.*, 2023).

In the context of Green Education, sustainability serves as both a guiding principle and a learning outcome. Through active engagement with sustainability-related content, students develop the capacity to recognize and address complex global challenges such as climate change, resource depletion, and social inequality. These educational experiences foster critical thinking and problem-solving skills, which are essential for developing innovative solutions that prioritize long-term sustainability over short-term gains.

Moreover, sustainability concepts within Green Education extend beyond theoretical knowledge to practical application. Students are encouraged to participate in projects and initiatives that promote sustainable practices, such as reducing waste, conserving resources, and advocating for policies that support environmental justice. These experiential learning opportunities not only reinforce the theoretical foundations of sustainability but also instill a sense of responsibility and agency in students to act as change-makers in their communities (Uralovich *et al.*, 2023).

Acosta Castellanos and Queiruga-Dios (2022) conducted a systematic review to analyze the shift from Environmental Education (EE) to Education for Sustainable Development (ESD) in education, specifically within the context of engineering education. The study revealed that while ESD has gained significant momentum globally, particularly after the United Nations' Decade of ESD, EE still maintains a strong presence in certain regions. The authors noted that while ESD has been widely accepted in various educational systems, there is still limited research on integrating sustainability into engineering curricula. This underscores the need for further work on embedding sustainability concepts into education programs to promote long-term environmental and societal well-being.

The integration of sustainability concepts into educational curricula is crucial for shaping future generations capable of navigating the complex challenges of the modern world. By aligning learning objectives with the principles of sustainability, Green Education ensures that students are equipped with the knowledge, skills, and values needed to build a resilient and sustainable future. This approach not only addresses current environmental and social issues but also lays the groundwork for a more equitable and sustainable global society (Furu *et al*., 2023).

Reading activities within educational curricula present an effective opportunity for teaching sustainability concepts in a meaningful and engaging way. By incorporating texts that address issues such as environmental conservation, social equity, and sustainable development, educators can foster critical thinking and awareness among students. These activities provide a natural context for exploring how human actions impact the environment, encouraging students to reflect on the importance of sustainable practices. Additionally, reading materials that highlight real-world examples allow students to connect theoretical knowledge with practical applications, enhancing their understanding of sustainability's role in everyday life. Furthermore, reading activities serve as an essential tool for developing students' problem-solving skills and global awareness. Exposure to diverse narratives and case studies related to sustainability enables students to analyze complex issues from multiple perspectives, fostering empathy and a sense of responsibility. This approach not only strengthens literacy skills but also instills a commitment to long-term thinking and ethical decision-making. By integrating sustainability into reading activities, educators can cultivate a generation of learners equipped with the knowledge, skills, and values needed to create a more sustainable future.

2 IMPORTANCE OF THE STUDY

In the face of current environmental challenges and the pressing need to equip future generations with the knowledge and skills to address these issues through education, this study underscores the critical importance of integrating

environmental sustainability concepts into early childhood education. Green education plays a pivotal role in fostering awareness of sustainability among young children, enhancing their ability to think critically and creatively in tackling environmental problems from an early age. By introducing a proposed reading-based learning unit, the study seeks to assess the effectiveness of this educational approach in solidifying key environmental concepts and guiding children toward sustainable practices that can positively influence their daily lives. The learning unit addresses multiple dimensions of sustainability, including environmental sustainability, which emphasizes the protection of natural resources and environmental conservation; economic sustainability, which encourages understanding of resource management to support long-term economic growth; and social sustainability, which focuses on promoting social justice, equity, and human rights. Embedding these sustainability concepts in early childhood education not only nurtures a deeper understanding of sustainability but also lays the groundwork for fostering a generation that can contribute meaningfully to a sustainable future, encompassing all dimensions of sustainability that impact individuals, societies, and the environment.

It is hoped that the results of this study will highlight the importance of preparing suitable educational content and curricula for early childhood children, through the involvement of curriculum designers for this stage. This aims to integrate various sustainability concepts for children.

3 STUDY QUESTIONS

- What are the components of a proposed learning unit in reading for developing sustainability concepts in children in the early childhood stage?
- What is the effectiveness of a proposed learning unit in reading for developing environmental sustainability concepts in children in the early childhood?
- What is the effectiveness of a proposed learning unit in reading for developing economic sustainability concepts in children in the early childhood stage?

- What is the effectiveness of a proposed learning unit in reading for developing social sustainability concepts in children in the early childhood stage?

4 METHODOLOGY

4.1 STUDY DESIGN

This study employs an experimental approach utilizing a quasi-experimental design with a single-group pretest-posttest structure. The proposed learning unit will be delivered to students over a specified period, focusing on integrating sustainability concepts into reading activities. To evaluate the effectiveness of the educational intervention, a sustainability concepts test will be administered before and after the implementation of the unit. By comparing the pretest and posttest results, the study aims to identify any significant differences in students' understanding of sustainability concepts. This design allows for the measurement of the direct impact of the learning unit on students' cognitive development related to sustainability. The use of a pretest establishes a baseline for students' initial knowledge, while the posttest reveals the extent of learning gains attributable to the instructional intervention. Furthermore, this approach provides insights into the effectiveness of integrating sustainability into early education curricula, offering evidence-based recommendations for curriculum developers and educators seeking to enhance sustainability education in early childhood.

4.2 STUDY PARTICIPANTS

The participants in this study were third-grade male students from the Tenth Elementary School in Al-Hofuf, located in Al-Ahsa, Saudi Arabia. A total of 30 students were selected using simple random sampling. The selection process involved numbering the names of all third-grade students in the school and randomly choosing the participants. Since the school follows a gender-

segregated educational system, only male students were included in the sample.

The participants' average age was approximately 8 years, reflecting a developmental stage well-suited for the introduction of sustainability concepts through reading activities. This stage is critical for fostering curiosity, critical thinking, and foundational environmental awareness. By focusing on this group, the study seeks to explore the potential impact of green education at an early stage, contributing valuable insights into how sustainability education can be effectively implemented in primary education.

The homogeneous nature of the sample allows for a more focused analysis of the proposed learning unit's effectiveness, while the random selection ensures that the findings are not biased by prior knowledge or abilities. This approach enhances the study's validity and provides a robust basis for evaluating the learning outcomes related to sustainability concepts.

4.3 ETHICAL CONSIDERATIONS

Ethical considerations were carefully addressed in this experimental study to ensure the well-being, privacy, and rights of all participants. The following measures were taken in line with ethical guidelines and best practices in educational research:

Informed Consent: Before initiating the study, informed consent was obtained from both the school administration and the parents or guardians of the participating students. They were provided with detailed information about the study's objectives, procedures, and potential benefits, emphasizing that participation was entirely voluntary.

Anonymity and Confidentiality: Participants' personal information was anonymized to ensure confidentiality. Data collected from pre- and post-tests on sustainability concepts were coded to prevent identification of individual students, and all results were used solely for research purposes.

Non-Harm Principle: The study design prioritized the psychological and emotional well-being of the participants. The educational unit focused on sustainability was designed to align with the existing curriculum and posed no

risks or stress to the students. All instructional activities were age-appropriate, engaging, and supportive of positive learning experiences.

Voluntary Participation and Withdrawal: Students and their guardians were informed that participation was voluntary and that they could withdraw from the study at any time without any negative consequences or academic penalties.

Fair Treatment and Equity: All participants were treated equitably, ensuring that each student had equal access to the learning activities and resources provided during the intervention. No participant was disadvantaged due to participation in the study.

4.4 DATA COLLECTION AND ANALYSIS

4.4.1 Data collection

The data collection process utilized a specially designed Sustainability Concepts Test, administered both before (pre-test) and after (post-test) the implementation of the educational unit. This test measured students' understanding of key sustainability concepts across three domains: environmental, economic, and social sustainability.

Pre-Test Administration: The pre-test was conducted prior to the introduction of the proposed educational unit to establish a baseline for each student's level of understanding. This ensured that any subsequent changes could be attributed to the intervention.

Implementation of the Educational Unit: The educational unit was delivered over a set period, using interactive reading-based activities to introduce sustainability concepts in an engaging and age-appropriate manner. Activities included storytelling, group discussions, and practical examples relevant to the students' daily lives.

Post-Test Administration: Upon completion of the educational unit, the same Sustainability Concepts Test was administered as a post-test. The test content remained unchanged, ensuring consistency and reliability in measuring the outcomes.

4.4.2 Data analysis

The analysis focused on evaluating the effectiveness of the educational unit using the following methods:

Descriptive Statistics: Descriptive measures such as mean, standard deviation, and percentage were used to summarize students' performance on the pre-test and post-test, providing a clear comparison of scores before and after the intervention.

Effectiveness Calculation Using Blake's Effectiveness Coefficient: The study employed Blake's Effectiveness Coefficient to quantify the effectiveness of the educational unit. This coefficient evaluates the degree of improvement between pre-test and post-test scores, offering a clear metric for the unit's impact. This approach ensures a more nuanced understanding of the educational unit's effectiveness beyond mere statistical significance.

Inferential Statistics: A paired-samples t-test was used to assess whether the differences in pre-test and post-test scores were statistically significant, confirming the reliability of the observed improvements.

4.5 STUDY TOOLS

4.5.1 Sustainability concepts list

A comprehensive list of sustainability concepts -environmental, economic, and social- was developed to ensure their integration into the proposed educational unit. This list aimed to identify key concepts necessary for fostering sustainability awareness in early childhood education. The development of the list was guided by a review of relevant literature and previous studies (e.g., Hung, 2023; Qing *et al.*, 2024; Eyo-Udo *et al.*, 2024; Rahman *et al.*, 2024; Warburton, 2003; Leal Filho *et al.*, 2018; Al-Shaikh & Hanaysha, 2023; Bathaei & Štreimikienė, 2023; Stolowy & Paugam, 2023). Each primary category was further divided into several sub-concepts, as follows:

Environmental Sustainability Concepts:

Conservation of natural resources (e.g., water, energy)

Waste reduction and recycling practices
Protection of biodiversity and wildlife
Pollution prevention (air, water, soil)
Sustainable use of renewable resources
Climate change awareness and mitigation
Eco-friendly habits and practices
Economic Sustainability Concepts:
Responsible consumption and production
Efficient use of resources (time, money, materials)
Financial literacy for sustainability (saving, budgeting)
Support for local and sustainable products
Long-term planning for resource management
Circular economy principles (reuse, repair)
Sustainable economic growth and employment
Social Sustainability Concepts:
Social justice and equality
Respect for cultural diversity and inclusion
Human rights and ethical behavior
Community engagement and collaboration
Health and well-being promotion
Conflict resolution and peaceful coexistence
Responsibility toward future generations

4.5.2 Sustainability Concepts Test

The Sustainability Concepts Test is a research instrument designed to assess students' understanding of sustainability across three key dimensions: environmental, economic, and social. Its primary purpose is to measure the growth in sustainability-related concepts among the participants before and after the implementation of the proposed educational unit. The test consisted of 21 questions, evenly distributed across the three main sustainability areas, with seven questions for each category. Each question was carefully crafted to evaluate specific sub-concepts identified in the Sustainability Concepts List,

ensuring comprehensive coverage of all key ideas. For instance, the environmental section included questions on resource conservation and pollution prevention, while the economic section addressed concepts such as responsible consumption and financial awareness. The social section covered topics like social justice, community participation, and ethical behavior.

To ensure the test's validity, the test was reviewed by five experts in education and sustainability to evaluate the clarity, relevance, and appropriateness of the questions. Their feedback was incorporated to enhance the accuracy and alignment of the test with the targeted sustainability concepts.

For reliability, multiple approaches were employed. The Cronbach's alpha coefficient was calculated to assess internal consistency, ensuring that the items measured the same underlying constructs cohesively. Additionally, the test-retest method was used by administering the test twice, with a two-week interval, to the pilot sample of 14 third-grade students not included in the primary study. The resulting correlation between the two sets of scores confirmed the stability of the test over time. The pilot study also provided feedback on the time required to complete the test, ensuring that it was age-appropriate and suitable for third-grade students.

4.5.3 The proposed unit

A specialized educational unit was developed for third-grade students participating in this study, grounded in the principles of green education, which are tailored to the cognitive and developmental needs of children at this age. These guiding principles include fostering environmental stewardship, promoting resource conservation, encouraging critical thinking, and nurturing social responsibility. The unit was designed to cultivate a comprehensive understanding of sustainability concepts in an age-appropriate and engaging manner.

Structure of the Unit: The educational unit comprised seven lessons, each focusing on a distinct aspect of sustainability. The lessons were carefully crafted to integrate core green education principles while aligning with the

targeted sustainability concepts: environmental, economic, and social. The topics covered included:

Caring for Our Planet: Understanding Ecosystems

The Journey of Water: Conserving Natural Resources

Energy Matters: Renewable vs. Non-Renewable Energy

The Value of Sharing: Sustainable Economic Practices

Our Waste, Our Responsibility: Recycling and Upcycling

Community Connections: Promoting Social Responsibility

A Sustainable Future: Making Everyday Choices Matter

Each lesson featured interactive activities designed to engage young learners, such as hands-on experiments, storytelling, and group discussions. Special attention was given to ensuring that the unit's activities were aligned with green education principles and the sustainability concepts outlined in this study.

Expert Review and Validation: To ensure the unit's content was both developmentally appropriate and pedagogically sound, it was reviewed by five experts in the fields of education and sustainability. These experts provided feedback on the relevance, clarity, and suitability of the materials for third-grade students. Adjustments were made based on their recommendations to ensure the unit effectively met the learning objectives and resonated with the students' abilities and interests.

5 RESULTS AND DISCUSSIONS

To evaluate the effectiveness of the proposed educational unit in developing sustainability concepts, including environmental, economic, and social dimensions, the sustainability concepts test was administered both before and after the intervention. Following the pretest, the unit was implemented with the participating students, and the results were analyzed using paired-samples t-test to compare pretest and posttest scores. The results are shown in Table 1.

Table 1

Differences in Students' Scores on the Sustainability Concepts Test

Dimension	Pretest Mean	Posttest Mean	Standard Deviation	t-value	Direction of Differences	Blake Coefficient	Cohen's d	Degrees of Freedom (df)
Environmental Concepts	3.5	6.8	1.0	9.10	Posttest	0.87	3.30	29
Economic Concepts	3.2	6.6	1.2	8.50	Posttest	0.85	3.00	29
Social Concepts	3.3	6.7	1.1	8.70	Posttest	0.86	3.10	29
Total Score	10.0	20.1	2.0	10.70	Posttest	0.86	3.10	29

The quantitative results in Table 1 show the pretest and posttest mean scores for the three sustainability dimensions (environmental, economic, and social). The table displays the standard deviations, t-values, and the direction of the differences favoring the posttest for all dimensions. Additionally, the table presents the Blake coefficient, Cohen's d for the effect size, and the degrees of freedom (df). The analysis indicates significant improvements in students' scores across all dimensions of sustainability, with larger effect sizes in environmental and social concepts.

The pretest mean for environmental sustainability concepts was 3.5, indicating a relatively low level of understanding prior to the intervention. Following the implementation of the educational unit based on green education principles, the posttest mean rose to 6.8. This substantial increase was statistically significant (t-value = 9.10), with a large effect size (Cohen’s d = 3.30). The direction of the differences shows that the students' understanding of environmental sustainability concepts, such as conservation of natural resources, pollution prevention, and climate change awareness, improved significantly after the intervention. The Blake coefficient (0.87) further supports the effectiveness of the unit in enhancing students' grasp of these concepts.

For economic sustainability, the pretest mean was 3.2, again indicating limited knowledge of economic aspects of sustainability. After the intervention, the posttest mean increased to 6.6, with a t-value of 8.50, reflecting a statistically significant improvement. The Cohen's d of 3.00 signifies a large effect size, demonstrating that the educational unit had a strong impact on

improving students' understanding of economic sustainability concepts, such as sustainable use of resources and the importance of renewable resources. The Blake coefficient of 0.85 indicates a substantial educational effect.

Social sustainability showed a pretest mean of 3.3, which is similar to the other dimensions, suggesting that students had a limited understanding of social sustainability aspects. However, after the educational intervention, the posttest mean rose to 6.7. The t-value of 8.70 indicates a statistically significant difference, and the Cohen's d of 3.10 suggests a large effect. This highlights the effectiveness of the educational unit in improving students' understanding of social sustainability, including the importance of community welfare, social equity, and promoting eco-friendly practices in daily life. The Blake coefficient of 0.86 further supports the positive impact of the intervention.

The total score, which combines all three dimensions (environmental, economic, and social), shows a clear and substantial improvement in students' overall understanding of sustainability. The pretest mean of 10.0 increased to 20.1 after the intervention, with a significant t-value of 10.70, indicating that the unit had a significant impact across all sustainability dimensions. The Cohen’s d of 3.10 reflects a large effect size, confirming that the educational unit was highly effective in promoting sustainability concepts in early childhood education. The Blake coefficient of 0.86 indicates a strong educational impact across all dimensions.

The statistical analysis demonstrates that the educational unit effectively enhanced students' sustainability concepts in environmental, economic, and social sustainability, as evidenced by the significant pretest-posttest differences and large effect sizes.

The inclusion of green education principles and interactive, age-appropriate activities played a vital role in enhancing students’ awareness of environmental, economic, and social sustainability. The unit's effectiveness can be attributed to its well-structured content and its alignment with the developmental needs of early childhood students. These results underscore the value of integrating sustainability education into early childhood curricula, as

it not only increases awareness but also empowers young learners to think critically and responsibly about the world around them.

The results indicate that the educational unit had a significant impact on improving students' understanding of environmental sustainability concepts. Prior to the intervention, students had limited knowledge of concepts such as conservation of natural resources, pollution prevention, and climate change awareness. However, following the application of the educational unit, which included activities and lessons aligned with green education principles, there was a noticeable improvement in students' ability to comprehend and apply these concepts. The unit's content and activities, focusing on real-world environmental issues, played a crucial role in fostering a deeper understanding of environmental sustainability.

Similarly, the educational unit was effective in enhancing students' understanding of economic sustainability. Before the intervention, students had a basic understanding of economic principles related to sustainability. Through engaging activities designed to promote the importance of sustainable resource use and the value of renewable resources, the unit successfully strengthened students' knowledge in this area. The interactive nature of the unit allowed students to connect economic sustainability to everyday life, which helped them develop a stronger grasp of the subject.

The unit also demonstrated a positive effect on students' understanding of social sustainability concepts. Initially, students showed limited awareness of issues like community welfare, social equity, and eco-friendly practices. However, the educational unit, which integrated social sustainability into discussions and activities, significantly improved students' comprehension of how individual and collective actions impact society. Through group discussions, role-playing activities, and practical examples, students were able to better understand the importance of social responsibility and equity within the context of sustainability.

6 CONCLUSIONS

The proposed educational unit, grounded in green education principles, proved effective in enhancing students' understanding of key sustainability concepts-environmental, economic, and social. The results demonstrated significant improvements in the students' pretest and posttest scores, highlighting the positive impact of the unit on their knowledge and awareness. By integrating engaging activities that aligned with sustainability principles, the unit fostered critical thinking and encouraged responsible behaviors among the participants. These findings underscore the value of incorporating sustainability-focused educational units into early childhood curricula. Additionally, the results strongly support the necessity for curricula to include sustainability concepts, emphasizing their importance in shaping future generations who are equipped to address global challenges related to sustainable development.

7 LIMITATIONS

Despite the significant findings, this study has several limitations that should be considered. First, the research sample was limited to a small group of third-grade male students from a single school, which may limit the generalizability of the findings to a wider group of students. Additionally, the study focused solely on a specific educational unit, and the long-term impact of such interventions on students' understanding of sustainability concepts was not assessed. Furthermore, the study did not account for potential external factors, such as family influence or prior exposure to sustainability topics, which may have impacted the results. Lastly, the study relied on a single posttest measurement, which may not fully capture the depth of students' learning or the retention of sustainability concepts over time.

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