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Environmental Education: To develop sustainability competencies related to experimentation with environmental materials among secondary school students

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Abstract

The study aims to measure the impact of environmental education on the development of sustainability competencies (SC) related to experimentation with environmental materials among secondary school students. Therefore, the quasi-experimental approach was used. The study sample consisted of 80 female students enrolled in the second year of secondary school, general track 2024-2025, in private education schools in Al-Ahsa. They were selected using a simple random method. They were divided into two equal groups: one experimental group (40 students) and one control group (40 students). The instruments included the Sustainability Competencies Scale Related to Experimentation in Materials (SCEEM) and the training program represented. The results showed that there was a statistically significant difference between the average scores of the experimental and control groups in the post-measurement on the SCEEM scale, in favor of the experimental group. There were no statistically significant differences between the average scores of the experimental group in the post-measurement and follow-up on the SCEEM scale, as the total value of the test reached 1.610, which is an insignificant value, indicating the continuity of the program's effect and its effectiveness. The study emphasizes the need for future research on sustainability competencies and environmental education, especially in material experimentation. It suggests exploring the link between these competencies and practical practices, individual differences, and academic performance. Longitudinal research and demographic considerations are crucial for inclusive educational strategies. Using diverse methods like mixed-methods and technology can provide deeper insights.

Keywords: Environmental education, experimentation, materials, sustainability competencies.

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1. Introduction

The lack of education and awareness of environmental issues threatens sustainable development worldwide, requiring a strong environmental education system to enhance human response and environmental security [1]. "Maintaining and sustainably managing the natural environment, including biodiversity, is crucial for the long-term sustainability of human existence" [2]. Our world is on an unsustainable path, which puts pressure on the sustainability of our living conditions due to climate change, pollution, and waste accumulation [3]. The United Nations Conference on the Environment (Stockholm Declaration) has endorsed several principles, including the emphasis on Environmental Education (EE) [2]. UNESCO emphasizes the crucial role of education in developing students' competencies, such as the knowledge and skills necessary to achieve sustainable development goals [4]. In addition, since environmental sustainability is a social imperative, including education, it seeks to develop the necessary knowledge and skills among students through formal and informal environmental education [5]. In this context, education is closely linked to sustainability at all levels through the competencies integrated into the curricula. It also highlights how the various aspects of sustainability (environmental, social, cultural, and economic) intersect and interconnect with disciplines and subjects [6].

Focusing on education for sustainable development (ESD) with sciences and arts is vital, as it enhances ESD competencies among students through artistic practices using materials and environmental waste [7]. Therefore, the Ministry of Education [8] in the Kingdom of Saudi Arabia has sought to link education with developmental goals, including that education and training enhance sustainability competencies (SC) among students to use natural resources more sustainably, and that educating girls improves participatory skills and capacities and enhances life opportunities. Sustainability has become linked to practice-based and experimental education, which shapes and develops the dynamic education system and enhances the concept of development. The Ministry has set the objectives of the high school arts curriculum, and among those objectives are linking the arts to the lives of learners and their role in society, guiding the individual's aesthetic behavior and preserving the environment, and developing creative thinking through artistic activities [9].

Environmental education and the arts work to enhance environmental culture and material expression among students, preserving and distinguishing their history and cultural values [10]. Over the past two decades, sustainability has included a fourth pillar, which is culture, intersecting with the fields of arts and aesthetics. It highlights the importance of imagination and aesthetics and reveals the potential for progress through interdisciplinary pluralism, paving the way for "artistic sustainability" [11]. Therefore, the sectors of art and education focus on the importance of environmental sustainability [12]. Given the complexity of the concept of sustainability, which generates conflicting emotions, practitioners of the arts must achieve the concept of environmental sustainability through experimentation and synthesis of materials, allowing them to explore their formative properties and then analyze and employ them to create an artwork [13]. This field allows for making the unknown visible, integrating fragments, and developing the sustainability competencies (SC) necessary for society [14]. By "competencies," it is meant "embodying sustainability values," "embracing complexity in sustainability," "envisioning a sustainable future," and "working towards sustainability" [6]. The cross-cutting competencies, such as critical thinking, systems thinking, self-awareness, and problem-solving, are classified by Sinnes [15], Segalàs et al. [16], and McMullen et al. [17] into three competencies: knowledge and understanding, skills and abilities, and attitudes. Social competence consists of cooperation, communication, self-reflection, values, attitudes, and motivations. Situational competence, or "work," includes design, creativity, proposing solutions, and performing activities. This is related to several traits that a practitioner of experimentation in materials must possess, such as risk-taking, openness to experience, inspiration, imagination, improvisation, and intuition [18]. Art enhances the living environment and vice versa, as both influence each other. Public spaces improve, and communication channels develop, which enhances the culture of quality of life in social environments [10].

Therefore, the objectives of the current study lie in measuring the impact of environmental education on developing sustainability competencies related to experimentation with environmental materials, revealing the relationship between experimentation with materials and environmental sustainability, enabling the study sample to contribute to artistic activities that support environmental sustainability, and building a scale for sustainability competencies related to experimentation with environmental materials.

Many studies, such as Annelin and Boström [19], have recommended conducting further research to understand how SC affects each other in different contexts, as well as studying the factors influencing each discipline [16]. It is important to mention that SC still requires significant improvement in order to be integrated into curricula. Brundiers et al. [20] indicate that SC may be relevant across contexts, which can help enhance learning outcomes and sustainability programs. Therefore, training programs are one of the appropriate means to equip trainees with the necessary skills to create sustainable environmental awareness. d'Orville [3] emphasizes that to achieve sustainable development goals, it is essential to enhance creativity and knowledge exchange. Lamanauskas and Malinauskienė [21], Miranda et al. [22], Yadav et al. [1], Nousheen et al. [23], Mundt et al. [24], Essa and Harvey [25] recommend conducting research aimed at enhancing the concept of environmental sustainability and environmental awareness among students, focusing on strategies that support ESD through training programs that measure their impact on students' behavior towards environmental issues [7]. It is crucial to emphasize the importance of activity-based education in interdisciplinary ESD projects in schools. On the other hand, Miranda et al. [22] believe that environmental education can contribute to environmental sustainability when it is considered a process that extends beyond the classroom, making it a lifelong experience.

Despite the importance of sustainability competencies, there is a deficiency in these competencies. This was clearly evident during field visits and the authors' follow-up on the artistic production based on experimentation with environmental materials among second-year high school students. Although sustainability has been integrated into the secondary education systems, including study units on the sustainable environment and environmental waste management, there remains a gap.

However, there is a gap in that the level of knowledge is not sufficient to develop environmental sustainability competencies among the students, and investigative activities that enhance cognitive level, intellectual interaction, and critical thinking to solve problems should be included to transform knowledge into something tangible [19]. Annelin and Boström emphasize the urgent need to better develop and integrate sustainability into educational curricula across disciplines.

Therefore, the authors developed a training program to enhance the sustainability competencies of female students related to experimental skills and to promote the concept of sustainability. Large quantities of waste, specifically "date palm waste," are present in our environment every year in all our streets in the Kingdom of Saudi Arabia. Experimentation is considered an expressive tool that helps convey environmental concepts and promote values and knowledge related to environmental conservation. It requires possessing a set of skills to explore the links between these variables to understand their impact on the behavior of female students. The research problem can be formulated in the following question:

- What is the impact of environmental education on developing sustainability competencies related to experimentation with environmental materials among high school female students?
- There are no statistically significant differences between the mean scores of the experimental and control groups in the post-test on the (SCEEM) scale.
- There are no statistically significant differences between the mean scores of the experimental group in the post-test and follow-up measurements on the (SCEEM) scale.

2. Literature Review

2.1. Environmental Education (EE)

Environmental education is a comprehensive framework aimed at creating a sustainable future through education. It focuses on using the best educational practices to promote societal change and address social and environmental issues [26]. It also aims to cultivate an environmentally educated society and promote knowledge and positive attitudes towards the environment. Fang et al. [27] emphasize that the goals of environmental education lie in "awareness, knowledge, attitudes, skills, and participation." The lack of awareness hinders conscious behavior, as enhancing environmental insight and attitude affects individuals' environmental behavior [28]. Since the 1960s, education has been linked to environmental management and international development efforts, where the UNESCO Man and the Biosphere Conference in Paris acknowledged global awareness of environmental education [29]. Therefore, more attention should be given to sustainability education, and there should be widespread participation in adopting and implementing sustainable development decisions regarding the education of today's youth [21-30]. In addition, Shutaleva [31] emphasizes that Environmental education enhances awareness of environmental issues and develops responsible citizenship skills, and it emphasizes that the goals of environmental education intersect with sustainability competencies through a comprehensive understanding of environmental issues. Problem solving. Collaboration, as environmental learning is more relevant to the lives of learners, is achieved through the integration of knowledge from different disciplines.

2.2. Sustainability Competencies

Sustainability competencies include a set of knowledge, skills, and attitudes necessary to effectively solve problems in sustainability challenges and opportunities [32, 33]. Therefore, it can be defined as the ability to influence future outcomes through effective participation and the promotion of sustainable practices in the community [34]. It emphasizes Wiek et al. [33] that competencies are necessary to solve problems in specific contexts, with a smooth transition from general and abstract competencies to specific and detailed learning objectives/outcomes. The key competencies framework consists of clusters of related competencies, such as futures-thinking, includes their own knowledge, skills, and abilities assessments, which involve knowledge, skills, motives, and attitudes for successful task performance [19, 20]. In addition to other competencies such as critical thinking and systems thinking, systems thinking can be better learned by applying knowledge in real-life experiences, while problem-solving competency includes the ability to apply all other sustainability competencies in a collective and coherent manner to solve complex sustainability problems. This forms an essential aspect of good academic programs and serves as a foundation for sustainable academic education [32, 33]. As classified by Mundaca and Mundaca [35], Table 1, Sustainability competencies in the 21st century are classified into three main dimensions: Cognitive, Intrapersonal, and Interpersonal. Each of them has specific competencies.

Table 1.
Sustainability Competencies in the 21st Century.

Dimensions	Competencies and Skills
Cognitive	Critical thinking Creativity and innovation Problem-solving: Communication Information management Digital technology proficiency
Intrapersonal	Reflective thinking Personal skills
Interpersonal	Collaboration Local, national, and global citizenship Social responsibility

2.3. Environmental Education and Sustainability Competencies

Education is an essential part of the international development agenda. UNESCO coordinates the efforts of the international community to achieve these goals through cooperation, capacity building, and monitoring, using the Education 2030 Framework as a roadmap [36]. Ensuring that future generations acquire the necessary awareness to preserve the environment, Bacigalupo [6] and Ferguson et al. [37] believe Formal and informal methods targeting all educational sectors are considered among the most successful ways to develop knowledge, skills, and attitudes that enhance thinking, planning, and working with a spirit of empathy and responsibility towards our planet. It contributes to enhancing experiences that provide solutions to environmental problems, which are among the most prominent global challenges. Where environmental education focuses on developing an eco-friendly mindset and an environmental value system, equipping individuals with the necessary skills to effectively solve environmental problems [38]. In addition, SOU [39] indicates that there are three basic criteria for sustainability education, which are:

- Students must understand the principles and concepts of sustainability and be able to apply them.
- Students' awareness that sustainability is linked to environmental, economic, and social systems.
- Students should develop an interdisciplinary approach to learning the knowledge, skills, and attitudes necessary for continuously improving the quality of life.

Competency-based education enhances the development of sustainability skills based on knowledge and responsible work, overcoming cognitive dissonance, and promoting action [6]. Knowledge is considered a fundamental skill that must be mastered when dealing with issues of sustainable education [40]. Therefore, Jones and Galloway [41] see that developing curricula from an ecological perspective is a creative and effective step to enhance educational practice and support sustainability across various disciplines. This allows learners to explore multiple cognitive fields, enabling them to create connections and enhance collaboration between disciplines, thus forming a "learning community."

OECD [42] indicates that although planning and attention to the quality of education in the Kingdom of Saudi Arabia align with internationally recognized practices, it still requires support, a clear vision, and performance indicators. Therefore, Saudi Arabia has given significant attention to the field of sustainable development. Which is based on three pillars: a vibrant society, an ambitious nation, and a thriving economy. Accordingly, 96 goals were set within Vision 2030 [25]. It worked on integrating sustainability into educational systems by implementing a set of educational initiatives, including the Lifelong Learning Sustainability Initiative [42]. The focus did not stop there; a special course on environmental sustainability was added to the secondary school curricula [8]. It covered a range of topics, including sustainable environment and environmental waste management. It aims for students to be able to: identify the risks resulting from the accumulation of various types of waste, apply a practical method for recycling waste and benefiting from it, contribute to spreading the culture of recycling in the community they live in, and propose new methods for investing in the production of recycled materials. In achieving the general educational goals in the Kingdom of Saudi Arabia [8]. And what Regier [30] pointed out is that integrating environmental education within the frameworks of general education is important, and it is necessary to involve the community because achieving sustainability does not rely solely on experts. Therefore, this can be an important step in alleviating the symptoms of environmental stress and reducing pollution, as education plays a crucial role in shaping behavior, values, and awareness of environmental challenges and sustainability [43].

2.4. Experimentation With Materials and Sustainability Competencies

Experimentation with materials requires a combination of sustainability competencies, such as the creative ability to turn ideas into reality and to find new alternatives and possibilities to solve problems for a sustainable future [3]. Therefore, we need to clarify the concept of experimentation. Dewey [44] sees experimentation as a means of artistic expression using various materials, where the student reshapes or combines them, employing structural principles such as deletion and addition, composition, and synthesis. Therefore, it is an activity that actively engages students in problem solving, research, and experimentation with environmental materials, Shahat et al. [13] and Budiawan and Martyastiadi [45] mention that the experience of producing artwork is a creative experience based on research processes, as artists indirectly adopt the scientific method, whether consciously or unconsciously. Experimentation is a research effort based on practice from multiple and diverse perspectives, and testing the knowledge gathered through a series of experiments. It enhances the student's perspective as a creator by freeing them from the demands of seriousness and perfection in their field [46, 47]. Creativity and culture are the essence of sustainability and are rooted in environmental, cultural, social, and economic practices. They are considered drivers and enablers of development, creating better ways of living through communication and inspiration [3]. Experimentation has styles, as indicated by Hayes [46], Shahat et al. [13], and Bippus [48]. Experimentation in (style, technique, idea, material) is a skill that must be developed by every individual. They should not confine themselves to one style or method, but rather seek new ways and techniques to bring life and attractiveness to their environments. In Figure 1, the relationship between experimental skills and environmental education objectives is established.

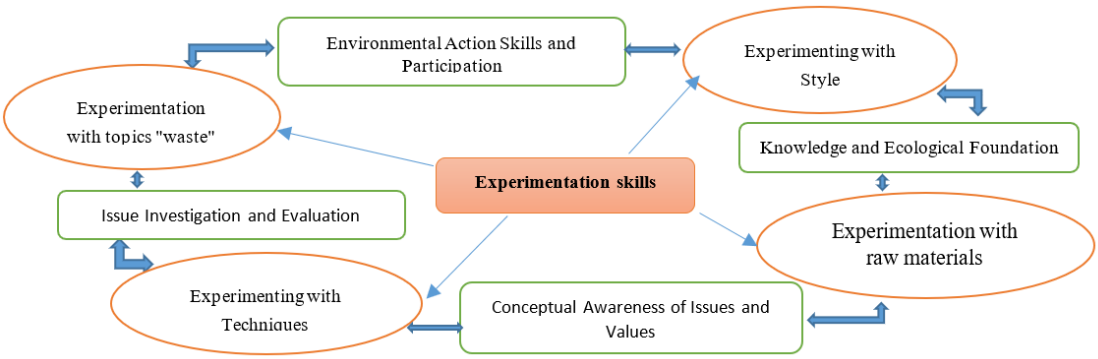

Figure 1.
Relationship of experimentation skills to environmental education objectives.

Experimentation embodies the idea of "learning by doing," where physical experiences influence the formation of concepts [49]. The philosophy of experimentation is based on the unity of knowledge, which enhances the integration between art and professional competencies [10]. Experiments create a multi-practice educational space, making it meaningful for students and enhancing their relationship with the surrounding materials. The future of these materials depends on how individuals interact with them [50].

Experimentation is considered a form of visual thinking; it is a representation of intellectual action in the material that focuses on the physical aspects and allows for changes in the artistic process to achieve different results. It is an experience that leads to knowledge, enabling the individual to expand their abilities, awareness, and ideas [47-49]. Exploring materials also enhances students' confidence in managing new materials, posing a challenge in reshaping them to fit their characteristics, thus becoming an alternative design process [49, 50].

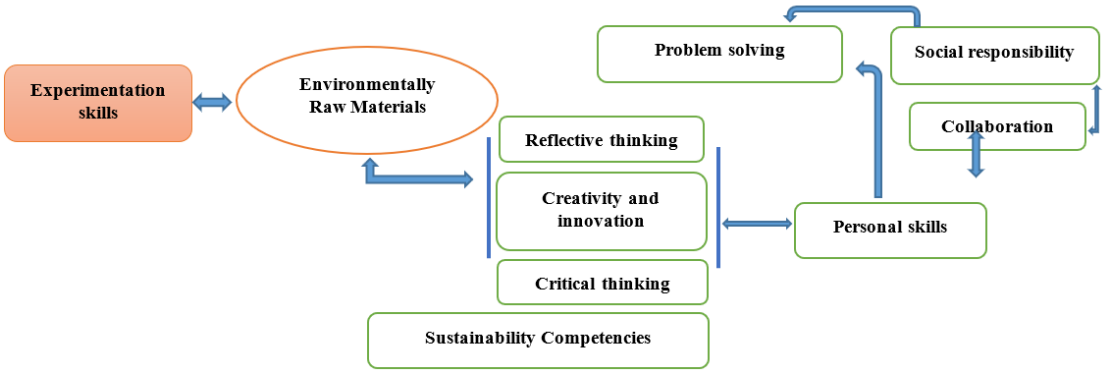

Figure 2.
Sustainability competencies linked to experimentation with materials.

The author sees that sustainability competencies in experimenting with environmental materials are interconnected and reinforce each other. Determining which competency comes first depends on the context and the specific goal, and critical thinking can be the foundation, as it enhances information evaluation and problem solving through diverse and creative thinking. This makes it easier to develop other competencies such as collaboration and responsibility. Meanwhile, systemic thinking promotes future-oriented thinking by understanding the interconnection between ecological and social systems to achieve sustainable development goals.

3. Methodology

The current study relies on a quasi-experimental design with experimental and control groups, aiming to measure the impact of environmental education on developing sustainability competencies related to experimentation with environmental materials. The study population consisted of 248 female students enrolled in private education in the second grade of the general track in the secondary stage in Al-Hofuf, Al-Ahsa Governorate, at the time of the study. The study sample comprised 80 female students randomly selected from private schools in the Al-Hofuf area of Al-Ahsa Governorate to ensure representation of the study population, taking into account age and educational background.

3.1. Study Tools

The Sustainability Competencies Scale Related to Experimentation in Environmental Materials (SCEEMS) was constructed based on some previous literature, namely [13, 21, 51, 52]. The goal was to measure (SCEEM) among high school female students. The scale included 12 items on a five-point Likert scale (always applies = 5, often applies = 4, sometimes applies = 3, rarely applies = 2, never applies = 1). The total score ranges from 12 to 60, with the highest possible score being 60, the average score being 23, and the lowest score being 12. A score above average indicates that the students possess (SCEEM), while a low score indicates that the participants lack these competencies.

The researcher used the SCEEM scale to verify the possession of these competencies by the study sample students, which was reviewed by seven experts in art education and psychology. The final SCEEM, consisting of 12 items, was created after deleting three items. The Cronbach's alpha coefficient for the scale was 0.778, confirming the scale's ability to accurately measure psychological traits.

The researcher confirmed the equivalence of the two groups in variables interacting with the independent variable in the dependent variable, calculated significance using a t-test in the SCEEM efficiency variable. Table 2 illustrates this.

Table 2.
Shows the value of (t) between the means of the two groups on the (SCEEM) scale.

Variable	**Group**	*N*	*M*	*SD*	*df*	*t*	*sig*
Scale (SCEEM)	Experimental	40	18.6750	1.83118	78	-1.261	.211
	Control	40	19.2500	2.22745			

Table 2 reveals that the t-values are not statistically significant, indicating the equivalence of the experimental and control groups in SCEEM.

3.2. The Program

The program aims to measure the impact of environmental education on the development of SCEEM among high school female students and to enhance their awareness of the concept of environmental sustainability. The program lasts for eight weeks, with one session per week lasting three hours. The program includes an introduction to environmental education, its importance and objectives, sustainability competencies, the nature of experimentation with materials and its relation to sustainability and environmental competencies, how to benefit from environmental materials and repurpose them with an informed understanding of their formative characteristics, illustrative presentations, materials and their types, and their impact on the environment, as well as workshops to explore the nature of materials. Brainstorming sessions are held to generate ideas for innovative artworks. By applying various experimental approaches, the following strategies are implemented: cooperative learning, project-based learning, modeling, and brainstorming. The goal is to propose innovative and contemporary ideas for utilizing environmental materials to produce artistic work.

A set of environmental materials (palm fronds, palm ribs, burlap, ropes, and some auxiliary materials) was adopted, employing some technical methods such as folding, layering, assembling, weaving, adding, and compiling. Participants were tasked with collecting palm waste materials and individually sketching their ideas to repurpose and assemble this waste, and to devise a strategy for construction and the auxiliary materials needed to create the artwork [7]. ESD topics challenge students to navigate complex emotional dilemmas without a clear "right" or "wrong" answer, fostering attitudes strongly influenced by emotions.

During the artistic construction, many creative aesthetic processes were applied. There were group sessions to discuss environmental pollution issues and the waste produced from date palms, and how it can be creatively employed and aesthetically utilized. The structural relationships and their importance in the design of the artwork were explained, along with methods for using appropriate tools for refining the material and handling it in a way that ensures the safety of the participants (working consciously with the material and tools). Then, they proceeded to follow the structure of their projects. Formative and continuous assessments were used during the implementation of activities and practical applications in building artworks based on date palm waste. Formative assessment is considered an important tool for guiding students towards environmental education goals and allows the instructor to impart sustainability competencies related to experimentation with materials. See Figure 3, 4, and 5. for examples of the experimental group's work in the post-test.

Figure 3.
Raw relationships.

Figure 4.
Environmental raw material values.

Figure 5.
Palm trees are a formative value.

4. Results

The first hypothesis states, "There are no statistically significant differences between the mean scores of the experimental and control groups in the post-test on the (SCEEM) scale." To test this hypothesis, the independent samples t-test was used to detect the significance of the differences between the scores of the students in the two groups, as shown in Table 3

Table 3.
The differences between the mean scores of the two groups' students on the SCEEM scale after the program implementation.

Groups	*N*	*M*	*SD*	*df*	*t*	*sig*	ή2
Experimental	40	38.25	2.047	78	34.65	0.001	0.94
Control	40	20.65	2.476				

It is clear from Table 3 that there are significant differences between the mean scores of the two groups on the (SCEEM) scale after the implementation of the program, in favor of the experimental group, where the "t" values reached 34.65, which are significant at the (0.001) level in favor of the experimental group students. Thus, the null hypothesis was rejected and the alternative hypothesis was accepted. The value of eta squared was (0.94), indicating a significant impact and practical importance of the current program in developing sustainability competencies related to experimentation with environmental materials.

The second hypothesis states that there are no statistically significant differences between the means of the experimental group's scores in the post-test and follow-up on the (SCEEM) scale. To test this hypothesis, a paired t-test was used to detect the significance of the differences between the post-test and follow-up test, as shown in Table 4.

Table 4.
Shows the significance of the differences between the post-test and follow-up measurements for the experimental group on the SCEEM scale.

Variable	Measurement	N	M	SD	df	t	sig
Scale (SCEEM)	Post-test	40	38.25	2.047	39	1.610	0.116
	Tracking	40	37.80	1.114			

The results shown in Table 4 did not reveal any significant differences between the mean scores of the experimental group students in the post-test and follow-up measurements on the (SCEEM) scale, as the value for the overall test score was (1.610), which is a non-significant value. Thus, the second hypothesis was confirmed, indicating the continuity and effectiveness of the program's impact.

5. Discussion

The current study aimed to measure the impact of an environmental education (EE)-based training program on the development of SCEEM. To answer the research question: What is the impact of environmental education on developing sustainability competencies related to experimentation with environmental materials among high school female students? The results indicate the effectiveness of the training program in developing those competencies, with the effects continuing through follow-up. Where environmental education works to expand students' awareness of environmental sustainability issues and to understand and support aspects of their ability to solve them. The authors believe that this approach connects the elements of the educational process, namely the curriculum, the student, and the environment, resulting in better outcomes in improving students' behavior and their relationship with the surrounding environment. This aligns with Nuangchalerm et al. [36] and Stoll et al. [7] who believe that active participation in environmental studies through environmental art enhances participants' awareness of environmental issues such as "waste," develops their ability to tackle environmental challenges, and enables them to make good decisions that promote a lifestyle impacting the community's insight in general. Traditional education cannot solve environmental degradation problems.

Therefore, the significant improvements in SCEEM align with the results of the first hypothesis of the current study, which is: There are no statistically significant differences between the mean scores of the experimental and control groups in the post-test on the (SCEEM) scale. The results indicate that the application of knowledge with understanding and practice has a positive relationship with learning and developing sustainability competencies related to experimentation with environmental materials among the students. This aligns with previous research conducted by Wang [10] and Mäkelä and Löytönen [49] which confirmed that physical experiments enhance concept formation and the development of professional competencies. The authors confirm that the significant improvement in SCEEM among the study sample is because environmental education is considered an ideal arena for creative learning, as it contributes to the development of critical thinking skills and social responsibility [7]. Moreover, the use of formative and continuous assessment during the students' implementation of their experimental projects with environmental materials shows a significant positive impact. This aligns with what Annelin and Boström [19] and Nuangchalerm et al. [36] indicated regarding the importance of this type of assessment in supporting teachers to understand the extent to which students possess sustainability competencies.

The authors attribute these improvements to the strategies used, such as "project-based learning, cooperative learning, and brainstorming," in the training program, which are considered appropriate methods and approaches for environmental education. These strategies enhance social and emotional responsibility by providing experimental-based alternatives to solve environmental waste problems and utilizing diverse thinking styles such as critical, pluralistic, and creative thinking, which supports interdisciplinary learning. This aligns with the findings of Shutaleva [31], who concluded that experiential learning is a valuable approach in environmental education, enhancing students' environmental knowledge, academic achievements, and social and emotional well-being. It may help bridge the gap between classroom learning and real-world application, making abstract concepts more realistic and applicable. The experimental practices carried out by the students supported the formation of sustainability concepts through action-based practice, as well as expanding their creative abilities. This aligns with what Mäkelä and Löytönen [49], Ayala [50], and Bippus [48] confirmed, that experimentation is a type of visual thinking that enhances the exploration of materials and creates a multi-practice educational space, making it meaningful for students and strengthening their relationship with the surrounding environment. The authors emphasize that sustainable education is not limited to providing knowledge, but also contributes to developing thinking skills that help protect the environment by creating new technologies committed to sustainability. Therefore, the integration of experimentation and effective evaluation represents two essential pillars in promoting environmental sustainability among the new generation.

6. Conclusions

It refers to Annelin and Boström [19]. Education plays a vital role in developing sustainability competencies among students, equipping them to work towards achieving sustainable development goals. Over the course of eight weeks, various topics, issues, and trends related to environmental sustainability competencies associated with experimenting with environmental materials were addressed. Through the training program content, strategies such as cooperative learning, project-based learning, modeling, and brainstorming were applied to equip participants with sustainability competencies such as critical thinking, creativity and innovation, personal skills, collaboration, responsibility, and problem-solving.

The activities revolve around how to produce artworks based on reusing environmental materials to reduce waste by integrating "knowledge and action" in the formative possibilities and technical treatments of environmental raw materials. Moreover, these tasks, projects, and discussions helped participants understand the importance of environmental sustainability and clearly demonstrated the concepts to them. They also highlighted the significance of artistic activities for

a sustainable environment and a better life, as they significantly contribute to reducing environmental pressure and waste and enhance the connection with the surrounding environment by reusing consumed natural or industrial materials, using various techniques in building the artwork, thereby linking students to the ideological reality. Consequently, these activities fundamentally intersect with sustainability competencies.

7. Recommendations

The study underscores the need for future research on sustainability competencies and environmental education, focusing on material experimentation, individual differences, and the relationship between variables and academic performance.

The authors emphasize the importance of longitudinal and cross-cultural research in understanding sustainability improvements over time and developing inclusive educational strategies.

Mixed methods and technology-based approaches can enhance environmental education interventions, provide deeper insights into student practices and experiences, and thus enhance sustainability competencies and academic engagement.

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