Effectiveness of Environmental Education and Awareness of Genetic Engineering Applications in Achieving Sustainable Development among Science Students in Palestine

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Abstract :

Background: Climate change is a top priority for the international community. In this context, there is growing recognition of the importance of education in combating this change, especially after the adoption of the Paris Agreement and the Climate Action Program, which were introduced at the Conferences of the Parties to the United Nations Framework Convention on Climate Change. The call for high-level international commitment has reached unprecedented levels. The Partnership for Green Education Conferences were held as part of the Transforming Education Summit in September 2022, establishing these conferences as an international initiative aimed at taking effective steps characterized by coordination and inclusivity. The Partnership for Green Education supports countries in accelerating educational transformation, making climate change studies and climate action programs integral to the educational process. As an inclusive partnership for all stakeholders, there are centers for green education that welcome anyone interested in joining, currently including over 700 organizations and 74 member countries. The goal is to "provide every learner with the knowledge they need about climate" through four actions: Green Schools, Green Curriculum, Green Capacity Building, and Green Communities. One such center is the Center for Green Education - (Heritage), from the land of Zayed (2022). In this field, I have had a strong interest since I worked as a biology teacher for high school and a supervisor of science and biology in Palestinian universities in the Gaza Strip. I aimed to make a difference in training future generations to harmonize with and preserve nature, and I have launched several initiatives in this area. Therefore, this study aims to clarify the effectiveness of environmental education and the development of awareness regarding genetic engineering applications in achieving sustainable development among science students in Palestine.

Materials and Methods*:* To achieve the study's objectives, three initiatives focused on environmental education, awareness of genetic engineering applications, and a deep understanding of nanotechnology applications in agriculture were implemented between 2012 and 2023. This involved designing tests and practical applications, as well as utilizing technology to facilitate these efforts. The study adopted a quasi-experimental design and targeted a sample from the three initiatives, including tenth-grade students in the Gaza Strip, eleventh-grade students, and science teachers in teacher education colleges. The study tools were applied to the sample, including cognitive tests and attitude scales..

Results: The study indicated in the first initiative the extent of the students' engagement in actively participating in cleaning the school environment, planting trees in the schoolyard, and promoting environmental awareness within the school. In the second initiative, the study revealed statistically significant differences at the significance level ($\alpha \leq 0.05$) between the mean scores of the experimental

group in the post-test regarding the cognitive aspects of genetic engineering after implementing the computerized program. The effect size for genetic engineering was η^2 (0.958), and the value of d was (9.61), indicating a very large effect size. This suggests that the independent variable (the proposed program) has a significant impact on the dependent variable (development of cognitive awareness regarding genetic engineering) in favor of the experimental group.

In the third initiative, the study found statistically significant differences at the level of (0.05) between the mean scores of the experimental group and the control group in the post-application of the deep understanding test for nanotechnology applications. These differences favored the experimental group, with the mean score of the experimental group in the post-test for deep understanding of nanotechnology applications being (26.458).

Conclusion: This means that the three initiatives are effective in environmental education, awareness of genetic engineering applications, and deep understanding of nanotechnology applications in agriculture among science students in Palestine. These results indicate that the students have a desire to enhance their knowledge and understanding of new developments.

Key Word*:* Environmental education – Genetic engineering – *Achieving Sustainable* – Smart applications – Tenth-grade students – Deep understanding.

INTRODUDTION

The life of humans on Earth has been linked to trees since the beginning of creation, particularly through the story of Adam and Eve and the tree. Trees hold great respect as they accompany humans in their daily needs throughout life. They also have a distinguished status in various situations, as their description is tied to the cosmic condition of humans, whether on Earth during life or after death.

Thus, it is our duty to pay attention to planting trees, as they are the lifeblood of our existence and the fruit of the struggles and efforts of citizens. Our activities should not stop at planting trees but should extend to caring for them. Let our motto be: "Plant and do not cut." Trees symbolize greenery, giving, and beauty. Therefore, I have initiated programs to raise environmental awareness among future generations to achieve sustainable development, harmony with nature, and its preservation. I have trained high school health committee students on proper methods for maintaining the school environment and plants, spreading awareness among all students.

It is expected that the world population will increase annually, necessitating large quantities of food and doubling the global demand for various food types due to rapid economic growth and urbanization. Consequently, there will be an increase in demand for livestock and poultry, which will require a rise in grain production, as livestock consume more grains. Due to the increasing demand for food and the desire to produce nutritionally richer and more environmentally resilient foods, scientists have managed to produce genetically modified crops that meet this need. Living cells are selected targets for genetic modification, and through genetic engineering techniques, copies of the desired genes can be multiplied to obtain vast numbers of genetically modified organisms capable of resisting pests and producing therapeutic proteins beneficial to humanity. (Al-Obaidi, 2007, p. 38)

In recent decades, many challenges have arisen that necessitate a critical need to ensure global food security, causing agricultural ecosystems to face numerous challenges, such as the persistent particles of various pesticide residues, the accumulation of heavy metals, and pollution from toxic elements that negatively impact the agricultural environment. This has led to numerous health effects, such as neurological disorders, bone marrow issues, metabolic disorders, infertility, disruption of biological functions at the cellular level, and respiratory and immune diseases. The need for monitoring agricultural ecosystems can be illustrated by the estimated 220,000 annual deaths reported due to the toxic effects of pesticide residues. Pankaj Sharma & Others (2021:1)

Many scientists have made efforts to define genetic engineering, which has been described
Khayal et al., 2012, p. 130)as the food obtained by transferring a gene from a plant, animal, or microbe, where the transferred gene responsible for a genetic trait merges with the DNA of the organism to be

genetically modified. Genetic engineering is one of the techniques under the umbrella of biotechnology, used for selective control or modification, or transferring genes from one organism to another to impart desirable traits. The benefits of genetic engineering can be summarized as follows: Khayal et al., 2012, p. 138)

1. Improving nutritional value and sensory properties (such as color, flavor, and texture) of various food products to reduce waste and lower food production costs for consumers.

2. Utilizing agricultural waste (food production waste) and converting it into value-added products, thus reducing environmental pollution, and using genetically modified microbes to produce many compounds helpful in the food industry, such as flavor and color enhancers.

3. Producing enzymes necessary for food processing, such as enzymes that break down starch and protein or those used to utilize waste resulting from food production.

Applications of genetic engineering include:

1. **Genetically Modified Plant Foods**: According to the U.S. Food and Drug Administration and the Department of Agriculture, there are over 40 types of genetically modified plants that have completed the official government requirements for commercial release. Examples include melons with modified ripening characteristics, soybeans and beets that have become resistant to herbicides, and corn and cotton that have increased resistance to insect pests.

2. **Genetically Modified Animal Foods**: Animal foods (meat, dairy, poultry, eggs, and fish) are primary sources of high-quality protein and other nutrients. To provide these foods through traditional methods, significant time is required to enhance animal productivity, which has led to the adoption of genetic engineering methods to increase livestock production.

3. **Applications in Processed Foods and Additives**: Genetic engineering offers a significant opportunity to introduce traits or properties that add specific value to food manufacturers, improving nutritional, functional, and processing characteristics while reducing moisture content and extending shelf life.

4. **Utilizing Food Manufacturing Waste**: The remarkable progress in genetic engineering brings new advancements daily across various fields. Significant amounts of food manufacturing waste are not utilized properly but can have high value by being transformed into beneficial products. For instance, researchers discovered a new enzyme capable of producing vanillin from agricultural processing waste and can convert crop residues and other waste into ethanol, a clean renewable fuel alternative to gasoline.

Ethical Concerns in Genetic Engineering: The topic of genetic engineering raises anticipated concerns if implemented without regulations, as it is a double-edged sword that can be used for good or evil. There are several effects that must be considered as we move forward with genetic engineering, which should be studied carefully. We cannot predict the ethical concerns and risks of genetic engineering if ethical standards are not adhered to, including: (Anastasia٢٠١٢ ،: 7)

1. Genetically modified crops may not be safe for long-term consumption.

2. Genetically modified crops could lead to unintended outcomes through pollen transfer between plants.

3. There may be less genetic diversity among genetically modified organisms, making them more susceptible to diseases if any defect occurs in these genes.

Regulations for Genetic Engineering in Plants, Animals, and the Environment: These should include: (Ibrahim, 2003, p. 69)

1. The intended benefits must be genuine, not illusory, and must achieve the necessary objectives of Islamic law.

2. No greater harm should arise from the intended benefits, whether to humans, animals, plants, or the environment.

3. It should not lead to altering the nature of animals in a corrupting manner.

From the above, we find that genetic engineering has diverse fields and many important applications for humanity, provided it is subject to strict state oversight and collaboration among scientists to ensure its safe use aligns with human benefit.

A proposed program has been developed to raise awareness of genetic engineering among science students in the Faculty of Education. To study the effectiveness and efficiency of the proposed program, it was applied to the experimental group, providing each student with a CD of the program to assist in self-learning.

The globally recognized need for advancing agriculture and more sustainable food systems has prompted the emergence of interdisciplinary solutions, including methodologies that utilize material properties at the nanoscale to address widespread and inefficient resource use. There is an opportunity to inform the sustainable design of agricultural chemicals that support nanotechnology Leanne M. Gilbertson &othars(2020), which is expected to become a driving economic force in the near future. Applications of nanotechnology in agriculture and sensors for rapid detection of plant pathogens, toxins, and other contaminants will utilize functionalized nanoparticles, playing a role in developing a new generation of safe pesticides by:

1. Applying nanosensors in crop protection to identify diseases and pesticide residues.

2. Using nanoscale devices for genetic manipulation of plants.

3. Diagnosing plant diseases through precision agriculture techniques to enhance crop yields without harming soil and water while reducing nitrogen loss.

3. Applications of nanotechnology in fertilizers, pesticides, and water treatment.

Nanopesticides containing active ingredients at nanoscale (10-15 nm) dissolve more rapidly in water than conventional pesticides and can more effectively target pests due to their small size, allowing them to penetrate the pest's body. Smart capsules at the micrometer scale contain nanosensors that control the release rate of the pesticide from the capsule and release it under specific conditions such as humidity, temperature, and pH levels.

Benefits of Using Nanopesticides: This technology reduces worker exposure to pesticides, as the pesticide is contained within the capsule, minimizing pesticide residues in the soil and decreasing harm to agricultural crops. It targets the intended pest without affecting surrounding crops.

MATERIALS AND METHODS

First Initiative: Environmental Awareness Development

This experimental study was conducted by 11th grade students in the public schools of the Ministry of Education/Gaza for the year 2012-2015 on his eye is made up of (20) female students. □

Study Design: This study based on the experimental approach and data collection .

Study Location: **-:** This study was in the public schools of the Ministry of Education/Gaza

Study Duration: - for the year 2012-2015.

Sample size: -20 tenth grader.

Sample size Calculation:— The sample was selected randomly as the sample size actually obtained for this study was 20 Grade 11 students.

Subjects & selection Method: —The study community was taken from the 11th grade students in the government schools affiliated to the Ministry of Education/Gaza according to the following random distribution,Gaza area (20).

Inclusion criteria:

1- 11 graders.

2- Studies in the State schools of the Ministry of Education.




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The Second Initiative: Raising Awareness of Genetic Engineering Applications

1. Material And Methods

This pilot study was conducted on female Science students in the Faculty of Education at the Islamic University of Gaza. This study was conducted in the first semester of the academic year (2012-2013) on a sample of (48) students.

Study Design: This study is based on the experimental curriculum, consisting of the two equal control and experimental groups and then collecting and analyzing the data.

Study Location: This study was conducted at the Islamic University and conducted on the Science students of the Faculty of Education.

Study Duration: In the first semester of the year (2012-2013).

Sample Size: (48) Science students, studying at the Faculty of Education.

Sample Size Calculation: The sample was randomly selected from the students of the Science Department at the Faculty of Education of the Islamic University; the original community included (133) students and the sample percentage was (60%). They were divided into two groups: the experimental group and the control group, with a sample size of 48 students.

Subjects & Selection Method: The study community was taken from the students of the Science Department at the Faculty of Education of the Islamic University according to the following distributions, group control (42) and experimental group (42).

Inclusion criteria:

1- Female Science or Biology students in the Faculties of Education.
2- Female students at the Islamic University.

Exclusion criteria

- Teachers working in the field.
- Teachers who are not specialized in Science or Biology

Procedure methodology

The researcher followed the experimental method and applied the study tool, which is a test of the cognitive aspects of genetic engineering.

Statistical analysis

There are statistically significant differences at the significance level ($\alpha \leq 0.05$) between the mean scores of the experimental group students in the post-test of the cognitive aspects of genetic engineering as a result of implementing the proposed program, where the program had a very significant effect. **Table (1):**

Table (1):Results of the "T" test to determine the level of the experimental sample before starting the program in the cognitive test.

Variable	Group	N	Mean	Standard Deviation	"t"	Significance Value	Significance Level
Genetic Engineering	Experimental	42	1.881	0.593	0.194	0.847	Not statistically significant

Table (2): Results of the "t" Test **for Determining the Level of the Experimental Sample After Implementing the Program in the Knowledge Test**

Dimension	Group	N	Mean	Standard Deviation	t Value	Significance Value	Significance Level
Genetic Engineering	Experimental	42	8.833	1.464	6.481	0.000	Statistically significant at 0.01

The tabulated "t" value at 82 degrees of freedom and a significance level of (α = 0.05)= 1.98
The tabulated "t" value at 82 degrees of freedom and a significance level of (α = 0.01)= 2.62

The previous **Table (2)** shows that the significance level is 0.000, which is less than 0.01. Additionally, the calculated t value is 6.481, which is greater than the tabulated t value of 2.62 (indicating that the calculated t value falls in the rejection region). This means rejecting the null hypothesis and accepting the alternative hypothesis, which states: "There are statistically significant differences at the significance level ($\alpha \leq 0.05$) between the mean scores of the experimental group students in the post-test regarding the cognitive aspects of genetic engineering."

Table(3) The values for "t," "η^2," and "d" to determine the effect size of the proposed program in the cognitive aspects of genetic engineering are as follows:

Skill	t Value	η^2 Value	d Value	Effect Size
Genetic Engineering	30.771	0.958	9.61	Very Large

Regarding the effect size for genetic engineering, the value of η^2 was 0.958, and the value of d was 9.61, indicating a very large effect size. This shows that the independent variable (the proposed program) significantly affects the dependent variable (the awareness of genetic engineering issues) in favor of the experimental group.

To address this question, the following hypothesis was formulated:
Using the program does not achieve a higher effectiveness level than 1.2, according to the Black adjustment gain ratio in developing awareness of the cognitive aspects of genetic engineering among science students.

To verify this, the Black ratio was used to calculate the adjusted gain percentage after applying the proposed program to the test as follows: **Table(4)**

Table(4) The value of the adjusted gain for the cognitive aspects of awareness of genetic engineering.

Dimensions	Final Score	Pre-Test Mean	Post-Test Mean	Difference Between Means	Adjusted Gain Ratio
Genetic Engineering	11	1.881	8.833	6.95	1.394

It is evident from the previous table that the adjusted gain ratio for the test of cognitive awareness regarding bioethical issues is (941.3), which is a high gain ratio compared to the minimum adjusted gain ratio set by Black at (1.2). This indicates that the program is effective in enhancing cognitive aspects of awareness regarding bioethical issues.

Based on this, the results can be interpreted as follows:

1. The ease with which the students accessed information in small, manageable segments, presented according to their needs with a flexible and non-linear organization, facilitated the mental formation of information in a way that aligns with their cognitive structure. This aligns with the findings of Al-Omrani (2009). Additionally, allowing students to navigate the information in a proportional sequence and creating

a flexible learning environment empowered them to make decisions regarding the content of the software. This approach led to meaningful use and control over the material, resulting in increased interaction between the students and the educational software, thereby enhancing their cognitive understanding of genetic engineering.

2. The educational software was enriched with visual stimuli, including written texts, colors, images, animations, and a variety of designs that were attractive and simple in presenting information. This aligns with the findings of Mahdi (2006), who emphasized the importance of incorporating numerous illustrations, images, and videos, and providing sub-screens for that purpose. Students were able to access content according to their abilities and interests, making the teaching process engaging and stimulating. This was particularly noticeable during the experimental group's interaction with the proposed program.

The Third Initiative: Developing a Deep Understanding of Nanotechnology in Agriculture

In this initiative, the study introduced a program based on a mobile application aimed at raising awareness of nanotechnology applications in agriculture among tenth-grade students in Palestine.

MATERIALS AND METHODS

This experimental study was conducted by 10th grade students in the public schools of the Ministry of Education/Gaza for the year 2022-2023 on his eye is made up of (48) female students divided into two groups, an experimental group of (24) female students, and the other is an officer of (24) female students. □

Study Design: This study based on the experimental approach and data collection .

Study Location: **-:** This study was in the public schools of the Ministry of Education/Gaza (Rafah).

Study Duration: - In the first semester of the academic year for the year 2022-2023.

Sample size: -48 tenth grader.

Sample size Calculation:— The sample was selected randomly as the sample size actually obtained for this study was 48 Grade 10 students.

Subjects & selection Method: —The study community was taken from the 10th grade students in the government schools affiliated to the Ministry of Education/Gaza according to the following random distribution, Rafah area (48).

Inclusion criteria:

1- Tenth graders.

2- Studies in the State schools of the Ministry of Education.

Exclusion criteria:

- Basic 10 students.

The study showed that there is a statistically significant difference at the level of 50.0 between the average scores of the experimental group and the control group in the remote application of the deep understanding test with nanotechnology applications, and it turns out that these differences were in favor of the experimental group, where the arithmetic average of the experimental group scores in the remote application of the deep understanding test with nanotechnology applications was 26.458 while the arithmetic average of the control group Students was 14.958, and the difference between them was 11.50 degrees. The presence of a significant statistical difference at the level of 50.0 between the average scores of the experimental group and the control group in the remote application of the future thinking skills scale, and it turns out that these differences were in favor of the experimental group, as the arithmetic average of the experimental group's scores in the remote application of measuring future thinking skills was 110.125, while the arithmetic average of the control group's students was 82.50, with a difference of 27.625 degrees, and the percentage of the average total score of the test is 1.393, all of which is more than the limit set by Black, which is 1.2, meaning that the proposed program based on smart applications is effective in developing deep understanding The percentage of the adjusted gain for the total score of the scale was 1.313, all of which exceeds the previously stated limit of 1.2 set by Black.

To answer the question ,is there a statistically significant difference (0.05 Pinterest a) between the average scores of the experimental group and the control group in the dimensional application to test the deep understanding of nanotechnology applications for the experimental group ?To verify the hypothesis ,there is a statistically significant difference (0.05 Ph. a) between the average scores of the experimental group and the control group in the dimensional application to test the deep understanding of nanotechnology applications .At the indication level (α 0.05), The T. Test Independent Sample was used to calculate the differences between the median grades of students from both the experimental group and the control group in the post-test test to test the deep understanding of nanotechnology applications as shown in **Table (5):**

Table 5. The T-test has the average scores of the experimental group and the control group in the post application of the deep understanding of nanotechnology applications test. .

value Sig	Calculated "T"	Degree of freedom	Total degree	Standard deviation	Arithmetic mean	Number	Test fields	
0.001	8.547	46	5	1.251	4.500	24	Experimental	Setting hypotheses
				0.537	2.125	24	Control	
0.001	8.866	46	6	0.770	5.375	24	Experimental	Forecasting
				1.442	2.417	24	Control	
0.005	2.947	46	5	1.013	4.375	24	Experimental	Fluency
				1.404	3.333	24	Control	
0.001	4.772	46	5	1.129	4.167	24	Experimental	Flexibility
				1.285	2.500	24	Control	
0.001	4.614	46	6	1.765	5.375	24	Experimental	Decision making
				1.100	3.417	24	Control	
0.001	6.166	46	3	0.917	2.667	24	Experimental	Explanations
				0.761	1.167	24	Control	
0.001	10.077	46	30	4.809	26.458	24	Experimental	Total degree of the test
				2.851	14.958	24	Control	

Table 6. ETA squared effect size to see if the differences are real and attributable to the use of smart applications to develop a deep understanding of nanotechnology applications among 10th grade students.

Effect size	value η 2	*df*	value "T"	Test fields
Big	0.614	46	8.547	Setting hypotheses
Big	0.631	46	8.866	Forecasting
Big	0.159	46	2.947	Fluency
Big	0.331	46	4.772	Flexibility
Big	0.316	46	4.614	Decision making
Big	0.453	46	6.166	Explanations
Big	0.688	46	10.077	Total degree of the test

Table 5 shows that For the total score for the test: The calculated "C" value (10.077) is greater than the tabular "C" value (2.013) at the indication level (0.05) and the degree of freedom (46), and the value (SIG.) The probability (0.001), which is less than the semantic level (0.05), which indicates a statistically significant difference between the average scores of the experimental group and the control group in the dimensional application of the nanotechnology awareness test. The average score for the experimental group in the dimensional application of the nanotechnology awareness test was 26.458, while the average score for the control group was 14.958, with a difference of 11.50 points.

For dimensions of deep understanding of nanotechnology applications: The calculated "C" value for all areas of testing (hypotheses, prediction, fluency, flexibility, decision-making, explanations) was greater than the tabular "C" value (2.013) at the indication level (0.05) and degree of freedom (46), and the SIG. All domains are below the semantic level (0.05), which indicates a statistically significant difference of (0.05) between experimental and control group averages in the dimensional application of nanotechnology awareness areas. Arithmetic averages show that those differences were in favor of the experimental group in all areas of testing.

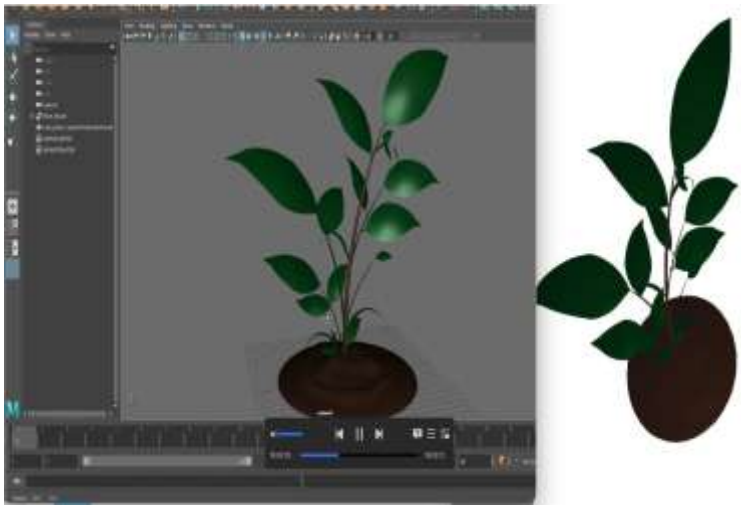
H1. The proposed program based on smart applications will achieve a magnitude of impact on the development of awareness of nanotechnology applications at least (0.14), according to ETA box.
In order to ascertain the magnitude of the impact to see whether the differences are real and attributable to the use of smart applications to develop a deep understanding of nanotechnology applications in tenth grade students, the magnitude of the effect is the one that most clearly confirms the effect, the "ETA" box is calculated as shown in **Table (6):**

This means that the values of the magnitude of the effect (η 2) for the test fields ranged from (0.159 - 0.631), to (η 2) for the total score of the test (0.688), all of which are greater than the limit (0.14), thereby accepting the hypothesis that: The proposed program based on smart applications will achieve a magnitude of impact on the development of awareness of nanotechnology applications at least (0.14) according to ETA box.

This result indicates that 68.8% of the variation in the overall score of the dependent variable (awareness of nanotechnology applications) is due to the effect of the independent variable (the proposed program based on smart applications), while the rest is due to experimental errors or other factors.

H2. The effectiveness of the proposed program based on smart applications in developing awareness of nanotechnology applications is higher than (1.2) gain based on the rate of gain adjusted for Black .

- To validate this hypothesis, the researcher used Black modified gain ratio to reveal the proposed smart application-based program to raise awareness of nanotechnology applications



Discussion

Scientists emphasize that environmental awareness requires individuals and communities to recognize the importance of the environment and the potential impacts of their behaviors towards it. Enhancing environmental awareness is a fundamental step toward achieving sustainability, which aims to meet the needs of current generations without compromising the ability of future generations to meet their own needs. Encouraging individuals to adopt sustainable behaviors to protect the environment is essential. Environmental education is crucial in addressing increasing environmental challenges such as climate change, loss of biodiversity, and pollution.

Therefore, supporting lifelong learning is vital; when we learn, we expand our knowledge base far beyond what we currently know. Learning can help us break out of certain patterns or routines, and the more we learn, the more our confidence grows. It's important to emphasize that youth are not just statistics; they are

a source of knowledge and talent that contributes to building a sustainable future. Integrating green skills into education can help reduce our carbon footprint in the world.

Conclusion

Looking at the previous initiatives focused on raising environmental awareness and agricultural biological culture, we find that technology contributes to making learning more engaging and interactive. This increases the likelihood of absorbing environmental information and supports the development of a strong awareness of environmental issues. It also enhances individuals' participation in sustainable solutions. Technology is a powerful tool in promoting environmental education, as it can be used innovatively to improve awareness and knowledge about environmental issues.

With the evolution of the global job market, future generations must be prepared to learn specialized skills for employment and improve their competencies through training. This includes fostering a commitment to lifelong learning, even after leaving the formal academic system.

Author contributions: All authors have sufficiently contributed to the study, and agreed with the results and conclusions.
Funding: No funding source is reported for this study
.**Ethical Statement:** The author stated that all participants were over the age of 15 and that their participation was entirely voluntary. The author also stated that since no personal data was analyzed and figures were used in this article, no Ethics Committee approval was required..
Declaration of interest: No conflict of interest is declared by the author.
Data sharing statement: Data supporting the findings and conclusions are available upon request from the author.

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