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The effect of an interdisciplinary sustainability education program on the sustainability consciousness and knowledge of 10th-grade students

RESEARCH ARTICLE OPEN ACCESS

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Article Info

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Highlights:
- The interdisciplinary application of sustainability education has a significant impact on students' sustainability consciousness.
- The interdisciplinary application of sustainability education has a significant impact on students' sustainability knowledge.
- Experimental studies are effective in improving sustainability knowledge, consciousness, awareness, and behavior.

Abstract

Education is essential for achieving the Sustainable Development Goals outlined in the UN 2030 Agenda. Sustainability is a multidisciplinary field. Therefore, this study developed an interdisciplinary education curriculum linking sustainability with Geography and Biology. The goal was to assess the impact of this curriculum on the sustainability awareness and knowledge of 10th-grade students. The research used a single-group pre-test and post-test experimental design. The curriculum focused on Sustainable Development, with sub-themes such as ecosystems, environmental issues, and biodiversity. The study involved 21 tenth-grade students from Aydın. The five-week program was conducted during the 2023-2024 academic year. The Sustainability Consciousness Scale and the Sustainable Development Knowledge Test were given before and after the intervention. Results from the related groups t-test showed a significant increase in scores from pre-test to post-test, indicating that the curriculum effectively enhanced students' awareness and understanding of sustainability.

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INTRODUCTION

The world we live in faces increasing environmental, social, economic, and humanitarian crises every day. Inequities in access to education and healthcare drive millions into despair and create a vicious cycle. A new understanding is needed to develop common solutions to global problems. This understanding is a sustainable development philosophy, which aims to ensure the long-term well-being of humanity and the planet by addressing environmental, social, and economic issues holistically. The term Sustainable Development (SD) was first introduced in the Brundtland report on global environment and development, published by the World Commission on Environment and Development (WCED) in 1987. In this report, SD is defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (UN, 1987). The report also presents a strategy that integrates development with environmental concerns. In this context, the United Nations advocates for a balanced integration of the economic, social, and environmental dimensions of sustainable development (UN, 2012). The economic aspect of sustainability involves more efficient resource use, the development of environmentally sustainable products, and encouraging people to voluntarily change their lifestyles responsibly (Beata et al., 2023). Environmental sustainability tackles issues such as biodiversity loss, freshwater scarcity, overfishing, global warming, extreme weather events, urban air pollution, and environmental noise (Vlek & Steg, 2007). The social dimension of sustainable development addresses social challenges such as poverty, unemployment, disease, and social exclusion, which significantly affect future generations (Anghel et al., 2014). Holistically viewing environmental issues today reveals their complex social and economic dimensions. Therefore, addressing environmental concerns alone is insufficient; fostering broad awareness of sustainability, including social and economic perspectives, is essential for meaningful solutions (Gericke et al., 2018).

By 2000, the Millennium Development Goals (MDGs) were adopted by the United Nations (UN) as the global framework for inclusive development, valid from 2000 to 2015. The MDGs focus on "striving to lift men, women, and children out of the degrading and inhumane conditions of extreme poverty" and on practical steps that help people worldwide improve their lives and prospects (UN, 2015). These efforts have grown into a more comprehensive system with the Sustainable Development Goals (SDGs). The UN 2030 Agenda, established in 2015, centers around 17 SDGs. The SDGs aim to ensure a sustainable, peaceful, and just life for everyone. While addressing climate change and environmental issues, the goals also respond to a range of social needs, including education, health, and employment opportunities (UNESCO, 2017). The 1992 UN Conference on Environment and Development's Agenda 21 report emphasized that education is vital for promoting sustainable development and enhancing people's ability to tackle environmental and development challenges (Carr & Norman, 2008). At this summit, a significant shift occurred, expanding the focus from solely environmental education to a broader paradigm. The inaugural step toward integrating different types of education, such as environmental, population, and development education, into a unified concept called education for sustainable development (ESD) was taken at this summit (Leicht et al., 2018).

According to the United Nations Educational, Scientific, and Cultural Organization (UNESCO), "Education should contribute to a new vision of sustainable global development" (UNESCO, 2015). Embarking on the path of sustainable development requires a fundamental change in how we think and act. To create a more sustainable world and enable individuals to contribute to sustainable development, they need knowledge, skills, values, and attitudes. Therefore, education is essential for achieving sustainable development (UNESCO, 2017). However, not all forms of education support sustainable development. Education that exclusively promotes economic growth can also lead to increased unsustainable consumption patterns. To address this issue, the sustainability education approach offers a meaningful and adaptable multidisciplinary framework for sustainability (Breunig et al., 2015). Sustainability can be integrated into all disciplines due to its "holistic structure" (Dolan, 2015). Sustainability education is a subject that can be understood and applied through interdisciplinary connections. As a result, sustainability literacy, the most important outcome of sustainability education, can be conveyed to individuals via interdisciplinary approaches (Özdemir, 2021). According to UNESCO (2020), sustainability education equips students with the knowledge, skills, values, and attitudes needed to make informed decisions and take responsible actions to ensure environmental integrity, economic viability, and a just society.

Today, education is crucial for developing the skills of tomorrow's leaders and citizens to create solutions and discover new ways toward a better, more sustainable future. Unfortunately, our current pool of human knowledge, skills, and experience cannot provide solutions to all of today's global environmental, societal, and economic challenges. Therefore, sustainability education is essential for a more sustainable future (UNESCO, 2012). Research on the knowledge, attitudes, and awareness levels of sustainability students at primary, secondary, and undergraduate levels has shown that a significant portion of students perceive sustainability as

the continuation of something (Aytar, 2016), their views on sustainability generally focus on the environmental dimension with less emphasis on the economic and social dimensions (Gökmen, 2014), and most students do not know the concept of sustainability (Yüksel & Yıldız, 2019a).

Interdisciplinary studies conducted to develop sustainability knowledge and consciousness demonstrate this. In a study exploring the effectiveness of interdisciplinary courses on students' sustainability knowledge, attitudes, and behaviors at a university in Germany, pre- and post-test results showed an increase in students' sustainability knowledge and behaviors. The study suggests that reducing barriers to interdisciplinary learning could help promote the development of students' sustainability knowledge and behaviors (Braßler & Sprenger, 2021). In another study, Bassachs et al. (2020) sought to demonstrate that interdisciplinary educational approaches enhance knowledge and skills for sustainable development in primary education. Their findings indicate that when interdisciplinary approaches are used, collaborative learning helps students develop a greater understanding of systems and sustainable development skills through critical thinking, analysis, interpersonal relationships, and teamwork. Gelbmann and Pirker (2023) demonstrated that interdisciplinary applied training can raise students' awareness of sustainable development and highlight the importance of an interdisciplinary approach to solving real-world problems within the framework of the Sustainable Development Goals. The study concluded that interdisciplinary applied training is a valuable tool for promoting sustainability education among university students and aids in their acquisition of sustainability knowledge and skills. Annan-Diab and Molinari (2017) aimed to emphasize the importance of adopting an interdisciplinary approach to education for sustainable development and to show how this approach can be advanced by considering different perspectives on sustainability across diverse contexts. A case study illustrates how to increase awareness of sustainable development among graduate students from diverse backgrounds in a course that integrates sustainable development concepts across disciplines. The case study demonstrated that the sustainability education module encouraged students to integrate knowledge from across disciplines to improve their understanding and actions on sustainable development issues.

Considering the literature, most studies were conducted at the higher education level. This study differs from others because it implemented an interdisciplinary curriculum linking sustainability to Geography and Biology at the high school level. Among the available studies on sustainability awareness in Türkiye, the following were conducted: an assessment of the perception of sustainability and environmental awareness among 400 kindergarten teachers working in Istanbul based on demographic and general characteristics (Aydın & Bakır, 2023); an investigation of the sustainability awareness levels of high school students, examining the relationship between various variables and sustainability awareness levels (Yüksel & Yıldız, 2019a); an examination of the green management perceptions and sustainability awareness of K12 schools in Turkey; and an analysis of Social Studies Textbooks in terms of sustainability awareness. Unlike survey studies that reveal only levels of sustainability knowledge and awareness and explore relationships between variables, this study conducted experimental research with an interdisciplinary approach to examine how sustainability education contributes to the development of sustainability knowledge and awareness.

Theoretical Framework

Sustainability education aims to equip students with the competencies needed for sustainability. These focus on helping students internalize sustainability values and develop their knowledge, skills, and attitudes about sustainability so they can think, plan, and act with sustainability in mind, living in harmony with the planet (Bianchi et al., 2022). Sustainability consciousness is a concept that emphasizes the experience or awareness of sustainability phenomena (Gericke et al., 2018). As a result, this concept is closely related to sustainability awareness. According to UNESCO, the goal of sustainability education is to redirect the education system towards sustainability, build capacity at all levels, and raise awareness of key issues. Students need the knowledge, skills, values, and attitudes to contribute to sustainable development. Therefore, sustainability education is essential because it empowers students to make informed decisions and act responsibly for environmental integrity, economic sustainability, and a just society on behalf of both present and future generations (UNESCO, 2017).

Sustainability education recognizes how the environmental, social, cultural, and economic dimensions of sustainable development are interconnected and embedded across disciplines and subjects. It aims to transform individuals and social institutions through a holistic approach (Bianchi et al., 2022). Sustainable development education should be both holistic and interdisciplinary. For this purpose, an interdisciplinary approach should be adopted, and training should be conducted in a comprehensive context that incorporates sustainability issues into programs (Eagan et al., 2002; Luppi, 2011; UNESCO, 2005). In this study, an interdisciplinary curriculum

combining biology and geography courses was designed to enhance high school students' knowledge and awareness of sustainability. Jacobs' interdisciplinary model (Jacobs, 1989) was used to develop this program.

The study aimed to evaluate the effect of the interdisciplinary sustainability education program on tenth-grade students' sustainability consciousness and knowledge. To achieve this, the following research questions were addressed:

- Is there a significant difference between the pre-test and post-test scores of the Sustainable Consciousness Scale for students who participated in the interdisciplinary sustainability education program?
- Is there a significant difference between the pre-test and post-test scores of the Sustainable Development Knowledge Test for students who participated in the program?

METHOD

Research Model

This research was designed using a single-group pretest-posttest experimental design. In the single-group pretest-posttest experimental model, the independent variable is applied to a randomly selected group before and after the experiment (Karasar, 2018, p. 131). In the experimental study, the 5-week 20-hour training program designed by the corresponding author for the pre-trial application of the thesis titled "Interdisciplinary sustainability education program" was applied to tenth-grade students in the second semester of the 2023-2024 academic year. Table 1 shows the study conducted with a single-group pretest-posttest experimental design.

Table 1. Single-group pretest-posttest experimental design

Group	Pre-test	Procedure	Post-test
G	P1	X	P2
Experimental Group (21 Students)	Sustainable Development Knowledge Test Sustainability Consciousness Scale Dependent Variable	5-Week Education Program (Experimental Intervention) Independent Variable	Sustainable Development Knowledge Test Sustainability Consciousness Scale Dependent Variable

The researcher designed the program based on Jacobs' interdisciplinary model (Jacobs, 1989), which is one of the integrated program models using concepts and perspectives from the Geography and Biology disciplines. The main theme of the program was identified as Sustainable Development. The learning outcomes from the 10th and 11th grade levels in the 2018 Geography and Biology curriculum of the Ministry of National Education (MEB) were reviewed, and those related to sustainable development were selected. In consultation with expert opinions, the learning outcomes for the interdisciplinary program were determined.

The researcher correlated the selected learning outcomes with each other. Based on these outcomes, the topics of sustainability in the ecosystem, environmental problems, and biodiversity were chosen as sub-themes of the program. The content for these themes was drawn from the MEB Biology 10 and MEB Geography 11 textbooks. The researcher developed learning, teaching activities, and assessment tools aligned with the program's objectives. Table 2 displays the related learning outcomes for the Biology and Geography courses.

Table 2. Correlating Biology and Geography course learning outcomes with sustainable development goals

Week	Theme	Concept /Topic	Biology (MEB, 2018)	Geography (MEB, 2018)
Week 1	Sustainability in the ecosystem	Energy flow in the ecosystem Sustainability in the ecosystem	10.3.1.1. Explain the relationship between living and non-living components of the ecosystem.	11.1.2. Distinguish the elements that make up the ecosystem.

Week 2		Water/Nitrogen/Carbon Cycle Sustainability of Water Resources	10.3.1.3. Explains the flow of matter and energy in the ecosystem. 10.3.1.4. Establishes a relationship between matter cycles and the sustainability of life.	11.1.3. Analyzes material cycles and energy flows in terms of ecosystem continuity. 1.1.4. Explains the elements and functioning of the aquatic ecosystem.
Week 3	Environmental problems	Soil/sea/water/air pollution Climate change/greenhouse effect Natural habitat destruction and forest fires	10.3.2.1. Evaluates the causes and potential consequences of current environmental problems. 10.3.2.2. Questions one's individual role in the emergence of environmental problems.	11.4.1. Classify environmental problems according to their causes.
Week 4		Ecological footprint, water footprint, and carbon footprint Human activities that harm the environment locally and globally	10.3.2.2. Questions one's individual role in the emergence of environmental problems. 10.3.2.3. Suggests solutions to prevent environmental pollution on a local and global scale.	11.4.2. Explains the environmental impacts of minerals and energy resources with examples. 11.4.6. Analyzes the formation and spread of environmental problems in terms of their global impact.
Week 5	Biodiversity	Endemic species, natural resources, gene bank, sustainability Recycling, waste management	10.3.3.1. Explains the importance of sustainability of natural resources. 10.3.3.2. Questions the importance of biodiversity for life.	11.4.4. Evaluates the use of natural resources in countries with varying levels of development in terms of their environmental impacts. 11.4.7. Evaluates the sustainable use of natural resources in terms of recycling strategies.

Participants

The study group for this research consists of 21 tenth-grade students attending a high school in the Efeler district of Aydın province during the second semester of the 2023-2024 school year. The reason the education program is applied to tenth-grade students is that the Biology and Geography courses are among the mandatory courses for tenth grade. Using an appropriate sampling method, one of the three tenth-grade sections was randomly selected as the study group in a school. All students in the chosen group volunteered to participate in the experimental study.

Data Collection Instrument

In this study, the Sustainable Consciousness Scale and the Sustainable Development Knowledge Test were used to evaluate the impact of the training program on sustainability awareness and knowledge. The "Sustainable Consciousness Scale," developed by Michalos et al. (2012) and updated by Gericke et al. (2018), was adapted to Turkish by Yüksel and Yıldız (2019b) after validation and reliability testing. The Sustainable Consciousness Scale consists of 50 items across three subscales, Knowledge, Attitude, and Behavior, covering economic, social, and environmental factors. It uses a five-point Likert scale ranging from "completely agree" to "strongly disagree." Scores on the scale range from 50 to 250, allowing classification of participants' sustainability awareness levels as low (50-117), medium (118-185), or high (186-250). Reliability analysis by Yüksel and Yıldız (2019) shows that the Cronbach's α coefficients for the subscales and items range from 0.655 to 0.882, with an overall scale Cronbach's α of 0.860. These results indicate that the scale has good reliability.

In this study, the "Sustainable Development Knowledge Test" was developed by the corresponding author, based on the learning outcomes of the interdisciplinary training program, to assess sustainability knowledge. The test consists of 25 questions, each with five answer options. Each question has one correct answer. To facilitate analysis of student answers, correct answers were coded as one and incorrect answers as 0. Opinions of two

experts were obtained to ensure content validity. Sustainable Development Knowledge Test Analysis Results are given in Table 3.

Table 3. Sustainable Development Knowledge Test Analysis Results

Number of Items	n	x	p	Ss	Kr-20
25	151	14,8675	,59	5,27	.76

The KR-20 reliability coefficient for the test, calculated with 25 items, was .76. According to Büyüköztürk (2013), a KR-20 value above .70 indicates that the test is reliable. Based on this criterion, the sustainable development knowledge test can be considered a reliable measurement tool.

Data Collection

The five-week training program was implemented by volunteer Biology and Geography teachers. The implementing teachers were informed about the experimental intervention process, lesson plans, and the interdisciplinary program. Before the experimental intervention began, the experimental group was administered a sustainability consciousness scale and a sustainability knowledge test. After each teacher completed the interdisciplinary sustainability training program, the sustainability awareness scale and sustainability knowledge test were administered again. The study's data collection process is presented in Table 4.

Table 4. The data collection process of the study

Stage	Application	Participants / Group	Explanation	Data collection tool
1. Pretest	An achievement test was applied to determine the initial level.	Experimental Group	Students' prior knowledge was measured.	Sustainable Consciousness Scale Sustainable Development Knowledge Test
2. Training Program Implementation (5 weeks 20 hours)	The prepared training program was applied to the experimental group by each teacher.	Experimental Group	The program was carried out according to the activities developed by the researcher.	Interdisciplinary Sustainability Training Program
3. Posttest	The same test was applied again to evaluate the effectiveness of the program.	Experimental Group	A comparison was made with the pretest.	Sustainable Consciousness Scale Sustainable Development Knowledge Test

Data Analysis

In this study, the experimental group consists of 21 students. In cases where the number of participants is less than 30, the Shapiro-Wilk test is recommended to test normality (Can, 2018; 89). Normality findings for the Sustainable Consciousness Scale pre-test and post-test data are given in Table 5.

Table 5. Sustainable Consciousness Scale Shapiro-Wilk Test Results

Scale	Statistic	df	p
Pre-test	,910	21	,055
Post-test	,976		,863

When Table 5 is examined, it is seen that the scores obtained from the pre-test and post-test of the students in the experimental group are normalized according to the results of the Shapiro-Wilk test ($p>0.05$). In this case, it was decided to compare the groups related to the parametric tests with the paired- samples t test. Normality findings for the Sustainable Development Knowledge Test pre-test and post-test data are given in Table 6.

Table 6. Sustainable Development Knowledge Test Shapiro-Wilk Test Results

Scale	Statistic	df	p
Pre-test	,937	21	,194
Post-test	,966		,655

When Table 6 is examined, it is seen that the scores obtained from the pre-test and post-test of the students in the experimental group are normalized according to the results of the Shapiro-Wilk test ($p>0.05$). In this case, it was decided to compare the groups related to the parametric tests with the paired- samples t test. In addition effect sizes (Cohen's d.) were calculated to calculate the magnitude of the significant difference using paired samples t test data. Cohen (1988) classified effect sizes as small ($d = 0.2$), medium ($d = 0.5$), and large ($d \geq 0.8$) (Sullivan and Feinn, 2012).

Limitations

In this study, since the experimental application data obtained from the pilot application of the corresponding author's thesis work were compared, the general scale score, which aims to examine the overall levels of the participants rather than focusing on subdimensions, was used. Furthermore, because the sustainability knowledge test and the sustainability awareness scale were applied together to collect data, it was considered sufficient for the pilot study application. Beside this because there was a pilot study, the 5-week experimental intervention program can be accepted as a limitation of the research. Because the research was organized according to a single-group experimental model, an experimental study group was identified.

RESULTS

Findings related to the research problem ("Is there a significant difference between the pre-test and post-test scores of the Sustainable Consciousness Scale of the students who applied the interdisciplinary sustainability education program?")

Sustainable Consciousness Scale t-test results for the related samples to determine whether there is a statistically significant difference between the means of the data values obtained from the pre-test and post-test measurements of the students in the experimental group are given in Table 7 were given under this title.

Table 7. Sustainable Consciousness Scale Related Samples for Experimental Group Pretest-Posttest Averages Paired-Samples T Test Results

Scale	n	x	Ss	sd	t	p	*d*
Pre-test	21	3,619	,4371				
				20	-5,01	,000	-1,09
Post-test	21	4,268	,3036				

Analyzing Table 7 reveals a significant difference between the mean pretest score ($x$pretest = 3,619) and the mean posttest score ($x$posttest = 4,268), as shown by the t-test for related samples conducted to determine whether there was a change in scores from the sustainability consciousness scale before and after the interdisciplinary sustainability training program ($t(20)= -5.016$, $p<0.01$). When considering Cohen's d, it is evident that the substantial difference between the pretest and posttest means ($d = -1.09$) reflects a high effect size. This indicates that the interdisciplinary sustainability education program implemented in the experimental group significantly influenced students' sustainability consciousness.

Sustainable Development Knowledge Test t-test results for the related samples to determine whether there is a statistically significant difference between the means of the data values obtained from the pre-test and post-test measurements of the students in the experimental group are given in Table 8 were given under this title.

Table 8. Sustainable Development Knowledge Test Related Samples for Experimental Group Pretest-Posttest Averages Paired-Samples T Test Results

Scale	n	$\bar{x}$	Ss	sd	t	p	d
Pre-test	21	11,952	4,387	20	-9,603	,000	-2,09
Post-test	21	20,000	2,190				

When Table 8 is examined, it is seen that there is a significant difference between the mean pretest scores ($\bar{x}_{pretest}$ = 11,952) and the mean posttest scores ($\bar{x}_{posttest}$ = 20,000) as a result of the t-test for related samples conducted to determine whether there is a difference between the mean scores obtained from the Sustainable Development Knowledge Test before and after the interdisciplinary sustainability education program ($t_{(20)=}$ -9,603, p<0.01). When Cohen's d is examined, it is evident that the significant difference between the pretest and posttest means (d = -2.09) indicates a large effect size. This shows that the interdisciplinary sustainability education program implemented in the experimental group had a significant impact on the students' sustainability knowledge.

DISCUSSION

Educational institutions draw on the knowledge, perspectives, and methods of various disciplines to nurture future generations with a sustainable outlook on life and greater sensitivity to the environment and humanity, aligning with the goal of ensuring the well-being of the planet and people. However, isolating disciplines can conflict with the holistic nature of sustainable development. Therefore, an interdisciplinary approach is essential to incorporate the environmental, social, cultural, and economic aspects of sustainability into educational programs in an integrated way. This study examined and confirmed the perspective that sustainability challenges should be addressed through an interdisciplinary approach. The results of this study, which evaluates the effect of an interdisciplinary sustainability education program on the sustainability awareness and knowledge of tenth-grade students, demonstrated that the program significantly enhanced students' sustainability consciousness and understanding. This indicates that the program effectively boosted students' awareness, knowledge, attitudes, and behaviors related to sustainability.

Several studies conducted in Turkey and abroad align with the findings of this research (Akgül, 2020; Aytar, 2016; Berasategi et al., 2020; Fernández et al., 2023; Liu et al., 2022; Mochizuki and Fadeeva, 2010; Tecimer Altınel, 2024; Walshe, 2017; Yüzbaşıoğlu, 2023). Akgül (2020), in a study examining the effects of eighth-grade students' science education supported by activities based on socioscientific issues on their awareness of sustainable development, found a statistically significant difference in posttest score averages favoring the experimental group. Results from focus group interviews with students in the experimental group indicated that implementing education for sustainable development supported by socioscientific issues increased students' awareness of sustainability. In a single-group pretest-posttest experimental study, Yüzbaşıoğlu (2023) aimed to determine the impact of practices using an interdisciplinary approach on students' awareness of sustainable living. A 33-week curriculum included 46 activities with middle school students across various courses and social clubs. Pretest and posttest data were collected using the Awareness of Sustainable Living Scale. The findings showed that, as a result of these activities, students' awareness of sustainable living increased significantly across all dimensions of the scale. The study concluded that activities conducted with an interdisciplinary approach positively influenced students' sustainability awareness. Walshe (2017) explored how an interdisciplinary approach to sustainability education improved high school students' understanding of sustainability in England, using drawings of sustainable cities, surveys, and semi-structured interviews to assess students' understanding of sustainable development within a constructivist case study. The study revealed that incorporating poetry into a geography course enhanced students' understanding of the social and economic dimensions of sustainability, although their focus remained primarily on the environment. These findings suggest that an interdisciplinary approach to sustainability education fosters more critical and effective engagement with the concept, promoting a more holistic understanding of sustainable development.

On the other hand, studies on the interdisciplinary implementation of sustainability education are mainly conducted in middle schools (Akgül, 2020; Aytar, 2016; Tecimer Altınel, 2024; Yüzbaşıoğlu, 2023) in Türkiye, while abroad, they are mostly carried out with university students (Craig et al., 2022; Fernández et al., 2023; Lozano et al., 2017). Therefore, this study, conducted with high school students, can be considered a contribution to the literature. Based on the results of this research, the following suggestions are proposed for future studies:

involve more disciplines to develop interdisciplinary programs, create a program covering all dimensions of sustainable development, explore how to integrate sustainability into curricula in education faculties, implement sustainability education for primary and secondary students, design programs to develop relevant competencies, and conduct long-term experimental studies to provide students with more detailed education.

Statement of Researchers

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