

Empowering Future Science Teachers for Quality Education (SDG 4): Cultivating Attitudes toward Sustainable Development*

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Abstract

In today's world, developing positive attitudes toward sustainable development among pre-service science teachers (PSTs) is crucial because future science educators can significantly influence how next generations perceive and respond to issues about sustainable development. Thus, this study set out to examine the effect of a course titled 'Sustainable Development and Education' on the development of pre-service science teachers' attitudes towards sustainable development. The research employed a single-group pre- and post-test design, with a sample of 50 PSTs enrolled in the course. Data were collected through the 'Attitudes toward Sustainable Development' scale and analyzed through paired sample t-tests. Findings revealed a statistically significant improvement in both overall and sub-dimension scores from pre- to post-test, favoring the latter. Put simply, the findings suggest that participation in the 'Sustainable Development and Education' course was associated with more positive attitudes toward sustainable development among pre-service science teachers.

Keywords: quality education, sustainable development goal 4, attitudes toward sustainable development, pre-service science teachers, sustainable development and education

Nitelikli Eğitim (SKA 4) için Geleceğin Fen Bilimleri Öğretmenlerini Yetiştirmek: Sürdürülebilir Kalkınmaya Yönelik Tutumların Geliştirilmesi

Öz

Günümüz dünyasında, fen bilimleri öğretmen adaylarının sürdürülebilir kalkınmaya yönelik tutumlarını geliştirmek çok önemlidir çünkü fen bilgisi öğretmen adayları, gelecek neslin küresel sürdürülebilirlik zorluklarını nasıl anladığını ve bunlara nasıl davrandığını şekillendirmede merkezi bir rol oynayacaktır. Bu bağlamda, bu araştırmanın amacı 'Sürdürülebilir Kalkınma ve Eğitim' dersinin fen bilgisi öğretmen adaylarının sürdürülebilir kalkınmaya yönelik tutumları üzerindeki etkisini incelemektir. Bu çalışmada tek grup ön test-son test modeli kullanılmıştır. Çalışmanın örneklemini, 'Sürdürülebilir Kalkınma ve Eğitim' dersine kayıtlı 50 fen bilimleri öğretmen adayı (FBÖ) oluşturmaktadır. Veriler, 'Sürdürülebilir Kalkınmaya Yönelik Tutumlar' ölçeği ile toplanmıştır. Veri analizinde bağımlı örneklem t testi kullanılmıştır. Sonuçlar, öğretmen adaylarının sürdürülebilir kalkınmaya yönelik tutumlarının ön test ve son test toplam ve alt boyut puanları arasında son test puanları lehine istatistiksel olarak anlamlı bir fark olduğunu göstermiştir. Özetle, bulgular, "Sürdürülebilir Kalkınma ve Eğitim" dersine katılımın fen bilimleri öğretmen adaylarının sürdürülebilir kalkınmaya yönelik tutumlarında olumlu bir gelişimle ilişkili olduğunu ortaya koymaktadır.

Keywords: nitelikli eğitim, sürdürülebilir kalkınma amacı 4, sürdürülebilir kalkınmaya yönelik tutumlar, fen bilimleri öğretmen adayları, sürdürülebilir kalkınma ve eğitim

Introduction

In the modern era, sustainable development has become a pressing global concern as societies face with environmental, economic, and social challenges like rapid population growth, urban expansion, industrialization, and hazardous waste. Sustainable development defined as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” covers three interconnected dimensions—environmental, economic, and social—and seeks to balance them harmoniously (Ferguson et al. 2021; WCED, 1987, p.43).

Education is widely recognized as one of the most powerful tools for achieving sustainable development worldwide. Universities have potential to cultivate knowledge, attitudes, and skills essential for critical thinking and informed decision-making in support of sustainable lifestyles (Concina & Frate, 2023; Leiserowitz et al., 2005; Michalos et al., 2012; Pamuk et al., 2022). Especially, teachers have the responsibility of shaping conscious individuals, however many face challenges in addressing complex and sometimes controversial topics like sustainable development (Borg et al., 2012; Corney, 2006; Dere et al., 2025; Dere & Demirci Dölek, 2024; Koçulu & Sert, 2024; Oulton et al., 2004; Summers et al., 2005). Teacher education plays an important role in driving social transformation toward a sustainable future (Nousheen et al., 2020). This highlights the significance of preparing pre-service teachers through teacher training programs.

Teacher education institutions have a crucial potential to develop awareness, knowledge, skills and values of teachers needed to create a just and sustainable future (Ćoćkalo et al., 2015; Koçulu, 2025; Kopnina, 2013). Higher education for sustainable development extends beyond knowledge acquisition, encouraging reflection on the long-term consequences of current actions and decisions within a global framework of responsibility (Barth et al., 2007). In this sense, education for sustainable development (ESD) empower learners to understand sustainability issues, develop practical skills for sustainable living, and cultivate personal and emotional qualities that inspire sustainable attitudes and behaviors (García-González et al., 2020; Maidou et al., 2019; Shephard, 2008; Torbjörnsson, 2011). In this manner, the current study examines the impact of a ‘Sustainable Development and Education’ course on PSTs’ attitudes toward sustainable development.

Research Background

Quality Education (Sustainable Development Goal 4)

Quality Education, Sustainable Development Goal 4, aims to make equitable and inclusive education accessible to all and to promote lifelong learning opportunities (UNESCO,2014). This goal ensures that individuals not only acquire knowledge but also gain the skills necessary for social equality, economic development, and democratic participation. The importance of quality education extends from children’s access to quality pre-school education at an early age to the provision of free and equitable primary and secondary education opportunities. Moreover, equal access to higher education and vocational training increases individuals’ participation in the workforce, becoming a cornerstone of sustainable development. Education, as stated in the Universal Declaration of Human Rights, is one of the most fundamental human rights and a critical tool for the realization of other rights (Rieckmann, 2017).

Quality Education, SDG 4, is shaped by an understanding that centers the role of teachers. This is because the most important factor determining quality in education is teachers’ quality and their opportunities for professional development (UNESCO,2014). Teachers are not only transmitters of knowledge, but also actors who guide students in developing problem-solving skills, critical thinking, and a sense of social responsibility. Hence, SDG 4 aims to invest in teachers' professional training, provide continuous development opportunities, and ensure a balanced distribution of teachers, especially in disadvantaged regions. Qualified teachers are indispensable for the realization of inclusive and equitable education; their empowerment is seen as one of the cornerstones of sustainable development.

Education and Sustainable Development

One of the most common informational tools is education that can cause changes in knowledge, attitudes and behavior change (Klaniecki et al., 2019; Steg & Vlek, 2009). Kougias et al. (2023) emphasize the significance of embedding Education for Sustainable Development (ESD) within school curricula, as this integration fosters sustainable mindsets, attitudes and behaviors among students (Michalos et al., 2015). According to Afroz and Ilham (2020), there is a strong positive correlation between the attitude and practice towards sustainable development and SDGs. ESD in higher education institutions can develop a suitable sense of responsibility towards sustainable development among their undergraduate students and youth participation is crucial for realizing the objectives of Agenda 2030 (Arbuthnott, 2009; Balakrishnan et al., 2020; Borojević et al., 2017; Wee et al., 2017). Raising public awareness and cultivating supportive attitudes toward the sustainable development and its goals is also a prerequisite for citizen engagement (Cirnu & Kuralt, 2013; Guan et al., 2019; Lindström, 2003). Enhancing quality of life on Earth requires individuals to adopt sustainability conscious attitudes, adjust behaviors, and embrace lifestyles that address ecological challenges (Khalfan & Alshannag, 2018; Vithessonthi, 2013). In this regard, sustainability-focused courses play an essential role in instilling values and practices of sustainable living among students (Dere & Çinikaya, 2023; Tang, 2018).

Attitudes Towards Sustainable Development

Attitudes toward sustainable development refer to individuals and societies acting responsibly in economic, environmental and social dimensions (Concina & Frate, 2023; Kalsoom, 2019). These attitudes involve developing conscious behaviors in areas like the conservation of natural resources, energy efficiency, social equality, and economic justice (Chen, 2015). Positive attitudes toward sustainable development go beyond simply protecting the environment; they also aim to create a more livable world for future generations (Nkaizirwa et al., 2021). Education, public awareness and media play a crucial role in fostering these attitudes. Raising younger generations with a strong awareness of sustainable development, in particular, facilitates the achievement of sustainable development goals in the long term (Smaniotto et al., 2020).

Developing science teacher candidates' attitudes towards sustainable development is critically important for raising future generations with environmental awareness and a sense of economical and social responsibility. To foster these attitudes, pre-service teachers' educational programs should include courses, projects, and practical activities related to the term of sustainable development. Since science education is directly related to the environment, energy, and natural resources, pre-service science teachers are expected to cultivate conscious and responsible individuals in these areas. Furthermore, developing pre-service teachers' problem-solving critical thinking and collaboration skills within the context of sustainable development is effective in creating lasting attitudinal and behavioral changes in students. This aims not only at the transfer of knowledge but also at instilling sustainable lifestyles. Universities can influence attitudes of students (Eilam & Trop, 2012; Kuchinka et al., 2018).

University students especially pre-service science teachers are regarded as key drivers of meaningful change in building a more equitable and sustainable future, and thus are expected to demonstrate a level of knowledge, awareness, attitudes and behaviors that exceeds the norm (Priestley et al., 2012). When they develop a comprehensive understanding of the sustainable development and its goals, pre-service science teachers and their future students can play an active role in advancing these objectives through research, innovation, and entrepreneurial initiatives (Kleespies & Dierkes, 2022; Maoela et al., 2024).

Method

Research Design

The present study employed a single-group pre- and post-test design as a quantitative research approach. In such a model, the same group is assessed both before and after undergoing a specific intervention (Cohen et al., 2007; Fraenkel et al., 2012). At the outset, the attitudes of PSTs toward sustainable development were measured prior to the commencement of the 'Sustainable Development and Education' course. Following the 10-week course, the 'Attitudes toward Sustainable Development' scale was administered again as a post-test to evaluate changes in their perspectives by the end of the program.

Sample

The sample consisted of 50 fourth-year pre-service science teachers enrolled in the Sustainable Development and Education course at a public university in Istanbul, Türkiye. Participants were recruited through convenience sampling, as all PSTs enrolled in the course during the study period were invited to participate. The participants were aged between 22 and 24 years, and the sample included 44 female and 6 male students. Prior to enrolling in the course, none of the participants had taken a formal course related to sustainable development. The pre-test was administered at first week of the course and the 10-week course was conducted during the semester, and the post-test was administered upon completion of the course.

Procedure

At the beginning of the course, the 'Attitudes toward Sustainable Development' scale was administered as a pre-test to evaluate PSTs' attitudes toward sustainable development. Subsequently, PSTs participated in the 10-week Sustainable Development and Education course. The course was delivered by the researcher and included a combination of lectures, classroom discussions, collaborative group activities, case analyses, and reflective learning tasks. Throughout the course, students engaged in activities designed to examine sustainability issues from environmental, social, and economic perspectives, discuss real-world sustainability challenges, and reflect on the role of education in promoting sustainable development. The course covered topics such as the concept, dimensions, and importance of sustainable development, the Sustainable Development Goals (SDGs), the interconnections among education, environment, economy, and society, sustainability-related educational practices in Türkiye and around the world, and guidance for lifelong learning and sustainable living (Table 1). At the end of the 10-week period, the same scale was administered as a post-test to examine changes in participants' attitudes toward sustainable development.

Table 1. Implementation of ‘Sustainable Development and Education’ Course

Weeks	Subjects	Instructional Format and Learning Activities
Week 1 (2 lesson hours)	Sustainable Development and its Dimensions and Importance	Interactive lecture, classroom discussion on the concept and dimensions of sustainable development, reflection on current sustainability challenges.
Week 2 (2 lesson hours)	Sustainable Development Goals (SDG 1, SDG 2, SDG 3, SDG 4)	Lecture and group discussions focusing on the goals, their indicators, and their relevance to education and society.
Week 3 (2 lesson hours)	Sustainable Development Goals (SDG 5, SDG 6, SDG 7, SDG 8)	Lecture and group discussions focusing on the goals, their indicators, and their relevance to education and society.
Week 4 (2 lesson hours)	Sustainable Development Goals (SDG 9, SDG 10, SDG 11, SDG 12)	Lecture and group discussions focusing on the goals, their indicators, and their relevance to education and society.
Week 5 (2 lesson hours)	Sustainable Development Goals (SDG 13, SDG 14, SDG 15)	Lecture and group discussions focusing on the goals, their indicators, and their relevance to education and society
Week 6 (2 lesson hours)	Sustainable Development Goals (SDG 16, SDG 17)	Lecture and group discussions focusing on the goals, their indicators, and their relevance to education and society
Week 7 (2 lesson hours)	Education and Awareness for Sustainable Development	Interactive lecture and discussion on the role of education in promoting sustainability awareness and responsible citizenship.
Week 8 (2 lesson hours)	Relationships between Education, Environment, Economy, and Society for Sustainable Development	Group discussions, concept mapping, and reflective activities exploring the interconnected dimensions of sustainable development.
Week 9 (2 lesson hours)	Educational Practices for Sustainable Development in Türkiye and around the World	Examination of national and international ESD practices through case studies and comparative discussions. Student-centered discussions and problem-based activities addressing sustainability challenges and possible solutions.
Week 10 (2 lesson hours)	Guide to Lifelong Learning and Sustainable Living	Reflective activities, classroom discussion, and development of personal action plans for sustainable lifestyles and lifelong learning.

Data Collection and Analysis

Data for this study were gathered through ‘Attitudes toward Sustainable Development’ scale, developed by Biasutti and Frate (2017) and later adapted into Turkish by Demirel and Sungur (2018). The instrument comprises 20 items organized into four dimensions: environment, economy, society, and education. Responses are rated on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The Cronbach’s alpha coefficient of the scale was found to be 0.854 by researchers who conducted the adaptation study (Demirel & Sungur, 2018). In the current research, Cronbach’s alpha coefficient was calculated as 0.853. For data analysis, a paired-samples t-test, which is a parametric statistical procedure, was employed because the difference scores between the pre-test and post-test measurements met the normality assumption. Normality was assessed through the examination of skewness and kurtosis values, as well as the Shapiro-Wilk test results, which indicated that the difference scores were approximately normally distributed.

Findings

In this study, the effect of ‘Sustainable Development and Education’ course on PSTs’ attitudes toward sustainable development were examined. The pre- and post-test results about PSTs’ attitudes toward

sustainable development were presented in Table 2 and Table 3. According to the findings, there were statistically significant differences between pre- and post-test scores in favour of both PSTs' post total test scores ($t(49) = -32.36, p < .05$). Furthermore, Cohen's d was calculated to estimate the effect size (Cohen's $d = \text{Mean}/\text{Standard Deviation}$) and yielded a value of 4.57, with corresponding 95% confidence intervals. This result indicates a very large effect, demonstrating a substantial improvement in PSTs' scores from pre-test to post-test of attitudes toward sustainable development.

Table 2. Descriptive Results for PSTs' Attitudes toward Sustainable Development

Attitudes toward Sustainable Development		Mean	N	Std. Deviation
Total	Pre-test	73.30	50	3.54
	Post-test	91.40	50	2.18

$p < .05$

Table 3. Results of Paired Samples t - test for PSTs' Scores of Attitudes toward Sustainable Development

					95% Confidence Interval of the Difference					
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	p	Cohen's d
Total	Pre-test-Post-test	-18.10	3.96	.56	-19.22	-16.98	-32.36	49	p < .001	4.57

$p < .05$

Results about Environment Dimension of Sustainable Development

Comparison of the pre-test and post-test scores revealed a statistically significant increase in attitudes toward the environment dimension of sustainable development following the *Sustainable Development and Education* course ($t(49) = -20.62, p < .05$), suggesting a positive effect of the intervention on participants' environmental attitudes (Table 4 and 5). Furthermore, the effect size, as measured by Cohen's d , was 2.91 (95% CI). This value represents a very large effect, indicating a considerable difference between PSTs' pre-test and post-test scores on the environmental dimension of attitudes toward sustainable development.

Table 4. Descriptive Results for 'Environment' Dimension of Sustainable Development

Attitudes toward Sustainable Development		Mean	N	Std. Deviation
Environment	Pre-test	18.18	50	1.47
	Post-test	23.16	50	1.31

$p < .05$

Table 5. Results of Paired Samples t- test for ‘Environment’ Dimension of Sustainable Development

					95% Confidence Interval of the Difference					
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	p	Cohen's d
Environment	Pre-test									
	Post-test	-4.98	1.71	.241	-5.47	-4.49	-20.62	49	p < .001	2.91

$p < 0.05$

Results about Economy Dimension of Sustainable Development

The findings showed that pre-service science teachers' attitudes toward the economic dimension of sustainable development increased significantly from pre-test to post-test following the Sustainable Development and Education course ($t(49) = -14.484$, $p < .05$) (Table 6 and 7). Notably, the economic dimension had the lowest mean score among all dimensions in the pre-test, but demonstrated a significant improvement after the intervention. In addition, Cohen's d was calculated to estimate the effect size (Cohen's d = Mean/Standard Deviation) and yielded a value of 2.05, with corresponding 95% confidence intervals. This finding indicates a very large effect, demonstrating a substantial increase in PSTs' pre-test to post-test scores in the economy dimension of attitudes toward sustainable development.

Table 6. Descriptive Results for ‘Economy’ Dimension of Sustainable Development

Attitudes toward Sustainable Development	Mean	N	Std. Deviation
Economy Pre-test	17.66	50	1.41
Post-test	21.86	50	1.43

$p < .05$

Table 7. Results of Paired Samples t- test for ‘Economy’ Dimension of Sustainable Development

					95% Confidence Interval of the Difference					
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	p	Cohen's d
Economy	Pre-test									
	Post-test	-4.20	2.05	.289	-4.78	-3.62	-14.484	49	p < .001	2.05

$p < .05$

Results about Society Dimension of Sustainable Development

The findings indicated that pre-service science teachers' attitudes toward the social dimension of sustainable development improved significantly after Sustainable Development and Education course. Comparison of the pre-test and post-test scores revealed a statistically significant increase in participants' attitudes toward the social dimension ($t(49) = -16.112$, $p < .05$) (Table 7 and 8), suggesting a positive effect of the intervention. In addition, the effect size, estimated using Cohen's d, was 2.28 (95% CI). This value represents a large effect, indicating a considerable difference between PSTs' pre-test and post-test scores on the society dimension of attitudes toward sustainable development.

Table 7. Descriptive Results for ‘Society’ Dimension of Sustainable Development

Attitudes toward Sustainable Development		Mean	N	Std. Deviation
Society	Pre-test	17.90	50	1.28
	Post-test	22.20	50	1.46

 $p < .05$ **Table 8.** Results of Paired Samples t- test for ‘Society’ Dimension of Sustainable Development

					95% Confidence Interval of the Difference					
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	p	Cohen's d
Society	Pre-test-Post-test	-4.30	1.89	,27	-4.84	-3.76	-16.112	49	p < .001	2.28

 $p < .05$

Results about Education Dimension of Sustainable Development

The findings indicated that pre-service science teachers' attitudes toward the education dimension of sustainable development improved significantly after Sustainable Development and Education course ($t(49) = -15.36$, $p < .05$) (Table 9 and 10). The education dimension yielded the highest mean score among all dimensions in both the pre-test and post-test measurements, suggesting that participants demonstrated particularly strong attitudes toward the educational aspect of sustainable development throughout the intervention. Moreover, Cohen's d effect size was calculated as the ratio of the mean difference to the standard deviation and was found to be 2.17, with corresponding 95% confidence intervals. This result indicates a very large effect, demonstrating a substantial improvement in PSTs' scores from pre-test to post-test in the education dimension of attitudes toward sustainable development.

Table 9. Descriptive Results for ‘Education’ Dimension of Sustainable Development

Attitudes toward Sustainable Development		Mean	N	Std. Deviation
Education	Pre-test	19.56	50	1.89
	Post-test	24.18	50	1.04

 $p < .05$ **Table 10.** Results of Paired Samples t- test for ‘Education’ Dimension of Sustainable Development

		95% Confidence Interval of the Difference								
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	<i>p</i>	<i>Cohen's d</i>
Education	Pre-test-Post-test	-4.62	2.13	.30	-5.22	-4.02	-15.36	49	p < .001	2.17

 $p < .05$

Discussion and Conclusion

The aim of the current study was to examine the association between participation in the course ‘Sustainable Development and Education’ and PSTs' attitudes toward sustainable development.

Findings indicated that PSTs' initial attitudes toward sustainable development were moderately positive, and their attitudes increased significantly from pre-test to post-test, reaching a high level by the end of the course. Similarly, research in current literature showed that university students and pre- or in-service teachers have positive attitudes toward sustainable development, although these attitudes are not always strong enough to drive consistent behavior (Anđić & Ćurić, 2020; Bask et al., 2020; Borges, 2019; Cotton et al., 2007; Drayson et al., 2013; El-hamed et al., 2022; Haldar et al., 2022; Letina & Diković, 2024; Liu et al., 2020; Naikoo, 2017; Nikolic et al., 2020; Soysal & Ok, 2021; Sunthonkanokpong & Murphy, 2019; Wendlandt Amézaga et al., 2022). This highlights the significance of strengthening pre-service teachers' attitudes through education. Supporting evidence comes from Nousheen et al. (2020), who revealed that pre-service teachers' attitudes improved positively with ESD, and Stewart (2024), who reported notable differences across dimensions of sustainable development after transformative education. Likewise, Tang (2018) demonstrated that an Engineering Sustainable Development course positively shaped engineering students' attitudes, beliefs and intentions toward sustainable development. Furthermore, Diez-Ojeda et al. (2025) showed in their study that the inclusion of service-learning program in the environmental education program significantly improved preservice teachers' attitudes toward sustainable development.

A change in attitude toward sustainable development means feeling bad for environmental, economical and social destructions and reflects a strong commitment to engaging in sustainability-oriented actions, whether taken individually or collectively (Kalsoom, 2019). Therefore, cultivating strong attitudes among pre-service science teachers is vital, as they will play a central role in preparing future generations to achieve sustainable development. Embedding courses on sustainability within science teacher education programs is a powerful means of fostering these attitudes. Ultimately, teacher education programs must respond to societal needs by preparing future educators to approach their profession through the lens of sustainable development.

Developing preservice science teachers' attitudes toward sustainable development is a crucial step in preparing them to become agents of change in education. By integrating sustainability concepts into teacher training programs, future educators can cultivate a sense of positive attitudes toward environmental stewardship, social equity, and economic viability. This involves not only providing knowledge about sustainable development but also fostering reflective practices, critical thinking, and values that encourage long-term commitment to sustainable living. When preservice teachers engage in experiential learning—such as interdisciplinary coursework and inquiry-based science activities—they begin to see sustainable development as a practical and ethical dimension of their teaching. Ultimately, shaping positive attitudes toward sustainable development ensures that these teachers will inspire their future students to adopt sustainable attitudes and contribute meaningfully to addressing global challenges.

Limitations and Future Research

Although the present study makes important contributions to the literature by providing evidence regarding the role of the Sustainable Development and Education course in fostering future science teachers' attitudes toward sustainable development, several limitations should be acknowledged. A key limitation of the present study is the small sample size. Future research could involve larger groups of students or diverse populations to strengthen the validity and generalizability of the findings. This study examined the impact of the 'Sustainable Development and Education' course on PSTs' attitudes toward sustainable development using a single-group pre- and post-test design, as only one class offered the course at the university. The absence of a control group and the limited number of participants restrict the generalizability of the results. Employing an experimental design with both pre- and post-tests and a control group in future studies would enhance reliability, validity, and generalizability. Additionally, this research relied solely on quantitative methods and a five-point Likert scale due to constraints in available instruments. Such reliance may introduce biases, including social desirability, central tendency, acquiescence, and limited interpretive depth, while also failing to capture the complexity of attitudes. To address these issues, future studies could use expanded Likert-

type scales with more items, or adopt qualitative and mixed-method approaches for richer insights. The current study reflects outcomes from a 10-week intervention; however, longitudinal designs can allow researchers to track changes over time and assess whether students adopt sustainable attitudes in practice. Follow-up evaluations can be conducted in the future research. Despite these limitations, this study represents an important early contribution, offering valuable insights for researchers, educators, and curriculum developers into how PSTs' attitudes toward sustainable development evolve—an area critical for shaping a sustainable future.

Author Contributions

The author declares that no other author contributed to this work and that they have read and approved the final version of the work.

Ethical Declaration

This study was conducted with the approval of the Yıldız Technical University Social and Human Sciences Research Ethics Committee, as granted at the meeting held on March 2, 2026 (Protocol No. 20260309198).

Conflict of Interest

The author declare that they have no conflict of interest with any institution or person within the scope of the study.

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