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Integration of STEM into Environmental Education: Preservice Teachers' Opinions

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Abstract

This qualitative study adopted a case study design to investigate preservice teachers' opinions of a STEM-integrated environmental education program (STEM-IEEP). The sample consisted of 12 preservice teachers recruited using purposive criterion sampling. Data were analyzed using content analysis. Participants had positive views of the STEM-IEEP. They stated that it raised their environmental awareness and helped them develop positive attitudes towards the environment and find solutions to environmental issues. They also noted that it changed their views on environmental engineering for the better. Lastly, they believed that STEM education was vital because it helped them develop 21st-century skills and contributed to advances in technology. Recommendations were made based on the results.

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Introduction

Advances in science and technology have significantly improved standards and quality of life, making people more focused on meeting their needs. However, the excessive and uncontrolled use of natural resources is causing an unprecedented environmental crisis (Alagoz & Akman, 2016). Countries, environmentalists, and educators have turned to environmental education because it is critical for finding solutions to environmental problems (Makki et al., 2003). Therefore, we need effective environmental education to solve environmental problems (Arslan & Albay, 2019). Teachers influence their students' knowledge and attitudes towards the environment (Mercan & Işık Mercan, 2020). In this context, we need to turn young generations into environmentally conscious people to create a better world.

Teachers are primarily responsible for turning students into environmentally conscious people. Therefore, we should provide teachers with training in environmental education. For example, students' performance depends on teachers' professional qualifications (Hibpshman, 2007). Teachers should know about environmental education to be able to raise students' awareness of environmental issues (Güler, 2009). Researchers focus on interdisciplinary educational approaches to instruct teachers on how to deliver environmental education (Güven & Hamalosmanoğlu, 2012) and participate in the process and come up with creative solutions (Türksoy, 1991). In this context, one of those educational approaches is STEM education, which has been popular in recent years.

STEM education incorporates the fields of science (S), technology (T), engineering (E), and mathematics (M) and relates them to daily life. We can integrate STEM education into environmental education to provide students with an interdisciplinary approach to raise their awareness of environmental issues (Karakaya et al., 2018). We can use STEM education to solve environmental issues and develop appropriate models for those solutions. In fact, people try to find ways to solve environmental problems (Karışan & Yurdakul, 2017). STEM education can help us address environmental issues.

Significance

This study involved a 12-week STEM-integrated environmental education program (STEM-IEEP) to help preservice teachers develop professional skills. All participants were interviewed after the program. Researchers have integrated STEM into different areas, developed curricula based on their results, and investigated preservice teachers' opinions of those curricula (Çakır et al., 2019; İnançlı & Timur, 2018; Köse & Ataş, 2020; Saraç & Doğru, 2021). However, there is a small body of research on integrating STEM into environmental education (Karahan & Ünal,

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2019; Kuvanç, 2018). Moreover, they were short-term studies that did not provide data on preservice teachers' opinions of STEM-IEEPs. Therefore, this is one of the first studies integrating STEM into environmental education and focusing on preservice teachers' opinions. Our results will guide researchers and educators in integrating STEM into environmental education. The main research question was, *"What do preservice teachers think about the integration of STEM into environmental education programs (STEM-IEEPs)?"*

Literature Review

Environment education

Advances in technology have mainly driven the extraordinary growth in purchasing power. Since people have higher living standards, it causes increasing consumption. However, excessive consumption has consequences, such as unplanned urbanization, depletion of natural resources, and environmental problems. Countries have taken several measures to address those problems. For example, they have been holding international meetings since 1972. As a result of those meetings, they have focused on environmental education to raise public awareness (Uzun & Sağlam, 2007). Environmental education is an approach, philosophy, tool, and profession (Monroe et al., 2008).

The primary objective of environmental education is to turn students into environmentally literate individuals who preserve the environment and restore it (UN Enviroment, 2019; Wheaton et al., 2018). Environmental literacy encourages people to solve environmental issues (Palmer, 1998) and make the world a better place for young generations. People with environmental literacy have to put knowledge into practice to build a healthy environment for future generations because If we do not turn environmental education knowledge into action, environmental education cannot achieve its purpose (Musser & Diamond, 1999). We should integrate theory with practice. Moreover, environmental education focuses on turning students into people who can solve environmental issues and develop models for those solutions (Gigliotti, 1990). We should regard environmental education as an interdisciplinary process and integrate it into lectures (Hamalosmanoğlu & Güven, 2014). These arguments show that environmental education should adopt an interdisciplinary approach. Therefore, we should integrate environmental education with STEM to turn students into people with 21st-century skills who adopt an interdisciplinary perspective to solve environmental issues. In this context, STEM education with an interdisciplinary approach can help us solve environmental issues and turn students into people who are aware of those issues.

STEM education

In the digital world, everybody should have creativity, information and communication technology (ICT) literacy, and problem-solving, critical thinking, and innovation skills (Akkuş, 2020). Countries adopt different educational approaches to help their citizens develop those skills and find solutions to problems (Aykan & Yıldırım, 2021). One of those approaches is STEM education.

STEM education incorporates the fields of science (S), technology (T), engineering (E), and mathematics (M) and relates them to daily life (Sarı et al., 2020). STEM education also integrates theory and practice (Ormancı, 2020). Different countries (USA, Turkey, South Korea, etc.) implement STEM education in formal and informal education environments (Arslan & Yıldırım, 2020) because it is an interdisciplinary approach that integrates theory and practice and helps learners develop 21st-century skills (Verdi & Yıldırım, 2020). STEM education also helps learners integrate new knowledge into daily life and find solutions to problems. Teachers are primarily responsible for applying STEM education (Türk et al., 2018). Therefore, they should know about STEM education and incorporate it with environmental education. In this way, we can turn learners into people who can solve environmental issues.

Method

Design

This study adopted a qualitative case study design to determine the effects of a STEM-IEEP objectively, validly, and reliably. A case study is a field study design used to investigate and interpret an event within its own reality

(Merriam, 1998). Therefore, this study regarded each participant as a case.

Participants

Participants were recruited using criteria sampling, a non-probability purposive sampling method. Criteria sampling involves the selection of a sample that meets a predetermined set of criteria (Yıldırım & Şimşek, 2011). Criteria sampling is a time- and cost-efficient method by which researchers select participants most suited to the research purpose (Patton, 2002). This study enrolled preservice teachers in the program and sought their opinions afterward. The inclusion criteria were (1) having received STEM education and (2) volunteering to participate. The sample consisted of 12 preservice teachers (seven women and five men). Each participant was assigned a pseudonym (Ali, Hayriye, etc.) for confidentiality.

Data collection tools

Semi-structured interview questionnaire (SSIQ)

Semi-structured interviews were conducted to unveil participants' views of the STEM-IEEP. The interviews were conducted using a Semi-Structured Interview Questionnaire (SSIQ) consisting of five intelligible and open-ended questions. Two experts checked the SSIQ. The first expert had a Ph.D. degree and studies in STEM education, while the second expert had studies on environmental education. The SSIQ was revised based on their feedback. Afterward, a pilot study was conducted with two teachers. The SSIQ was finalized based on their feedback.

Data analysis

Qualitative data were collected through face-to-face interviews. Each interview lasted 15 to 20 minutes. The interviews were transcribed and then analyzed using content analysis. Themes, categories, and codes were developed based on the content analysis. Afterward, findings were developed. The findings were presented and interpreted in Tables to make it easy for readers to understand. Two experts performed the content analysis and developed the themes, categories, and codes separately. They identified the parts on which they agreed and disagreed. They discussed the codes on which they disagreed until they reached a consensus. They developed themes, categories, and codes and calculated the interrater reliability, which was 84% (Miles et al., 2014).

Context

This was a 12-week study conducted within the scope of the "Instructional Technique and Material Design" and "Environmental Education" courses. The study aimed to provide preservice teachers with the STEM-IEEP. The study focused on environmental issues and solutions. Table 1 presents the activities performed within the scope of the STEM-IEEP.

Table 1.
Data collection and education process

No	Duration	Activity
1	2 weeks	We are reducing water pollution and collecting garbage.
2	2 weeks	We are intervening in oil pollution.
3	2 weeks	We are reducing water pollution and designing watercraft powered by renewable energy sources.
4	2 weeks	We are designing a chimney filter.
5	2 weeks	We are reducing CO_2 emissions and using solar power.
6	2 weeks	We are collecting garbage and recycling it.

Participants conducted a lot of reading and researching before designing. They read texts from different sources about STEM education and environmental pollution. They performed discussions based on what they learned about STEM education and environmental pollution. After the discussions, they decided on their designs and then drew them out. The designs consisted of two stages: knowledge and practice.

Findings

The first research question addressed participants' views of the STEM-IEEP. Participants stated 11 advantages of the STEM-IEEP: (1) interdisciplinary integration, (2) learning by doing and living, (3) relating to daily life, (4) learning retention, (5) active learning, (6) comprehending the significance of environmental education, (7) raising environmental awareness, (8) finding solutions to problems, (9) developing different perspectives, (10) concrete learning, and (11) learning to create designs with all kinds of materials. The following are quotes from participants:

> *Ali: The STEM-IEEP helped us find solutions to environmental issues. We achieved concrete learning because we put things into practice based on daily problems.*
>
> *Hayriye: We learned how to come up with solutions to problems by using different materials. Besides, we did things by ourselves.*
>
> *Fatma: I learned how important the environment was and how important it was to preserve it.*

The second research question discussed participants' views of the contribution of the STEM-IEEP to environmental education. Participants noted that the STEM-IEEP promoted (1) concrete learning, (2) raised their awareness, (3) made them more conscious about the environment, helped them (4) comprehend the importance of the environment, (5) develop problem-solving skills, (6) come up with designs to address environmental pollution, and (7) develop positive attitudes towards the environment. The following are quotes from participants:

> *Mehmet: We designed different things for environmental issues, like filters for factory chimneys and whatnot.*
>
> *Halil: The program helped me realize the importance of preserving the environment.*
>
> *Gül: The program helped me develop positive attitudes towards the environment.*

The third research question looked into participants' views of the connection between STEM education and environmental pollution. All participants regarded environmental pollution as a problem and noted that STEM education helped them find solutions. In other words, they stated that STEM education focused on environmental pollution. The following are quotes from participants:

> *Dilek: STEM education first involves information and then a problem. It helps us come up with products based on engineering design processes. Considering this process, environmental pollution includes more than one problem. STEM education helps us come up with products to solve those problems.*
>
> *Serkan: STEM education focuses on one problem. This problem is solved by engineering design processes. Since environmental pollution is a problem, we can use STEM education to solve that problem.*
>
> *Veli: Environmental pollution is a problem. STEM education focuses on finding solutions for it.*

The fourth research question addressed participants' views of the contribution of the STEM-IEEP to learning-teaching processes. Participants noted that the program promoted concrete learning and teaching, applied education, and learning retention, turned them into conscious individuals, and helped them relate knowledge to daily life and develop positive attitudes towards environmental education. The following are quotes from participants:

> *Büşra: The program was very instructive that made it easier for me to learn stuff.*
>
> *Ebru: The activities were all about concrete situations. In this way, we moved from concrete to abstract in our activities.*
>
> *Duygu: The program can raise people's awareness about what to do to prevent environmental pollution.*

The fifth research question investigated whether the STEM-IEEP changed participants' views on environmental engineering. All participants noted that the program changed their opinions about environmental engineering for the better. The following are quotes from participants:

> *Büşra: Now, I see the program as part of environmental engineering because it helped me put theory into practice. Environmental engineers also use both theoretical and practical knowledge.*
>
> *Hayriye: I think that the program contributed to my knowledge of environmental engineering.*
>
> *Ali: I think that the program changed my mind about environmental engineering for the better.*

The sixth research question focused on participants' views of the importance of STEM education. Participants remarked that STEM education was an applied approach that contributed to technological developments and content knowledge and helped them develop 21st-century professional skills, integrate disciplines, learn by doing and living, and relate knowledge to daily life. The following are quotes from participants:

> *Ebru: The program is important because it helps us develop critical thinking and creative thinking skills.*
>
> *Serkan: The program contributes to technological developments because it allows us to come up with products.*
>
> *Dilek: The program helps people learn by doing and living.*

Discussion and Conclusion

The first research question addressed participants' views of the STEM-IEEP. Participants believed that the program helped them integrate disciplines, learn by doing and living, relate knowledge to daily life, and learn permanently. They also added that the program helped them become more sensitive to the environment and develop different perspectives about environmental issues. Ua-Umakul and Chaiwatchatuphon (2018) reported that students could employ STEM education to address environmental issues. Helvacı and Helvacı (2019) found that STEM education made students more environmentally conscious. Our results are consistent with the literature (Mercan & Işık Mercan, 2020; Sümen & Çalışıcı, 2015).

The second research question discussed participants' views of the contribution of the STEM-IEEP to environmental education. Participants stated that the program contributed to environmental education from different dimensions. They noted that the program raised their awareness of the environment and encouraged them to find solutions to environmental issues. Nugyen et al. (2020) determined that STEM education turned students into individuals who recognized the importance of the environment and found ways to solve environmental issues. Helvacı and Helvacı (2019) noted that STEM education raised students' awareness of the environment and encouraged them to come up with designs to address environmental issues. Research, in general, shows that STEM education helps raise students' awareness of environmental problems (Syahmani et al., 2021; Tadena & Salic-Hairulla, 2021; Widowati et al., 2021; Yeşilyurt et al., 2020).

The third research question looked into participants' views of the connection between STEM education and environmental pollution. All participants regarded environmental pollution as a problem and noted that STEM education helped them find solutions. STEM education helps students solve real-life problems (Bybee, 2010; Lai, 2018). For example, Tadena and Salic-Hairulla (2021) found that STEM education could be used to solve environmental education problems. Ua-Umakul and Chaiwatchatuphon (2018) also maintained that STEM education could be used to find solutions to environmental problems. Nguyen et al. (2020) highlighted that STEM education was an effective tool for solving environmental problems. Our results are consistent with the literature.

The fourth research question addressed participants' views of the contribution of the STEM-IEEP to learning-teaching processes. Participants stated that the program had numerous contributions to teaching-learning processes. They noted that the program was an applied approach that facilitated learning-

teaching processes, promoted concrete learning, turned them into environmentally conscious individuals, and helped them develop positive attitudes towards environmental education. Çalışıcı and Benzer (2021) found that STEM education helped students develop positive attitudes towards environmental education. Mercan and Işık Mercan (2020) noted that environmental education turned students into environmentally conscious individuals and helped them develop positive attitudes towards the environment. Our results are consistent with the literature (Helvacı & Helvacı, 2019; Syahmani et al., 2021).

The fifth research question investigated whether the STEM-IEEP changed participants' views on environmental engineering. All participants remarked that the program changed their minds about environmental engineering positively. Research, in general, shows that STEM education helps students develop positive views on environmental engineering (Çevik, 2018; Tekerek, & Karakaya, 2018; Yıldırım, & Türk, 2018). Our results are consistent with the literature.

The sixth research question focused on participants' views of the importance of STEM education. Participants remarked that STEM education was an applied approach that contributed to technological developments and helped them develop 21st-century professional skills and integrate disciplines. Research also shows that students consider STEM education important (Hacıoğlu & Gülhan, 2021; Karademir & Yıldırım, 2021; Li, & Wang, 2021; Stretch, & Roehrig, 2021).

Implications for Further Research

The STEM-integrated environmental education program (STEM-IEEP) positively changed preservice teachers' views. Therefore, we can integrate STEM education into environmental education to turn preservice teachers into environmentally conscious individuals. We can use STEM-IEEPs to help preservice teachers develop professional skills and positive attitudes towards the environment. This study focused only on preservice teachers' views of the STEM-IEEP. Future studies should use mixed methods to achieve data diversification. Researchers should employ STEM education to solve environmental problems and develop new models.

Limitations

This study had two limitations. First, the sample consisted only of preservice science teachers. Second, the study focused only on environmental problems.

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