Bartin University Journal of Education
https://doi.org/10.14686/buefad.1755710

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Research Article

The Impact of Argumentation-Based Environmental Education on the Environmental Literacy of Pre-service Science Teachers

Argümantasyona Dayalı Çevre Eğitiminin Fen Bilimleri Öğretmen Adaylarının Çevre Okuryazarlığı Üzerindeki Etkisi

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Citation: Acar, B. G., Çetin, P. S., & Capkinoglu, E. (2026). The impact of argumentation-based environmental education on the environmental literacy of pre-service science teachers. *Bartin University Journal of Faculty of Education, 2026*(2), 729-754. https://doi.org/10.14686/buefad.1755710

Article Information

Article History

Received:
01 August 2025
Accepted:
30 March 2026
Published:
02 May 2026

Keywords

Argumentation-based education
Environmental literacy
Pre-service science teachers

Abstract

Purpose: *This study investigates the impact of argumentation-based environmental education on the development of environmental literacy among pre-service science teachers (PSTs) using an explanatory sequential mixed-methods design.* ***Method:*** *A total of 55 PSTs were divided into experimental (n=28) and comparison (n=27) groups. Over a seven-week period, the experimental group received scenario-based argumentation instruction on environmental issues, while the comparison group followed a traditional instructional approach. Quantitative data were collected using the "Environmental Literacy Scale", and qualitative data were gathered through semi-structured interviews.* ***Findings:*** *Independent samples t-tests revealed that the experimental group demonstrated significantly higher gains in environmental knowledge ($t(53)=4.86$, $p<0.001$), environmental attitude ($t(53)=2.97$, $p< 0.01$), and environmental use ($t(53)=2.85$, $p< 0.01$) compared to the comparison group. Furthermore, qualitative findings supported the statistical results, indicating that argumentation-based instruction enhanced PSTs' critical thinking, motivation, and ability to connect scientific concepts with real-world environmental issues.* ***Conclusion:*** *These findings suggest that argumentation-based environmental education is an effective approach for fostering environmental literacy in science teacher education programs.*

Makale Bilgisi

Makale Tarihçesi

Geliş Tarihi:
01.08.2025
Kabul Tarihi:
30.03.2026
Yayımlanma Tarihi:
02.05.2026

Anahtar Kelimeler

Argümantasyona dayalı eğitim
Çevre okuryazarlığı
Fen bilgisi öğretmen adayları

Özet

Amaç: *Bu çalışma, açıklayıcı sıralı karma yöntem tasarımını kullanarak, fen bilgisi öğretmen adaylarının çevre okuryazarlığının gelişimi üzerinde argümantasyona dayalı çevre eğitiminin etkisini araştırmaktadır.* ***Yöntem:*** *Toplam 55 öğretmen adayı, deney (n=28) ve kontrol (n=27) gruplarına ayrılmıştır. Yedi haftalık bir süre boyunca, deney grubu çevresel konularda senaryo tabanlı argümantasyon eğitimi alırken, kontrol grubu geleneksel bir öğretim yaklaşımını izlemiştir. Nicel veriler, "Çevre Okuryazarlığı Ölçeği" kullanılarak toplanmıştır. Nitel veriler ise yarı yapılandırılmış görüşmeler aracılığıyla toplanmıştır.* ***Bulgular:*** *Bağımsız örneklem t-testleri, deney grubunun, kontrol grubuna kıyasla çevresel bilgi ($t(53)=4.86$, $p<0.001$), çevresel tutum ($t(53)=2.97$, $p<0.01$) ve çevre kullanımı ($t(53)=2.85$, $p<0.01$) konusunda önemli ölçüde daha yüksek kazanımlar gösterdiğini ortaya koymuştur. Ayrıca, nitel bulgular istatistiksel sonuçları destekleyerek, argümantasyona dayalı eğitimin öğretmen adaylarının eleştirel düşünme, motivasyon ve bilimsel kavramları çevre sorunlarıyla ilişkilendirme becerilerini geliştirdiğini göstermektedir.* ***Sonuç:*** *Bu bulgular, argümantasyona dayalı çevre eğitiminin, fen bilgisi öğretmen yetiştirme programlarında çevre okuryazarlığını geliştirmek için etkili bir yaklaşım olduğunu göstermektedir.*

Introduction

Environmental problems resulting from human production and consumption activities have become an international issue that could threaten not only countries but also the future of the world (United Nations Environment Program [UNEP], 2002). At the core of these environmental issues are people's behaviors and habits, and the most significant role in preventing those still falls on people. Therefore, children need to encounter environmental education at the earliest possible age and to begin receiving education on these issues from a young age (Basile, 2000; Wilson, 1996). To solve environmental problems and achieve a sustainable environment, it is necessary for every individual to receive environmental education. This necessity was emphasized during the Stockholm Conference held in 1972 in order to draw attention to the global scope of environmental issues and environmental education, a decision was made to prepare an environmental education program that is multinational, multicultural, interdisciplinary, and covers all levels of formal and informal education (United Nations Educational, Scientific and Cultural Organization [UNESCO], 1975, p.15). In this context, it could be concluded that one of the most important goals of environmental education is to cultivate environmentally literate individuals. Environmentally literate individuals have knowledge and responsibility regarding how environmental systems operate and the impact of human factors on these systems (Kaplowitz & Levine, 2005; Moody, Alkaff, Garrison, & Golley, 2005).

To create a sustainable living environment and leave a habitable universe for future generations, the younger generation still needs to address environmental problems such as the misuse of natural resources, environmental pollution, and recycling.

Providing effective environmental education to pre-service science teachers (PSTs) studying in education faculties at universities is crucial for training them to be environmentally literate so they can educate their future students with the same level of consciousness. As a matter of fact, Ernst (2007) pointed out that teachers have a high level of environmental literacy display environmental awareness, positive environmental attitudes, and openness to environmental education. Therefore, it is necessary to adopt teaching methods that go beyond traditional approaches and encourage active student participation to provide effective environmental education. Many researchers emphasize that the significance of education lies in the active participation of students throughout the process for permanent learning, the students' willingness to engage in the process, and the conversion of learned information into desired behaviors (Espino, 2009; Liu, Teng, & Han, 2020; Ozey, 2009). The authors of the present study also believe that an active university education that promotes student engagement plays a significant role in fostering environmentally literate individuals.

Argumentation is one of the teaching techniques that ensures active student participation in the learning process. Recent research confirms the benefits of this approach in various science education settings (Altun & Özsevgeç, 2024; Kaçar & Balım, 2021). Argumentation-based implementations involve students in the existing problem or situation, enable them to think about the issue, require them to collect the necessary data for the solution, enable them to discuss some activities, and eventually reach a solution. Since both inquiry and reasoning processes are actively used in argumentation-based implementations (Hohenshell, 2004), the use of argumentation in environmental education becomes a preferred approach for science educators. Environmental education through argumentation will enable individuals to think critically about environmental problems, question them, develop effective solutions, and adopt a sustainable understanding of the environment throughout their lives (Okumus, 2012). Hence, the authors of this study argue that argumentation-based learning environments are a suitable approach for effectively providing environmental education. From this viewpoint, we have developed an argumentation-based environmental education and investigated the effect on PSTs' environmental literacy.

In the science education literature, there is a large body of research on argumentation in environmental education (Cicek Senturk & Selvi, 2023; Jime´nez-Aleixandre, 2002; Fettahlioglu, 2018; Fettahlioglu & Aydogdu, 2020; Oliveira, Akerson, & Oldfield, 2012; Pekel, 2019). When these studies were analyzed, it was observed that they investigated the effects of argumentation implementation on variables such as argumentation quality, environmentally responsible behaviors, self-efficacy beliefs, conceptual understanding, scientific reasoning skills, and decision-making regarding various environmental issues. Similarly, recent studies have explored environmental literacy across various educational levels. For instance, Rodríguez Pérez et al. (2024) examined pre-service teachers' perceptions of environmental literacy in the context of the socio-environmental impact of food consumption. Additionally, Batchar and Abad (2023) assessed pre-service teachers' readiness for environmental education, highlighting the

need to integrate green technology into classroom practices. Dada, Eames, and Calder (2017) investigated the impact of an environmental education course on the environmental literacy of beginner pre-service teachers in New Zealand, finding that while participants demonstrated positive attitudes toward the environment, their conceptual understanding remained limited. Gheith (2019) analyzed Jordanian pre-service classroom teachers' environmental literacy and found that although attitudes were generally positive, both environmental knowledge and behavioral tendencies toward environmental responsibility were low. Tran, LePage, and Fang (2022) focused on Vietnamese preschool teachers and emphasized that environmental teaching activities were positively associated with environmental literacy, especially in behavioral aspects. Tuncer et al. (2009) assessed Turkish pre-service teachers and revealed a moderate level of environmental literacy overall, with significant correlations among knowledge, attitude, and behavior subdimensions. Similarly, Vilmala et al. (2023) explored Indonesian science teacher candidates' levels of environmental literacy. They found that while participants had strong environmental concern, their ability to act on it through informed decision-making remained limited. Unlike these studies, Güvenir and Türkmen (2024) conducted a study with kindergarten pupils to examine the impact of an intensive education program based on basic science process skills, including the 'reduce, reuse and recycle (3Rs)' paradigm, on the environmental attitudes and awareness of preschool children. The authors revealed that the implemented education program positively affected children's attitudes and awareness towards the environment. Collectively, these studies emphasize the multidimensional nature of environmental literacy and underscore the need for instructional approaches that integrate knowledge, attitudes, and responsible behavior. In addition to these studies, Fettahlioglu and Aydogdu (2020) investigated the effect of implementing argumentation-based environmental education to develop environmental literacy. Similarly, Wang (2014) compared web-based and traditional argumentation in developing environmental literacy. However, the number of studies that directly explore the concepts of argumentation and environmental literacy is limited. Due to this deficiency, the authors of this study proposed investigating the effect of argumentation-based environmental education on environmental literacy. In light of this argument, the purpose of the current research is to explore the influence of an argumentation-based environmental education on PSTs' environmental literacy.

Theoretical Framework

Environmental Literacy

Charles Roth first used the concept of environmental literacy in 1968 (Roth, 1968). According to Roth, environmental literacy is the individual's effort to maintain, enhance, and restore the natural balance of the human-environment system when it is disrupted, to preserve the natural equilibrium. In this respect, the characteristics of environmentally literate people are as follows; they should always be in tune with nature, possess knowledge about the use of natural resources provided by the environment (such as renewable resources), be environmentally sensitive, collect information about environmental issues, inform those around them, seek solutions, and put these solution

suggestions into practice, they should be able to reject decisions that can hurt the environment in scientific, social, political, and economic matters (Loubser, Swanepoel, & Chacko, 2001). Environmental literacy comprises environmental knowledge, a positive attitude and values towards the environment, skills, and responsible behaviors. The knowledge component encompasses an in-depth understanding of the environment and environmental concepts, as well as the relationships between natural and artificial elements that impact the ecological system. The attitude and values component emphasizes the need for individuals to take responsibility for the environment and environmental issues, and to consider the ethical values of their society in their behavior. The skills component is an individual's ability to use their environmental knowledge, attitudes, and values to resolve environmental issues. The behavior component, encompassing knowledge, attitudes, values, and skills, requires individuals to actively participate in solving environmental issues. In addition to traditional definitions, recent studies emphasize that environmental literacy today must also encompass systems thinking and socioscientific decision-making skills (Author, 2024; Batchar & Abad, 2023), which are often underrepresented in existing teacher education programs.

Individuals' environmental literacy levels differ depending on their behaviors. Roth (1992) examined environmental literacy at three levels, and the characteristics of individuals at each level are different.

- Nominal (Pseudo) Environmental Literacy: At this first level, individuals know basic environmental concepts and what they mean. They develop sensitivity and awareness of the environment and environmental systems, but lack knowledge of their functioning and their interactions with humans.
- Functional Environmental Literacy: At this level, individuals have comprehensive knowledge about the functioning of environmental systems and the relationship between humans and these systems, for which individuals at the first level lacked adequate knowledge. They also share the comprehensive knowledge they have acquired about environmental issues with others and engage in solution-oriented practices to address the social and technological factors driving environmental problems.
- Operational Environmental Literacy: This level represents the highest level of environmental literacy. Individuals who reach this level possess advanced environmental knowledge. They stay up to date on current environmental issues and translate what they learn into environmental behaviors. They are aware of their responsibilities towards the environment and actively participate in environmental activities to create a sense of responsibility and awareness in other members of society. They have also integrated environmental literacy and environmentally beneficial activities into their lifestyle.

Educators should be aware of the characteristics of each level and consider these features when educating environmentally literate individuals.

Argumentation-based Education

In the science education literature, argumentation is defined as a process in which different ideas are examined, and opinions are interpreted (Walton, 2006). In this process, the relationships among individuals' claims are examined with evidence (Yerrick, 2000). Argumentation provides some advantages such as enabling meaningful learning by ensuring participation in cognitive and metacognitive processes, improving students' communication skills, critical thinking, and reasoning skills, supporting students' understanding of scientific culture and applications of science, acquiring scientific literacy, and strengthening students' ability to speak and write in the language of science in science classrooms (Jiménez-Alexandre & Erduran, 2007). Therefore, argumentation is accepted as a powerful tool that allows students to develop conceptual and epistemic understanding of science by many science educators (Erduran, Ozdem, & Park, 2015; Jimenez-Aleixandre, Rodriguez, & Duschl, 2000; Pabuccu & Erduran, 2017).

Toulmin, often regarded as the father of argumentation, holds a significant place in the implementation of argumentation in science education as well. He proposed a model named Toulmin's argumentation model in which a complete argumentation should include some components such as 'claim', 'data', 'warrant', 'backing', 'rebuttal', and 'qualifier' (Toulmin, 1958). In this model, claim is an assertion that people hold in any subject, data is the statements that could be used as the evidence for supporting claim, warrant is the statement that shows the relationship between the claim and data, backing is additional and comprehensive information that supports warrant, qualifier is special and restricted condition that claim is true, rebuttal is the circumstance that claim is not valid and the statement that contradicts with data, warrant, backing, and qualifier. According to Sadler and Fowler (2006), within these components, 'data', 'warrant', and 'backing' can be represented in the form of 'evidence'. After all, Toulmin's argumentation model highlights the significance of evidence and focuses on the connection between evidence and theories as the primary content of argumentation (Wang, 2014).

Argumentation-based education is a learning approach in which arguments are used to analyze, assess, challenge, and support data collected from experiments or other sources in social settings (Jiménez-Alexandre, 2002). In a classroom in which argumentation-based education is implemented, students learn to construct a claim and defend their ideas behind it with data, warrants, and backing (Martin-Gamez & Erduran, 2018), and to justify and evaluate their own and others' claims (Duschl & Osborne, 2002). In this process, students use their prior knowledge and the data they obtained to support their views. They also clearly articulate their opinions and propose alternative ideas, even when they hold opposing views (Driver, Asoko, Leach, Mortimer, & Scott, 1994). They could also revise the models they construct in their minds and compare them with their peers' models (Pekel, 2019). By using an argumentation-based learning model (Hogan, 2002), students can enhance their decision-making skills in socioscientific subjects through the practice of analyzing information. Furthermore, argumentation implementations are vital for shaping the frameworks and theories used to interpret socioscientific issues (SSI) (Erduran & Jimenez-Aleixandre, 2012). Since the

environmental issues addressed in this study also fall within the scope of SSI, we believe that argumentation-based education plays an important role in environmental education.

Despite growing interest in both argumentation-based instruction and environmental literacy, empirical research on the direct impact of argumentation-based environmental education on PSTs' environmental literacy remains limited. While several studies have explored the effects of argumentation on variables such as reasoning skills, conceptual understanding, or environmentally responsible behavior, few have directly measured its influence across all core dimensions of environmental literacy (knowledge, attitude, use, and interest). Furthermore, research combining a quasi-experimental design with in-depth qualitative analysis to reveal PSTs' lived experiences in such contexts remains limited. Therefore, this study offers a novel contribution by systematically examining the effectiveness of argumentation-based environmental education through both quantitative and qualitative lenses, providing a comprehensive understanding of how such instruction shapes PSTs' environmental literacy.

Purpose of the Study

In this research, we aimed to investigate the effect of argumentation-based environmental education on PSTs' environmental literacy. The specific research questions were the following:

(1) What is the effect of argumentation-based environmental education on PSTs' environmental literacy?

(2) What are the perceptions of PSTs regarding the effectiveness of argumentation-based environmental education in enhancing their environmental literacy?

Methodology

Research Design

In this study, a mixed-methods approach was utilized, specifically the explanatory sequential mixed-methods research design as delineated by Creswell and Clark (2007). This method involves collecting and analyzing quantitative data first, followed by qualitative data to provide a deeper understanding of the quantitative findings. The qualitative phase is designed to explain, elaborate, or contextualize the results of the initial quantitative analysis. Initially, a non-equivalent comparison group design, as part of a quasi-experimental approach proposed by Gay and Airasian (2000), was utilized in the first phase of the study. Random assignment was used to designate one class as the experimental group and another as the comparison group. One of the study's authors delivered lessons in both classes. Throughout the seven-week treatment period, each group received two 50-minute lessons per week. Data collection took place during the first and last weeks of the study. In the instructional phase, the experimental group engaged in explicit argumentation lessons focused on environmental problems.

In contrast, the comparison group experienced traditional instructional methods during this period. At the beginning of the study, a brief introductory session on argumentation was provided to both groups to establish a common baseline understanding of basic concepts (e.g., claim, evidence, and reasoning). This session was limited to a general overview and did not involve any structured argumentation activities. Its purpose was to ensure that participants were familiar with the terminology used during the study and to prevent potential confusion. Importantly, only the experimental group engaged in systematic argumentation-based practices throughout the intervention, whereas the comparison group did not participate in argumentation-based activities during the instructional process.

During implementation, emphasis was placed on air pollution, water pollution, soil pollution, erosion, radioactive contamination, noise pollution, and battery waste. A sample worksheet used in both groups is provided in the appendix. Subsequently, the second phase of the study, employing qualitative methods, focused on gaining deeper insights into the intervention's outcomes. Semi-structured interviews were conducted with the participants to explore their perspectives. Qualitative content analysis, following Schreier's (2012) method, was employed to analyze the interview data.

Participants

A total of 55 pre-service first-grade science teachers, comprising 7 males and 48 females, pursuing certification in elementary-level science from a public university, participated in this study. The participants were recruited from two intact classes taught by the same instructor during the second semester of the 2021/2022 academic year. The administration assigned students to their respective classes based on arbitrary student numbers, with half placed in one class and the other half in the other class. While the actual class sizes were larger, only data from students who attended all lessons and completed both pre- and post-instruments were included in the study. The participants were enrolled in a four-year program encompassing science and education courses. The classes were randomly assigned as the experimental group (28 students) or the comparison group (27 students). The age range of these PSTs was 18 to 21 years. Their selection was based on convenient accessibility and proximity to the researcher.

Data Collection

Data collection for the research unfolded in two distinct stages. Initially, PSTs' learning was evaluated using the Environmental Literacy Scale, which was administered both before and after the final investigation. This phase of data collection was designed to address the first research question. Subsequently, to address the second research question, interviews were conducted with PSTs in the experimental group to gain insights into their experiences with argumentation-based environmental education.

Environmental Literacy Scale

The scale was developed and implemented at Michigan State University (MSU-WATER, 2001-2006) and adopted for Turkish language and culture by Teksöz, Şahin, and Ertepınar (2010). The scale aims to assess PSTs' environmental literacy across four sub-dimensions: knowledge, attitude, usage, and interest. Teksöz et al. (2010) reported that, for content validity, the scale was reviewed by three experts in the field of Environmental Education and evaluated by two faculty members from the Department of Basic English. To assess the scale's construct validity, Teksöz et al. (2010) conducted a factor analysis with Varimax rotation. The results related to factor analysis indicated a KMO value of 0.88, confirming the appropriateness of the data for factor analysis (Leech, Barlett, & Morgan, 2005). The researchers reported that Bartlett's test yielded a result of 17.848.672 ($p<0.000$), demonstrating that the data originated from a multivariate normal population (Albayrak, 2006). The factor analysis results revealed that the items were grouped into four dimensions, consistent with the original scale. Teksöz et al. (2010) conducted a study in which internal consistency test results for the four dimensions of the scale were found to be 0.70 for the attitude sub-dimension, 0.88 for the knowledge sub-dimension, 0.81 for the usage sub-dimension, and 0.88 for the interest sub-dimension. The environmental knowledge section of the scale consists of 11 multiple-choice questions aimed at determining the level of knowledge of PSTs regarding environmental issues. Each item in the scale is scored as '1' for the correct answer and '0' for the incorrect answer.

Additionally, the option 'I do not know' is provided for each item in the knowledge scale. The attitude section regarding the environment consists of 9 items on a 5-point Likert scale. The goal of the attitude sub-dimension of the scale is to determine the feelings of PSTs towards the environment. The 9 items in the scale offer response options such as 'Strongly Agree', 'Agree', 'Undecided', 'Disagree', and 'Strongly Disagree'. Similarly, the usage dimension related to the environment comprises 19 items on a 5-point Likert scale. This scale aims to measure PSTs' behaviors and sense of responsibility toward the environment. The last sub-dimension of the Environmental Literacy Scale, which is the interest section regarding the environment, consists of 9 items on a 5-point Likert scale. The goal of the interest dimension of the scale is to determine PSTs' level of interest in environmental issues. For each item in the interest scale, expressions such as 'Very Interested', 'Interested', 'Partially Interested', 'Not Interested', and 'Not at all Interested' are provided. The interest level is scored from very interested to not at all interested, with ratings of 5, 4, 3, 2, and 1, respectively. While statistical analysis of the total scores for the knowledge, attitude, and usage sub-dimensions of the scale is appropriate for comparing groups, statistical analysis of the items in the interest sub-dimension, the last dimension of the scale, is not suitable due to its nature. For this sub-dimension, only descriptive analysis was performed, and the findings were presented based on frequency values. The scale was administered to participants as a pre-test and post-test, both before and after the intervention. The time allotted to complete the scale is 30 minutes.

Interviews

To examine potential factors underlying the quantitative results, semi-structured interviews were conducted with PSTs from the experimental group. Employing random sampling, six PSTs were chosen to participate. Semi-structured interviews were conducted to analyze PSTs' views on argumentation-based environmental instruction in enhancing their environmental literacy (Table 1).

Table 1: *Interview Questions*

1. Did engaging with environmental issues through argumentation-based instruction influence your thoughts and feelings about the environment? Why?
2. Do you think participating in argumentation-based instruction influenced your behavior toward the environment? Why or why not?
3 .Did argumentation-based instruction in your lessons contribute to your learning? (If "Yes," a follow-up question was asked: "In what ways?")
4. What were the positive and negative aspects of this course on your environmental literacy?

Conducted by the second author one week after implementation, each interview was audio-recorded and subsequently transcribed. Adopting a constructivist-grounded approach informed by Charmaz (2006), the analysis of interview data unfolded across multiple phases. Initially, we identified instances reflecting student reactions to the instruction, a process that required several rounds of analysis. Subsequently, we distilled these instances into overarching themes, drawing upon the framework outlined by Braun and Clarke (2006). Ultimately, we assessed how frequently these thematic patterns emerged across interviews conducted with six PSTs.

The semi-structured interview questions were developed based on a comprehensive review of the literature on argumentation-based instruction and environmental literacy (e.g., Erduran & Jimenez-Aleixandre, 2012; Jiménez-Aleixandre & Erduran, 2007; Teksöz et al., 2010). In addition, feedback was sought from two experts in science education to ensure content validity and alignment with the research purpose. In addressing the trustworthiness of the qualitative phase, Lincoln and Guba's (1985) criteria were taken into account. Credibility was ensured through peer debriefing and prolonged engagement during the seven-week instructional period. Transferability was addressed by providing thick descriptions of the participants, instructional context, and the intervention process. Dependability was enhanced by maintaining a detailed audit trail of the data collection and analysis process. Confirmability was supported through the use of verbatim quotations and the independent coding of interview data by two researchers, followed by consensus discussions.

Classroom Intervention

Participants in the research engaged in a two-hour weekly course dedicated to specific themes within the realm of environmental education. During the instructional sessions, they actively participated in five different activities addressing key issues such as air pollution, water pollution, soil pollution, erosion, radioactive contamination, noise

pollution, and battery waste (Table 2). At the beginning of the term, a schedule outlining the weekly topics was distributed to participants in both groups. Furthermore, before the commencement of lessons related to environmental education, all participants took part in an argumentation session designed to introduce the definition of argumentation, its components, the characteristics of strong and weak arguments, and the role of argumentation in science and science education.

In the comparison group, traditionally designed environmental instruction was used. This type of instruction is primarily based on lecturing and discussion. At the beginning of each session, the instructor presented a video or newspaper article pertaining to the environmental subject of the day. Subsequently, the PSTs were instructed to verbally articulate their reflections on the video or article. After a few participants shared their ideas, the instructor expounded on the topic. Throughout the lessons, the instructor systematically elucidated the subject matter, illustrating main concepts and principles on the board. Finally, just before concluding the lesson, the instructor prompted participants to share their opinions and ask questions about the environmental issues discussed.

Table 2: *The Implementation Process for the Groups*

Weeks	Implementation in the comparison group	Implementation in the experimental group
1	Environmental Literacy Test pre-test application	Environmental Literacy Test pre-test application
	Brief introduction to argumentation (orientation session)	Argumentation instruction
2	Air pollution, water pollution	Water pollution, Soil pollution
3	Soil pollution, erosion	Soil pollution, Air pollution, Water pollution
4	Radioactive contamination, noise pollution	Noise pollution, Erosion
5	Battery waste	Radioactive contamination
6	Soil pollution	Battery waste
7	Environmental Literacy Test post-test application	Environmental Literacy Test post-test application

The experimental group received environmental education using the argumentation method. In this context, the environmental education provided to the PSTs was conducted through scenarios. Although the distribution of topics across weeks was designed to be comparable across groups, some environmental topics were revisited in the experimental group within different argumentation scenarios. This was primarily due to the structure of the scenarios, which were intentionally designed to address multiple environmental issues simultaneously and from different perspectives. As a result, certain topics (e.g., air, water, and soil pollution) appeared more than once in the experimental group. However, these repetitions did not involve simple content duplication; rather, they aimed to deepen students' reasoning, support multi-dimensional evaluation of environmental issues, and enhance the quality of argumentation. The scenarios used were written by the researchers and are provided in Table 3.

Table 3: *Scenarios Used in the Experimental Group*

Scenarios	The focal environmental topic	Argumentative Questions
"The precautions taken for entry to the Horse Plateau"	Water pollution, Soil pollution	Authorities aim to protect nature by implementing strict measures for entry to picnic areas. On one hand, some citizens argue that these rules are too stringent and that restricting free access to green spaces is unconstitutional. If you were in the position of the authorities, what would you do?"
Activities related to gold production	Soil pollution, Air pollution, Water pollution	Considering all the advantages and disadvantages, would you allow the opening of a gold mine in your region?
Construction of roads for picnic areas	Noise pollution, Erosion	If you were a citizen living in Bolu and had to participate in a vote regarding the improvement of roads to picnic areas through tree cutting, what would your vote be? Please explain in detail with your reasons.
Akkuyu Nuclear Power Plant	Radioactive contamination	Is the Akkuyu Nuclear Power Plant a necessary energy investment for Türkiye, or is it a project to be avoided due to its environmental risks? Please explain your answer with reasons.
Establishment of a battery manufacturing plant	Battery waste	Would you support the opening of a battery factory in your country? Explain your answer with reasons.

Each scenario is designed to address both the positive and negative aspects of the respective subject equally in the experimental group. After distributing the scenarios to the PSTs, the researcher set a specific time for them to read and conduct research on the topic. Participants were tasked with articulating their viewpoints on the provided scenarios in writing. Throughout this process, they were motivated to generate detailed responses for each situation. Once the PSTs read the scenarios and answered the relevant questions, the scenarios were discussed in class under the researcher's moderation. To foster their discussion, prompting questions like 'What decision have you arrived at?', 'Do you require additional information to make your decision?', 'Why do you think that is the case?', and 'How do you convince those who do not share your viewpoint?' were posed. This process was carried out identically across all scenarios. The argumentation process was implemented through a structured sequence involving both individual and collaborative phases. First, PSTs individually analyzed the given scenario and constructed written arguments, including their claims and supporting justifications. Following this, students engaged in small-group discussions where they shared, compared, and critically evaluated their arguments. These group discussions were then followed by whole-class discussions moderated by the instructor, during which students were encouraged to defend their claims, challenge opposing views, and refine their arguments based on peer feedback. Prior to the intervention, all participants received an introductory session on argumentation, including the basic components of Toulmin's argumentation model (claim, evidence, and reasoning). During instruction, students were explicitly encouraged to use these components when constructing and evaluating arguments. The instructor guided the discussions using prompting questions (e.g., justification of claims, evaluation of evidence, consideration of counter-arguments) to support the development of

structured argumentation practices. The written responses and classroom discussions provided evidence that students engaged with key elements of argumentation, including constructing claims, supporting them with evidence, and evaluating alternative perspectives

Findings

This section presents the findings from the statistical analysis of pre-test and post-test data, as well as those derived from the analysis of PSTs' perspectives on argumentation-based environmental instruction, addressing the research questions of the quantitative and qualitative phases of the study.

Attitude towards the Environment

To assess the impact of instruction based on argumentation on the attitudes towards the environment among PSTs, the responses of PSTs to the attitude sub-dimension of the Environmental Literacy Scale (A_ELS) were examined. The results indicated that, although the average scores of the experimental and the comparison group did not show significant differences compared to the pre-A_ELS scores ($t(53) = 0.757$, $p > 0.05$), the PSTs in the experimental group achieved significantly higher scores than those in the comparison group in the post-A_ELS ($t(53) = 2.97$, $p < 0.05$). A summary of the mean PST scores is presented in Table 4.

Table 4: *The Independent Samples t-test Results for the Experimental and the Comparison Group PSTs' Scores for the Pre- and Post-A_ELS*

	Group	*N*	$\overline{X}$	*S*	*df*	*t*	*p*
Pre-test	Experimental	28	33.82	5.65	54	0.75	0.452
	Comparison	27	34.74	2.83			
Post-test	Experimental	28	39.89	4.17	54	2.97	0.004
	Comparison	27	37.00	2.89			

According to the interviews, three PSTs stated that argumentation-based environmental education positively impacted their critical thinking skills. They emphasized that when forming arguments about environmental problems presented in given scenarios, they needed to consider different aspects of the events to reach an informed conclusion. The PSTs highlighted that this process also enhanced their environmental literacy. When we asked the PSTs which specific part of the lesson helped develop their critical thinking skills and enhance their environmental literacy, two PSTs mentioned that the inclusion of both positive and negative aspects of the environmental issue in the given scenarios was key. This required them to evaluate different perspectives and reach a conclusion. The other PST highlighted the need to understand their peers' viewpoints to develop counterarguments and refute classmates' arguments. The following excerpt is an example of this view:

> *In the scenario about opening a gold mine, I argued in favor of the mine's opening, supporting my claim with economic reasons. When trying to refute my peer's argument that humans are not*

the only dominant force in nature, I had to analyze this viewpoint critically. By thoroughly examining this perspective and attempting to disprove my peer's ideas, I improved my critiquing skills and increased my interest in environmental issues.

Knowledge about the Environment

The effect of argumentation-based instruction on PST's environmental knowledge was evaluated by analyzing their responses to the knowledge sub-dimension of the Environmental Literacy Scale (K_ELS). The results indicated that, although the average scores of the experimental and the comparison group did not show significant differences compared to the pre-K_ELS scores ($t(53) = 0.275$, $p > 0.05$), the PSTs in the experimental group achieved significantly higher scores than those in the comparison group in the post-K_ELS ($t(53) = 4.86$, $p < 0.05$). A summary of the mean PST scores is presented in Table 5.

Table 5: *The Independent Samples t-test Results for the Experimental and the Comparison Group PSTs' Scores for the Pre- and Post-K_ELS*

	Group	*N*	$\overline{X}$	*S*	*df*	*t*	*p*
Pre-test	Experimental	28	5.75	2.25	54	0.275	0.784
	Comparison	27	5.88	1.36			
Post-test	Experimental	28	8.60	1.64	54	4.86	0.00
	Comparison	27	6.29	1.87			

According to the interviews, all the PSTs who participated in the interviews unanimously supported the view that argumentation-based instruction allows them to bridge the gap between theoretical knowledge and real-world situations, which, in turn, makes it easier to understand and see the tangible impact of their actions on the environment. One PST elaborated, noting that when they engage in debates about battery waste, they are not just passively absorbing information. Instead, they actively apply what they have learned from textbooks and lectures to real-life scenarios. This active engagement helps them grasp complex concepts more effectively and see their practical applications. This process of connecting theoretical knowledge with real-world events and concerns not only deepens their understanding but also makes the learning experience much more engaging and meaningful. The following excerpt is representative of the PSTs' evaluation of argumentation-based instruction:

During a class debate about setting up the Akkuyu Power Plant, I could connect the scientific material we learned in textbooks to real events and concerns about energy production and its environmental impact. This helped me see the real-world implications of such projects. By connecting what we learn in theory to what is actually happening, it becomes easier to understand why our actions matter and how they can affect the environment. This approach really boosted my environmental literacy and made me more aware of why these issues are important.

Three of the PSTs who participated in the interview emphasized that the lessons they attended improved their engagement and motivation, which significantly

contributed to their development in the knowledge dimension of environmental literacy. They noted that using argumentation in environmental instruction makes the learning process more engaging and interactive. These PSTs explained that combining argumentation with active learning strategies, such as argumentation, increases their participation and fosters a more personal and in-depth connection with environmental topics. Engaging in debates and discussions about real-world environmental issues motivates them to participate actively and makes it easier for them to acquire and understand concepts. By using real-world scenarios as lesson material, PSTs are better able to relate theoretical knowledge to concrete examples, helping them internalize and understand this information more effectively. To exemplify this sentiment, the following excerpt provides an example of their evaluation:

> *When I was asked to participate in the discussions actively, I felt I needed to fully understand the topic to defend my own views and refute my classmates' opposing opinions. I wanted to speak up during the debates, and the environment encouraged me to share my ideas. This motivation led me to learn more about the subject.*

The four PSTs who participated in the interview also highlighted that the argumentation-based instruction enhanced their understanding of scientific evidence. They said to learn to analyze and interpret data effectively, using scientific evidence to support arguments in discussions. They mentioned that this process not only taught them how to distinguish between reliable and unreliable sources but also equipped them with the skills to apply scientific reasoning to environmental issues. By actively engaging with scientific evidence in the context of real-world environmental problems, they claimed to have developed a more nuanced understanding of scientific concepts and greater awareness of environmental issues. The following excerpt is an example of this view:

> *While discussing scenarios in the classroom, I needed strong evidence to defend my own ideas. In finding this evidence, I not only gained a better understanding of the topic but also had to decide what was more important to me regarding the environment.*

Environmental Uses

The influence of argumentation-based instruction on PSTs' environmental practices was evaluated by examining their responses to the use sub-dimension of the Environmental Literacy Scale (U_ELS). The results indicated that, although the average scores of the experimental and comparison group students did not differ significantly from the pre-U_ELS scores. The PSTs in the experimental group achieved significantly higher post-A_ELS scores than those in the comparison group ($t(53) = 2.854$, $p < 0.05$). A summary of the mean PST scores is presented in Table 6.

Table 6: *The Independent Samples t-test Results for the Experimental and the Comparison Group PSTs' Scores for the Pre- and Post-U_ELS*

	Group	*N*	$\overline{X}$	*S*	*df*	*t*	*p*
Pre-test	Experimental	28	74.57	13.78	54	0.575	0.568
	Comparison	27	76.22	5.81			
Post-test	Experimental	28	83.32	6.86	54	2.854	0.006
	Comparison	27	79.00	3.90			

Interest for the Environment

In this section, the interests of the experimental and comparison group PSTs regarding current environmental issues are presented before (Table 7) and after (Table 8) the implementation.

Table 7: *The Frequency Distributions of the Responses Given by the Comparison and the Experimental Group Students to the Environmental Interest Questions in the Pre-Test*

Question/Percent answer (%)	Comparison Group			Experimental Group		
	Interested	*Partially Interested*	*Not interested*	*Interested*	*Partially Interested*	*Not interested*
1. Air pollution	8.15	3.33	8.52	7.86	28.57	3.57
2. Water pollution	9.26	7.04	.70	1.43	25	3.57
3. The gases emitted from automobile exhausts	0.74	2.22	7.04	6.43	42.86	10.71
4. Industrial pollution	2.22	9.63	8.15	6.3	35.71	17.86
5. Toxic waste	4.44	4.44	1.11	2.86	39.28	17.86
6. Poor quality drinking water		8.15	1.11	1.43	21.43	7.14
7. Thirst	6.67	9.63	.70	5	10.71	14.29
8. Depletion of the ozone layer	5.92	7.04	7.04	9.28	42.86	17.86
9. Climate Change	3.33	8.15	8.52	0.72	28.57	10.71

When examining the frequency distributions of the responses to environmental interest questions in the pre-test for the comparison and the experimental group PSTs, it is observed that the most significant environmental issues that attract attention are 'water scarcity' (66.69% for the comparison group and 75% for the experimental group) and, accompanied by 'water pollution' (59.26% for the comparison group and 71.43% for the experimental group). The least interesting environmental issues for both the comparison and experimental group PSTs in the pre-test are 'industrial pollution' (48.15% for the comparison group and 17.86% for the experimental group) and 'thinning of the ozone layer' (37.04% for the comparison group and 17.86% for the experimental group). Based on this observation, it can be said that the environmental topics the

experimental and comparison group PSTs are more and less interested in, respectively, are parallel at the beginning of the study.

Table 8: *The Frequency Distributions of the Responses Given by the Comparison and the Experimental Group Students to the Environmental Interest Questions in the Post-Test*

Question/Percent answer (%)	Comparison Group			Experimental Group		
	Interested	*Partially Interested*	*Not interested*	*Interested*	*Partially Interested*	*Not interested*
1. Air pollution	62,96	37,04	0	71,43	28,57	0
2. Water pollution	74,08	25,92		75	21,43	3,57
3. The gases emitted from automobile exhausts.	51.85	37.04	11.11	60.71	21.43	17.86
4. Industrial pollution	40.74	37.04	22.22	75	10.71	14.29
5. Toxic waste	62.97	33.33	3.70	75	14.29	10.71
6. Poor quality drinking water	92.59	7.41	0	75	25	0
7. Thirst	100	0	0	85.71	14.29	0
8. Depletion of the ozone layer	59.26	40.74	0	67.86	28.57	3.57
9. Climate Change	66.67	33.33	0	78.57	21.43	0

When looking at the frequency distributions of responses to environmental interest questions in the post-test for the comparison and the experimental group PSTs, the most significant environmental issue attracting attention is 'water scarcity' (100% for the comparison group and 85.71% for the experimental group). While the comparison group students also show high interest in the issue of 'low-quality drinking water' (92.59%), experimental group PSTs are interested in 'climate change' (78.57%), 'water pollution' (75%), 'industrial pollution' (75%), 'toxic waste' (75%), and 'low-quality drinking water' (75%). The least interesting environmental issues for the comparison group PSTs in the post-test are 'industrial pollution' (22.22%), followed by 'automobile exhaust gases' (11.11%) and 'toxic waste' (3.70%). Similarly, it is observed that the experimental group PSTs have the least interest in environmental issues in the posttest, specifically 'automobile exhaust gases' (17.86%), 'industrial pollution' (14.29%), and 'toxic waste' (10.71%).

Discussion and Conclusion

This study aimed to investigate the impact of argumentation-based environmental education on PSTs' environmental literacy and to explore their perceptions related to instructional approach. This section presents the discussion and conclusions regarding the findings related to the four sub-dimensions of environmental literacy and the interviews. The study's findings revealed that argumentation-based environmental education had positive effects on PSTs' environmental knowledge, attitudes, behaviors,

and interests. Recent studies further support this conclusion. For instance, Altun and Özsevgeç (2024) reported that structured argumentation modules improved pre-service science teachers' reasoning and argument construction skills. Similarly, Namdar and Topbaş (2024) demonstrated that participation in online argumentation workshops significantly enhanced PSTs' awareness and concern regarding climate change-related environmental problems. These findings align with the current study in showing that argumentation-based instruction promotes both conceptual understanding and affective engagement with environmental issues.

The findings show that the experimental group receiving environmental education through argumentation exhibited higher attitudes than the comparison group receiving it through traditional methods. The experimental group had higher scores on the attitude dimension because it not only engaged in argumentation but also acquired skills such as defending, strengthening, gaining different perspectives, and altering arguments (Kolsto, 2010; Waghid, 2005). This allows PSTs to ask each other question and to support or refute each other's ideas. At the end of this process, different claims are evaluated, and the best idea is chosen based on evidence. Therefore, providing environmental education aimed at cultivating environmentally literate individuals through student-centered teaching methods, such as the argumentation approach rather than traditional methods, positively influences PSTs' attitudes towards the environment. Similar conclusions were drawn by Namdar and Topbaş (2024), who demonstrated that engaging pre-service teachers in online argumentation around climate change scenarios increased not only their awareness but also their sense of ethical responsibility toward environmental problems. This finding is consistent with PSTs' interview responses. They reported that the argumentation-based environmental education was highly beneficial for improving their environmental literacy. This educational approach enhanced their learning experience by enabling them to evaluate peers' perspectives, scientific evidence, and all aspects of the scenarios presented. Indeed, at the attitude dimension, individuals have a sense of concern and responsibility for the environment and its issues, and consider the ethical values of their society in their behaviors (Faize & Akhtar, 2020). Consistent with this dimension, argumentation involves acting on ethical values and concerns by considering various perspectives on the subject. Moreover, argumentation enables the emergence of different solutions to environmental issues. Thus, the skills gained through argumentation contribute to the development of a positive attitude towards the environment. Finally, this study demonstrated that not only the experimental group but also the PSTs in the comparison group did not exhibit low attitudes. In parallel with this study, Koc and Kuvac (2016) found that PSTs displayed moderately favorable attitudes toward the environment.

As mentioned before, studies investigating the relationship between argumentation-based environmental education and environmental literacy are limited. One of these studies investigated the comparison of web-based and traditional argumentation in developing elementary school students' environmental literacy (Wang, 2014). The results demonstrate that students participating in web-based argumentation

groups have significantly better learning and also show significantly greater improvement in environmental literacy. On the other hand, besides studies showing that the use of the argumentation method in teaching environmental education creates a significant difference in students' environmental attitude levels, there are also studies indicating that it does not yield a significant difference. For instance, some studies concluded that the argumentation-based learning method did not affect students' environmental attitudes (Eroglu, 2019; Hamalosmanoglu & Varinlioglu, 2019).

The t-test results evaluating the significance of the difference in knowledge scores indicate a significant benefit for the experimental group. Knowledge dimension involves comprehensive knowledge of the environment and environmental concepts, including an understanding of the interplay between natural and artificial elements that influence the ecological system (Roth, 1992). Consistent with the constructivist approach, engagement in argumentation activities led to heightened knowledge among PSTs through active participation, argument formulation, critical thinking, permanent learning (Espino, 2009; Schmoker & Graff, 2011), and conceptual understanding (Psycharis, 2013). PSTs who participated in the interviews emphasized similar points. The interview findings indicated that the PSTs underscored the enhancement of their critical thinking skills and the practical application of theoretical knowledge acquired from textbooks when assessing the scenarios presented. Especially, it is quite remarkable that their active engagement, connecting theoretical knowledge with real-world events and concerns, rather than passively absorbing information. This emphasis demonstrated that the argumentation-based learning environment supported a more effective learning experience of environmental knowledge. A similar emphasis on conceptual development through argumentation-based environmental instruction was also reported by the Erenler, Cetin, & Eymur (2024), who found that engaging PSTs with climate change-related socioscientific scenarios significantly improved their ability to reason about complex ecological systems and apply scientific knowledge to real-world environmental contexts. Therefore, these experiences improved PSTs' environmental literacy. Classroom debates and practical studies in small groups enhance learners' comprehension of related concepts more effectively than traditional learning methods, as found by Kabapinar (2019). This further supports Naylor and Keogh's (2013) opinion that instructions centered around argumentation and group discussions not only challenge students' existing knowledge but also serve as motivating factors for embracing scientific reasoning. Also, other studies have underscored this relationship, highlighting the effectiveness of argumentation in enhancing students' understanding of environmental concepts (Burek, 2012; Deniz, 2014; Fettahlioğlu, 2016; Hamaloğlu & Varinlioğlu, 2019). For instance, Burek (2012) found that a treatment group instructed with a socio-scientific issue (SSI)-based curriculum showed statistically significant improvements in their environmental knowledge. Similarly, Hamaloğlu and Varinlioğlu (2019) explored the effects of scientific argumentation-focused teaching methods on the environmental knowledge of seventh-grade Turkish students. They reported significant gains in students' knowledge within the human and environment unit. Furthermore, Faize and Akhtar (2020) examined the relationship between environmental knowledge and attitude

among undergraduate students, revealing that those exposed to nature visits and scientific argumentation performed better in both domains. These studies collectively reinforce the conclusion that argumentation-based educational environments are instrumental in enhancing environmental knowledge, fostering critical thinking, and promoting responsible ecological behavior.

Another important result of the study indicates that argumentation-based environmental education is also effective in the environmental use dimension. As evaluated by the PSTs who participated in the interview, this approach enables PSTs to analyze environmental issues more comprehensively and develop a more holistic understanding of complex topics. Argumentation-based environmental education requires PSTs to evaluate different perspectives and support their claims about environmental policies or practices with evidence. This process renders their decisions regarding environmental use more informed and responsible. By better understanding their environmental impact, PSTs are more inclined to exhibit sustainable behaviors at both the individual and societal levels. This finding aligns with Rodríguez Pérez et al. (2024), who observed that pre-service teachers became more environmentally responsible when they engaged with real-life consumption-based environmental issues, and with Batchar and Abad (2023), who reported a similar increase in pro-environmental behavior when PSTs were exposed to experiential and reflective environmental education practices. This conclusion is strongly corroborated by a PST interviewee's statement that "……it became easier to understand why our actions matter and how they can affect the environment".

It is seen that courses that include argumentation-based practices are especially effective in developing students' critical thinking and problem-solving skills, as found by Gultepe and Kılıc (2021). As mentioned before, the argumentation method actively engages students in real-world problems, enables data collection for problem-solving, encourages discussions among students about various approaches or activities, and formulates a viable solution. PSTs who acquire these skills have increased their knowledge, responsibility, and ability to make ethical decisions regarding environmental problems in this study. At the usage dimension, individuals' behaviors and sense of responsibility toward the environment are considered. In this regard, Gokce et al. (2007) noted that although pre-service teachers' knowledge of the environment was low, their attitudes and use of the environment were high. Similarly, Kışoğlu (2009) found in his study that although pre-service teachers had high attitudes and usage levels towards the environment, their knowledge about the environment was low. Another study focused on the effect of argumentation and problem-based learning approaches on the development of environmentally responsible behaviors among PSTs (Fettahlioglu & Aydogdu, 2020). Parallel to our research, this study found that an argumentation-based learning approach is effective in developing positive, environmentally responsible behaviors. According to this study, PSTs learn to address an environmental problem and to find solutions through the argumentation process.

Lastly, when the impact of argumentation-based environmental education on environmental interest is examined, it is found that the PSTs in the experimental group attained notably higher scores than those in the comparison group. The literature suggests that argumentation-based environmental education can significantly impact individuals' interest in the environment by providing immersive experiences, promoting sustainable practices, and fostering environmental awareness from early childhood through adolescence (e.g., Ide et al., 2019; Ţigan et al., 2021). In the scope of environmental interest items, the most significant environmental issue drawing attention is "water scarcity" for both groups after the implementation. Independent of the present study, the fact that both groups are interested in or not interested in similar environmental problems may be due to their influence. Because environmental issues related to "water scarcity" frequently appear across media platforms such as television and the internet due to global climate change. In a study conducted by Fettahlioglu (2013), it was determined that the environmental problems that PSTs are most interested in are air, water, and visual pollution. On the other hand, in the present study, the least interesting environmental issues for both the comparison and experimental group students at the post-test are "industrial pollution" and "automobile exhaust gases". The reason for this result is that there are fewer industrial activities in the region where PSTs live, and the visible effects of these problems are less pronounced than in other regions.

Limitations and Recommendations for Future Research

Only two treatment groups –27 PSTs in the comparison group and 28 PSTs in the experimental group– were used in this research. If future research increases the number of participants in each group, it will enhance the statistical power of the findings. The effect of this method on students' environmental literacy should be compared at different grade levels, such as middle school, high school, and university levels, and different subjects, so that the effectiveness of argumentation-based education might be better understood.

Ethics Approval

The authors of this study declare that the ethical principles of the publication process of the Bartın University Journal of Faculty of Education were followed. Ethics Committee Approval was obtained from the university where the research was conducted (approval granted at the meeting dated 30 January 2022, meeting no. 2022/01, application no. 2022/07).

Conflict of Interest

The authors declare no conflict of interest.

Plagiarism Checks

Ithenticate

Artificial Intelligence Usage Statement

AI tools were not used in the writing of this article.

Acknowledgment

This article has been generated from Busra Gulfem Acar's master's thesis titled *The Effect of Argumentation-Based Environmental Education on Prospective Science Teachers Environmental Literacy*.

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