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ARTICLE

Making Argumentation-Based Learning and Teaching Happen: Exploring the Development of Pre-Service Science Teachers' Argumentation Competencies

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Abstract
It is essential for pre-service science teachers to have knowledge and skills about argumentation, which has a central role in science education, to be able to create learning environments based on argumentation, to gain written and oral argumentation competencies, and to equip students with these competencies. In this regard, this study aims to improve the argumentation competencies of pre-service science teachers, and it consists of two interrelated phases. In the first phase, pre-service science teachers participated in a 10-session instructional module on argumentation. In this process, the improvement of the pre-service teachers' argumentation competencies was examined. In the second phase, the transfer of argumentation competencies gained by the pre-service teachers in the first phase to their learning environments was assessed. The result of the study indicated that the pre-service science teachers' written and oral argumentation competencies were improved, they preferred to use certain argumentation schemes (causal argumentation schemes, argument from consequences, argument from examples, and argument from classification) when constructing their arguments, they employed some argumentation schemes as alternatives to each other according to their standpoints, and they chose to present their standpoints by using multiple argumentation schemes. The study also determined that the participants were able to transfer the knowledge and skills they gained during the instructional module process to real learning environments, became more confident in using different pedagogical strategies as they gained experience, and were successful in creating argumentation-based learning environments.

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1 Introduction

The primary goal of scientific inquiry is to guide students towards engaging in the activities and cognitive processes employed by scientists, so that they can develop a conceptual understanding of the natural world. Scientific inquiry should include not only discovery and experimentation but also explanation and argumentation (Ministry of National Education in Türkiye [MoNE], 2013). In this regard, argumentation, referred to as the language of science, holds central importance, especially in science classes, due to its similarity to the process scientists undergo when constructing and presenting knowledge (Brohinsky et al., 2022; Chan & Erduran, 2023; Driver et al., 2000; Erduran et al., 2004; McNeill et al., 2016; Şahin-Kalyon & Özdem-Yılmaz, 2023; Skoumios, 2023).

Although oral argumentation is important in argumentation-based learning environments, it is not sufficient on its own; writing is also significant in addition to talking (Chen, 2011; Chen et al., 2016; Wallace, 2007; Yaman & Hand, 2022; Yore & Treagust, 2006). According to Wallace (2007), "… talk is most important for distributing knowledge, while writing is important for manipulating, consolidating, and integrating knowledge" (p. 11). Writing is a social practice embedded in particular social events with all of the complex social and cultural processes involved in human relationships (Newell et al., 2019, p.1360). Also, writing is a cognitively demanding, goal-directed, problem-solving process that requires individuals to allocate limited cognitive resources to control and manage various sub-processes, such as planning, composing, and revising (Fan, 2019, p. 4). Argumentative writing is a realization and rhetorical production of argumentative knowledge (functions and forms of argumentative components, including claim, evidence, warrant, counterargument, and response to counterargument) in writing (Lin et al., 2020, p. 2553). In a well-structured argumentative essay, in order to persuade the reader, it is necessary to make a clear claim, present reasons for the claim, rebut possible opposing views by considering alternative standpoints on the issue, and make a general evaluation (Ferretti et al., 2000; Song, 2012; Yaman & Hand, 2022). Therefore, argumentative writing has long been considered an essential skill for disciplinary learning (Lin et al., 2020), developing conceptual knowledge (Chen et al., 2020; Huerta & Garza, 2019), and academic success (Landrieu et al., 2023; Lee & Lee, 2024). Furthermore, if students are to take full advantage of educational, occupational, and civic responsibilities, they must master of writing (Graham & Alves, 2021, p. 1613).

Writing is an essential skill used extensively in both daily life and working life that enables individuals to transfer information effectively and express themselves better (Chen et al., 2016; Kroesch et al., 2022; Lee & Lee, 2024; Wallace, 2007), and it should not be regarded as independent from oral argumentation. In the argumentation process, there should be two arguers; one of the arguers should put forward an argument, and the other arguer should make a countermove against this argument by creating an alternative argument or asking a critical question (Walton, 1996, 2006). The argumentation process has a dialogic nature. These kinds of dialogues can take two different forms: written and oral (Yaman & Hand, 2023, p. 4). In oral argumentation, the dialogic process is concluded by a series of oral exchanges between the respondent and the proponent. In argumentative writing, on the other hand, the author, undertaking both of the said roles, analyzes the issue according to alternative standpoints, comes to a conclusion by presenting a clear standpoint and rebutting the alternatives, and writes it down in a structured way. Taken together, the synergic use of oral argumentation and argumentative writing can support students' engagement in argumentation with higher-level cognitive processes (Chen et al., 2016, p. 106), foster their inquiry skills (Rivard, 2004; Sampson et al.,

2011), and enable them to construct higher-quality arguments (Chen, 2011; Kelly & Takao, 2002; Kelly et al., 2000). Oral and writing argumentation are both important learning tools in science education (Cavagnetto et al., 2010; Chen, 2011) and are reported to be more effective when they are used together in education (Chen, 2011; Chen et al., 2016; Rivard, 2004; Sampson et al., 2011; Yaman & Hand, 2022, 2023; Yore & Treagust, 2006). In this context, examining written arguments is as important as examining oral arguments in assessing individuals' argumentation skills.

Argumentation-based learning environments play a crucial role in raising science-literate individuals, which is one of the main objectives of science education (Cavagnetto, 2010; Chen, 2011; Khishfe, 2024; Martin-Gamez & Erduran, 2018; Sandoval & Reiser, 2004; Zembal-Saul, 2009). Therefore, it is crucial for teachers to establish argumentation-based learning environments through appropriate activities and tasks and to encourage students to construct arguments and critique alternatives (Boyer, 2012; Chen, 2011; MoNE, 2013, 2018; Sampson & Blanchard, 2012). Despite the responsibilities attributed to teachers, it is stated that they are often unaware of how to create argumentation-based learning environments, how the process will unfold, and the roles they need to assume, indicating a need for help (Cavagnetto, 2010; Chan & Erduran, 2023; Chen, 2011; Khishfe, 2024; Martin-Gamez & Erduran, 2018; McNeill & Knight, 2013; Sampson & Blanchard, 2012; Zembal-Saul, 2009).

It is essential for pre-service science teachers to have knowledge and skills about argumentation, which has a central role in science education, to be able to create learning environments based on argumentation, to gain written and oral argumentation competencies, and to equip students with these competencies. However, pre-service teachers are not at the desired level in terms of these skills (Capkinoglu et al., 2021; Martin-Gamez & Erduran, 2018; Palma-Jimenez et al., 2023; Zhao et al., 2021). Pre-service teachers have difficulty in understanding arguments and different pedagogical strategies to promote argumentation in the classroom (Martin-Gamez & Erduran, 2018, p. 463). Creating a culture of argumentation in the science classroom requires adequate argumentation competence among future teachers (Palma-Jimenez et al., 2023, p. 1). In this context, pre-service teachers need to gain experience in this field by participating in different instructional practices to improve their argumentation competencies. Pre-service teachers can apply argumentation in various classroom settings only after they experience it themselves (Martinez-Chico et al., 2019). Hence, this study aims to improve the argumentation competencies of pre-service science teachers before they start their profession by training them in the relevant field and to assess the contribution of the training to their professional development. To this end, answers to the following research questions are sought:

1. How does the argumentation-based instructional module (IM) affect the improvement of pre-service science teachers' argumentation competencies?
2. How effective is argumentation-based IM in providing pre-service science teachers with the knowledge and skills necessary to create an argumentation-based learning environment?

2 Theoretical Framework

2.1 Argumentation in Science Teacher Education

Argumentation is a verbal, social, and rational activity aimed at convincing a reasonable critic of the acceptability of a standpoint by putting forward a set of propositions

to justify or rebut the proposition expressed in the standpoint (van Eemeren & Grootendorst, 2004, p. 1). It is not enough for students to hear or read explanations from information sources such as books, the Internet, and teachers; students should be given the chance to participate in scientific practices and construct and defend their own views (Driver et al., 2000; Puvirajah, 2007). In the argumentation process, students identify evidence to support their claims, justify and explain their claims, try to rebut or defend arguments by critiquing them, and construct knowledge in this way (Driver et al., 2000; Chin & Osborne, 2010; Martin-Gamez & Erduran, 2018).

Many researchers advocate for the necessity of creating environments where students can construct their arguments, explanations, models, and theories, just like scientists who use evidence to support their claims, engage in dialogue with each other, and compete their views (Albe, 2008; Chin & Osborne, 2010; Martin & Hand, 2009; McNeill & Pimentel, 2010). Science education is particularly important in meeting this need. The information found in books can be easily memorized, recalled, and reiterated, whereas structured knowledge is much different from this (Puvirajah, 2007). Learning science requires more than just repeating without understanding the conceptual knowledge dimension of science; it necessitates students' engagement in argumentative processes, involving understanding what evidence, questioning, claims, and reasons are and recognizing the relationships among them in order to construct strong arguments (Chen, 2011).

Toulmin's argumentation pattern (TAP) holds a significant place in studies related to argumentation (Driver et al., 2000; Erduran et al., 2004; Lazarou & Erduran, 2021; Osborne et al., 2004; Skoumios, 2023). In his book *The Uses of Argument* (1958), Toulmin analyzed arguments and their components, leading to the adoption of this structure across various disciplines. TAP offers a systematic structure for constructing and structurally analyzing arguments. It has also been utilized as a teaching and learning heuristic, either for helping students express their arguments or for helping science teachers organize their argumentation interventions explicitly or implicitly around the pattern (Lazarou & Erduran, 2021, p. 306). All of these have increased the number of studies on the use of TAP in the field of education day by day, but these studies have also revealed some limitations of the model. It is noted that it may be difficult to distinguish argument components from each other and thus to determine the quality of argument because discourses may have different meanings depending on the context in the argumentation process (Driver et al., 2000; Kelly & Takao, 2002; Kim & Roth, 2018; McNeill et al., 2016; Sadler, 2004; Skoumios, 2023). It is also stated that the model does not focus enough on the social dimension of argumentation and will be insufficient for evaluating processes with multidirectional interactions (Kim & Roth, 2018).

Douglas Walton (2006), who defines argumentation as a dynamic process in which conversational moves are made, states that in order for an argument to be put forward, there must be a situation open to doubt and that this doubt must be eliminated in dialogic interaction. Walton's framework is pragmatic; that is, the structure and content of an argument are shaped by the joint goals of the reasoner and the other parties with whom they are reasoning (Nussbaum, 2011, p. 87). Walton's argumentation framework has three main components. The first component is type of dialogue. There are six different types of dialogue: persuasion, inquiry, negotiation, information seeking, deliberation, and eristic. Each type of dialogue has its collective goal as a framework governing both participants and all their moves (Walton, 2006, p. 183). The type of dialogue shapes argumentative discourse, but the discourse is also shaped by the specific *argumentation schemes* that the parties use in their discourse (Nussbaum, 2011, p. 88). According to Macagno et al. (2018),

> The argumentation schemes provided in [Walton et al., 2008] describe the patterns of the most typical arguments, without drawing distinctions between material relations (namely relations between concepts expressed by the warrant of an argument), types of reasoning (such as induction, deduction, abduction), and logical rules of inference characterizing the various types of reasoning (such as modus ponens, modus tollens, etc.). (p. 520)

Argumentation schemes serve at least two functions (Gordon et al., 2018, p. 91–92):

> They provide normative standards for critically evaluating arguments by matching arguments to schemes to see if they fit acceptable patterns of argumentation, to identify missing premises, and to facilitate the asking of critical questions.
> They provide guidance for making (constructing, inventing, and generating) good arguments in the first place, i.e., arguments that will satisfy the normative standards specified by the schemes.

There are two basic ways to attack an argument. One is to present a rebuttal or counterargument, a comparatively strong form of attack. The other is to ask questions that raise doubts about the argument without going so far as to rebut it by putting forward a counterargument (Walton, 2006, p. 27). Every scheme has a corresponding set of critical questions, representing its defeasibility conditions and the possible weak points that the interlocutor can use to question the argument and evaluate its strength (Macagno et al., 2018, p. 519). For example, argument from expert opinion is one of the argumentation schemes defined by Douglas Walton. Argument from expert opinion is based on the assumption that the source is alleged to be in a position to know about a subject because they have expert knowledge of that subject (Walton, 2006, p. 86). There are six basic critical questions matching the appeal to expert opinion, such as "How credible is E as an expert source?", "Is E personally reliable as a source?", or "Is E's assertion based on evidence?" (Walton, 2006, p. 88).

These two patterns are related in some aspects. According to Nussbaum (2011), all arguments have some sort of conditional premise, which corresponds to the notion of *warrants* in Toulmin's model, which shows how Walton's theory is partially based on Toulmin's (p. 80). Additionally, Toulmin's notion of a warrant in informal logic and argumentation theory was generalized into rich classifications of argumentation schemes for presumptive forms of reasoning, while his notion of a rebuttal was generalized into lists of critical questions attached to argumentation schemes (Prakken, 2018, p. 80). In conclusion, TAP and Walton's theory are frequently used in educational research. In the study, both models were introduced during the IM sessions, and the participants gained experience with these two models through various activities. In the IM process, the participants constructed their arguments using the argument components defined by Toulmin, identified the argumentation schemes they used in their arguments, and gained experience on how to use the critical questions defined for each scheme to refute the arguments in the argumentation process.

2.2 Instructional Supports for Pre-Service Teachers in Argumentation

Teachers' pedagogical competencies and beliefs about argumentation can impact whether and how science practice is integrated into their classrooms (McNeill et al., 2016), as well as how students engage in the argumentation process and the direction of interactions (Gonzalez-Howard & McNeill, 2019). Teachers play a vital role in implementing argumentation in classroom (Gonzalez-Howard & McNeill, 2019), and teachers' instructions

is essential to reinforce students' argumentation competence (Zohar & Nemet, 2002). For teachers to nurture argumentation skills among students, they should first be competent in this field themselves (Boyer, 2012; Martínez-Chico et al., 2019; Palma-Jimenez et al., 2023;), but they struggle to promote argumentation in the classroom (Capkinoglu et al., 2021; Martin-Gamez & Erduran, 2018; McNeill & Pimentel, 2010; McNeill & Knight, 2013). One of the important goals of science education is for teachers to understand the importance of argumentation, to improve their skills in this field, and to learn how to integrate argumentation into their classroom practices (Zembal-Saul, 2009). In this context, it is important for teachers to participate in practices aimed at improving their argumentation competencies before starting their profession and to gain experience through these practices. Only when pre-service and in-service teachers experience argumentation themselves can they apply it in different classrooms (Martinez-Chico et al., 2019). Teachers' gaining experience with argumentation affects their confidence in teaching argumentation (McNeill et al., 2016).

Knight-Bardsley and McNeill (2016) examined the relationships between pedagogical content knowledge (PCK), beliefs, and classroom practices of teachers who participated in a series of personal development workshops (PDW) on how to integrate the CER (Claim-Evidence-Reasoning) framework into classroom practice. The study determined that some of the participants just renamed the existing instruction as argumentation rather than trying new practices. These teachers preferred to rely more on PCK, personal teaching resources, and beliefs. In addition, it was noted that those teachers who were willing to transfer the skills they gained in the PD process to classroom practices showed more improvement in argumentation, and therefore, PD practices should definitely be supported by in-class practice experience.

Palma-Jimenez et al. (2023) designed an experimental study in which they examined the effect of SSI-based argumentation instruction on pre-service teachers' argumentation competencies. In that study, explicit instruction was employed in the experimental group. At the end of the experiment, it was found that the pre-service teachers in the experimental group improved their argumentative competencies and were able to transfer the skills they gained to a different context.

According to the literature, the role of the teacher is essential for implementing argumentation, partly because their beliefs about argumentation can impact whether and how this science practice is integrated into their classroom (McNeill et al., 2016; Zohar & Nemet, 2002), and explicit instruction supports written and oral argumentation skills (Alexander et al., 2023; De La Paz et al., 2023; Ferretti & Lewis, 2019; Graham & Alves, 2021; Khishfe, 2014, 2024; Nokes & De La Paz, 2023; VanDerHeide et al., 2023). In this study, IM was constructed explicitly. Also, as stated by Knight-Bardsley and McNeill (2016), the IM process was supported by micro-teaching practices and teaching practice in real learning environments in order for pre-service teachers to gain experience in argumentation competencies.

3 Method

3.1 Research Model

The study consists of two interrelated phases. In the first phase, the participants participated in a 10-session argumentation–based IM. In this phase, the participants' progress

was attempted to be determined in detail through various data collection tools. In the second phase, it was attempted to reveal in detail how the participants transferred the argumentation competencies they gained in the first phase to different learning environments. The first phase involved influencing the participants through an IM, while the second phase involved evaluating the outcomes regarding such influence. The phases were not independent of each other but interacted with each other. The study followed a mixed research approach. According to Creswell and Plano Clark (2011), a mixed approach involves collecting, analyzing, and integrating both quantitative and qualitative data in a single study or a series of studies to understand the research problem. In the present study, qualitative and quantitative data were collected interactively, rather than independently, with equal priority and at the same time. In parallel with that, quantitative and qualitative data were analyzed and presented in an integrated way.

Most studies structured with an integrated design include an experimental implementation phase. Qualitative phases can be incorporated before, during, or after this phase (Creswell & Plano-Clark, 2011). In the present study, qualitative phases were included before, during, and after the IM. Prior to the IM, the qualitative phase was used to determine the general characteristics of the group from which the participants were selected, to structure and pilot the intervention process, and to develop data collection tools. During the IM, qualitative data were collected as well, since relying solely on quantitative data would be insufficient to capture competency development. This approach aimed to provide a detailed description of the participants' improvement. After the IM, the qualitative phase was included to reveal how the participants transferred their experiences to different environments. In this phase, the teaching practices of two participants were monitored to detail the long-term results of the IM. In this context, the study employed an embedded design, which is a type of mixed methods design.

3.2 Study Group

The study was conducted with 12 pre-service teachers (PsSTs) studying science teaching at a state university in Türkiye. First, before starting the observations to determine the participant pool, a "student identification form" was distributed to the whole sample. The PsSTs were asked to fill in and submit the forms on a voluntary basis. The form included questions about students' weighted grade point averages (GPAs), reading habits ("What is the last book you read?", "How many books do you read on average per month?", "How would you evaluate yourself in terms of reading competencies?"), the clubs they are a member of, the trainings they have received since starting university, and the projects they have participated in.

To determine the actual IM participant pool, the researcher monitored the PsSTs for one semester in two different courses. Informed consent was obtained from the participants separately for the observation of both courses. The first course was a vocational course, where the researcher served as an assistant instructor. Within the scope of the course, the PsSTs were given theoretical and practical information about the methods and techniques that can be used in science teaching. Field notes were kept about the PsSTs' participation in the course, content knowledge, and communication skills.

The second course where the PsSTs were monitored was a different vocational course, where the PsSTs were required to form groups of two and conduct a 45-min micro-teaching practice within the scope of the outcomes given to them. The researcher attended the second course together with the instructor of the course and participated in the classes only

as an observer. During the second course observed, field notes were kept regarding the quality of the learning environments created by the participants in micro-teaching practices, the methods and techniques they used, the questions they asked, and the instructions they gave. After the completion of each observed class, open-ended questions were asked to the PsSTs about the quality of the questions and instructions they asked during the micro-teaching practice, their communication skills in the micro-teaching process, their command of content knowledge, whether the selected pedagogical strategies could be used appropriately, whether an argumentation-based learning environment could be created, and whether the other group member fulfilled the responsibilities required by the group work. The forms were distributed in written format at the end of the class and were collected the next day from the PsSTs who voluntarily completed them.

A participant pool of 30 PsSTs was formed by taking into account the data collected from the PsSTs using different data collection tools throughout the semester. Then an informative meeting was held with the PsSTs. After the meeting, 12 PsSTs who volunteered to participate in the IM were selected as the study group.

Before the IM started, a pre-IM interview was conducted with 12 PsSTs participating in the study. The pre-IM interview consists of three sections. In the first section, the participants were asked questions about their demographic characteristics. In the pre-IM interviews, the participants were also asked questions about their reading habits, professional competencies, and communication and group work skills. In the categorization of the participants according to their characteristics, their weighted GPAs were taken into consideration in determining their academic achievement levels. In the university where the research was conducted, the weighted GPA is calculated according to the 4-point system. In this context, those with a weighted GPA above 3.00 were categorized as "successful," those with a weighted GPA of 2.00–3.00 as "average," and those with a GPA below 2.00 as "weak." The communication skills, attendance in classes, group work skills, reading habits, beliefs about content knowledge competence, and willingness to engage in argumentation were categorized according to the data obtained from observations, field notes, student identification forms, evaluation forms submitted in written form after micro teaching, and pre-IM interviews. The participants' levels of knowledge about argumentation were categorized according to their answers to the questions in the second section of the pre-IM interview form.

Based on the data obtained from the different data collection tools conducted before the IM, the characteristics of the group participating in the research are given in Table 1.

According to Table 1, the participants show a heterogeneous distribution in terms of academic achievement, communication skills, class participation, group work skills, willingness to engage in discussions, reading habits, and content knowledge competence beliefs.

Prior to the IM process, interviews were conducted to determine the participants' levels of knowledge about argumentation. The pre-IM interviews involved questions in the categories of the definition and characteristics of argument and argumentation, science-argumentation relationship, characteristics of argumentation-based learning environments, teacher roles, student roles, advantages and disadvantages, and integration into the learning environment. In the interviews, two of the participants defined the concept of argument as "reasons on a particular issue" (PsST1) and "presenting an opinion by explaining the reasons well" (PsST4). Five of the participants (PsST3, PsST7, PsST9, PsST10, and PsST11) provided definitions of argument with misconceptions such as "something similar to a metaphor" (PsST3), "designing a model" (PsST7), and "combining two things" (PsST11). Five participants (PsST2, PsST5,

Table 1 Characteristics of the participants

Categories		Level	Pre-service teacher
Academic achievement		Successful	PsST (2, 4, 6)
		Average	PsST (1, 3, 5, 7, 8, 10, 12)
		Weak	PsST (9, 11)
Communication skills		Strong	PsST (1, 2, 3, 4, 5, 6, 8, 10)
		Weak	PsST (7, 9, 11, 12)
Attendance in classes	Specialized courses	Active participant	PsST (2, 4, 6)
		Passive listener	PsST (1, 3, 5, 7, 8, 9, 10, 11, 12)
	Vocational courses	Active participant	PsST (1, 2, 4, 5, 6, 8, 10)
		Passive listener	PsST (3, 7, 9, 11, 12)
Group work skills		Strong	PsST (1, 2, 4, 6, 7, 8, 10)
		Weak	PsST (3, 5, 9, 11, 12)
Willingness to engage in argumentation		Yes	PsST (1, 2, 4, 6, 8, 10)
		No	PsST (3, 5, 7, 9, 11, 12)
Reading habits		Yes	PsST (1, 2, 3, 4, 6, 8, 9)
		No	PsST (5, 7, 10, 11, 12)
Beliefs about content knowledge competence		Yes	PsST (4, 6)
		No	PsST (1, 2, 3, 5, 7, 8, 9, 10, 11, 12)
Knowledge about argumentation		Knowledge consistent with the literature	PsST4
		Misconceptual knowledge	PsST (1, 3, 7, 9, 10, 11)
		None	PsST (2, 5, 6, 8, 12)

PsST6, PsST8, and PsST12) stated that they had not heard the concept of argument before and did not answer the question. Similar results emerged regarding the definition of the concept of "argumentation." Six of the 12 participants made definitions that contained misconceptions, while five participants stated that they had never heard of the concept before. Only PsST4 defined the concepts of argument and argumentation in a manner consistent with the literature. Hence, it was concluded that all but one of the participating PsSTs either had no knowledge about argument and argumentation or held misconceptions about it.

3.3 Argumentation-Based IM and Data Collection Tools

3.3.1 Designing and Implementing Argumentation-Based IM

The study was designed and implemented in six interrelated phases. The details of these phases are given in Table 2.

The research process was completed in six phases. Firstly, what the PsSTs knew about argumentation was determined. In the needs analysis phase, it was found that most of the PsSTs did not have conceptual knowledge of argumentation, and the arguments they formed were weak. These results revealed the need for training the PsSTs on argumentation. Then, in the second phase, a 10-week IM was prepared considering the objectives of the science teaching undergraduate program, subject area competencies for teachers, the content of the science course curriculum, and the literature on argumentation. The IM was piloted with six PsSTs in order to determine its deficiencies and shortcomings. After the necessary changes were made, the IM was implemented with 12 different PsSTs, following the criteria in Table 1, with one session held each week on the same day and time (Fridays from 3 p.m. to 6 p.m.). Following the main implementation, the micro-teaching practices of all participants were monitored in the monitoring phase I. In the monitoring phase II, observations continued in real learning environments as it was aimed to determine how the participants transferred the knowledge and skills they acquired to real learning environments and how they improved these competencies as they gained experience. The performances shown in phase 4 and phase 5 were taken into consideration in the selection of the participants to be monitored in real learning environments. Considering the performances of the participants, two PsSTs who best represented the group were selected. While the performance of PsST5 in these two phases was weak, the performance of PsSTs 8 was adequate.

Argumentation-based IM was designed to serve two different purposes. The first one was to provide the participants with theoretical knowledge about argument and argumentation, as well as to introduce different argumentation patterns to them. The first three sessions were prepared for this purpose. In addition to the theoretical component, these sessions involved various sample activities in which the participants could create arguments, compare their arguments, and use critical questions. The second aim was to provide the participants with experience on how to create argumentation-based learning environments. For this purpose, the participants participated in sessions that included sample activities using different pedagogical strategies. At the end of each session, discussions were held regarding how the relevant activities could be transferred to real learning environments and the tasks assigned to them. Additionally, various examples from the literature were critiqued.

Table 2 Argumentation-based IM phases

		Action taken	Study group
Design of the IM	Phase 1	Needs analysis	The research process started with a needs analysis. To this end, 1 year before the actual study aimed at determining the argumentation competencies of PsSTs, a different group of PsSTs were monitored for seven weeks (28 h). During this process, an effort was made to assess the current status of the PsSTs by examining the instructions they used in micro-teaching practices, the quality of the questions they asked, the lesson plans they prepared, and the quality of the pedagogical strategies they employed. In this phase, unstructured observations, field notes, and semi-structured interviews were used to collect data, and the plans prepared by the pre-service teachers were examined. The collected data were analyzed, and the scope of IM was determined by identifying the current status, deficiencies, and needs of the PsSTs
	Phase 2	IM development phase	The data obtained from the needs analysis phase were related to the objectives of the science teaching undergraduate program, subject area competencies for teachers, the content of the science course curriculum, and the literature on argumentation. Based on these connections, a 10-session IM and data collection tools were developed to improve the argumentation competencies of the PsSTs. After the IM was prepared, three field experts were consulted, and necessary revisions were made
	Phase 3	IM pilot implementation	To identify the shortcomings and deficiencies of the IM, a pilot implementation was conducted with six different PsSTs. During the pilot implementation process, the feasibility of both the data collection tools and the IM was tried to be determined. Based on the pilot study, the IM was finalized by making corrections in the data collection tools and IM sessions in line with the researcher's field notes, observation reports, audio recordings, and participants' feedback (see Table 3)
Implementation of the IM	Phase 4	IM main implementation phase	After the pilot implementation was completed and the necessary revisions were made, the actual implementation was conducted with 12 PsSTs continuing their education in the 4th grade in a science teaching program. The IM, which was revised at the end of the pilot study, was completed with one session scheduled per week. After the sessions were completed, data collection tools were applied as pre- and post-tests. This phase lasted 12 weeks
Evaluation of the IM	Phase 5	Monitoring phase I	In this phase, the micro-teaching practices of the participants were examined in order to determine how the participants transferred the argumentation competencies they gained in the IM to the learning environment. In this phase, the participants' micro-teaching practices were audio-recorded

Table 2 (continued)

	Action taken	Study group
Phase 6	Monitoring phase II	This phase is a continuation of phase 5. Two of the participants (PsST5 and PsST8) continued to be monitored in real learning environments as part of the "teaching practice" course. "Teaching practice" is a compulsory course enrolled in the fall and spring semesters of the last year of the science teaching undergraduate program, where pre-service teachers gain professional experience in different middle schools with the assistance of a mentor. The participants' mentor was a PhD student in science education program and had taken many courses on argumentation. In this phase, the mentor actively participated in the data collection process. This phase lasted for 3 months

Table 3 Implementation sessions of argumentation-based IM

Session no	Session title	Session content	• Techniques/activities used
Session 1 (3 h)	Introduction Introduction to argumentation	• Defining argument and argumentation • Purposes of using argumentation-based learning environments in education • The importance of argumentation-based learning environments in education, especially in science education	• Small group-large group discussion • Activities for constructing and competing arguments
Session 2 (3 h)	Toulmin Argument Pattern (TAP)	• TAP • The components of TAP and the relationships between them • Practices for constructing arguments and breaking them down into their components	• Small group-large group discussion • Sample discussion activity
Session 3 (3 h)	Walton's argumentation model	• Walton's argumentation theory • Walton's argumentation schemes • Critical questions about argumentation schemes • Short practices for using critical questions	• Small group-large group discussion • Activities based on using critical questions
Session 4 (3 h)	Introducing discussion and teaching techniques that can be used in argumentation-based learning environments	• Pair discussion, pairs to fours, listening triads, ambassadors, role-playing, large group discussion, opinion development technique, argumentative vee diagrams, brainstorming, competing theories-cartoons, competing theories-ideas and evidence, competing theories-story, table of statements, constructing an argument, designing an experiment, predict-observe-explain, concept map of student ideas, KLEWS chart	• The "Mandatory Organ Donation" activity
Session 5 (3 h)	Nuclear power plants in light of risks and advantages	• Introducing the topic • Sample practice	• Constructing an argument • Argumentative vee diagrams • Small group discussion
Session 6 (3 h)	Cloning in light of different purposes	• Introducing the topic • Sample practice	• Constructing an argument • Argumentative role playing • Small group-large group discussion

Table 3 (continued)

Session no	Session title	Session content	• Techniques/activities used
Session 7 (3 h)	Global climate change	• Introducing the topic • Sample practice	• Constructing an argument • Brainstorming • Pairs to fours discussion technique
Session 8 (3 h)	Genetically modified organisms	• Introducing the topic • Sample practice	• Constructing an argument • Opinion development technique • Small group-large group discussion
Session 9 (3 h)	Examination of alternative activities I	• Examining and critiquing various practices/ activities in national and international literature on argumentation	• Small group-large group discussion
Session 10 (3 h)	Examination of alternative activities II	• Examining and critiquing various practices/ activities in national and international literature on argumentation	• Small group-large group discussion

3.3.2 Data Collection Tools

Various data collection techniques were used to make detailed inferences about the research questions of the research. The data collection tools used within the scope of the research questions of the research are given in Table 4.

Document Review The argumentative essays written by the participants before and after the IM and the lesson plans they prepared in the monitoring phases I and II were evaluated.

The pre-service teachers' argumentative writing skills were examined to reveal their argumentation competencies within the scope of the IM. To this end, they wrote argumentative essays before and after the IM about the establishment of hydroelectric power plants, one of the local socio-scientific issues. In the analysis of written arguments, argumentative elements were identified. In the analysis of argumentative texts, arguments were analyzed structurally. For this purpose, structural analysis units used in Fan (2019), Ferretti et al. (2009), Song (2012), and Song and Ferretti (2013) were used. The units of analysis used in the study are as follows:

> (a) identify the participant's standpoint(s) about the controversial issue (i.e., the standpoint advanced by the participant), (b) identify the participant's reasons that are offered as support for the standpoint (i.e., the propositions that support the participant's standpoint or serve as elaborations of reasons), (c) identify counterarguments that could be used to object to or undermine the participant's standpoint (i.e., potential criticisms of either the participant's standpoint or reasons for the participant's standpoint), (d) identify rebuttals of the counterarguments (i.e., the participant's explanation of why the counterarguments are wrong or bad reasons), (e) identify alternative standpoint(s) of the controversial issue (i.e., standpoints of other people that the participant disagrees with), (f) identify reasons for the alternative standpoint (i.e., the propositions that support other people's standpoint), (g) identify rebuttals of the alternative standpoint (i.e., propositions that attack an alternative standpoint or its reasons and thereby strengthen the participant's standpoint). (Song & Ferretti, 2013, p.76)

When analyzing the essays, they were segmented into sections according to relevant headings, and the elements were identified. After identifying the elements, the frequency of their usage by the participants in both pre- and post-essays was determined and compared statistically.

Following the identification of the elements contained in the argumentative essays, the argumentation schemes present in the essays were determined. While determining the argumentation schemes, the argumentation schemes in Walton's (1996, 2006) theory were taken into consideration. In Walton's theory, the argumentation scheme is determined according to the reason on which the claim is based. Studies on the determination of argumentation schemes have employed various methods. Özdem (2009) aimed at determining the argumentation schemes created by PsSTs in the context of various practices, examined all argumentation schemes in Walton's (1996) theory separately and did not make a classification. Puvirajah (2007) stated that it may be difficult to distinguish argumentation schemes according to the subject context and analyzed the argumentation schemes that emerged within the scope of their research in three categories: experiential, referential, and provisional. Similarly, Basel et al. (2013) noted that it was difficult to distinguish schemes,

Table 4 Data collection tools based on research questions

Research questions	Document review		Interview		Observation
	Pre- and post-argumentative essay	Lesson plans I–II	Pre- and post-interviews	Monitoring phases I–II interview	Monitoring phases I–II structured observation
How does the argumentation-based IM affect the improvement of pre-service science teachers' argumentation competencies?	√	-	√	-	-
How effective is argumentation-based IM in providing pre-service science teachers with the knowledge and skills necessary to create an argumentation-based learning environment?	-	√	√	√	√

especially those based on causal relationships, and, by combining some schemes, examined arguments in eight different categories: causal schemes, argument from example(s), argument from analogy, classifying schemes, argument from identity, inductive schemes, argument from authority, and argument against the proposition. In this study, classification was also made according to the type of reasoning. The classification employed the systematic structure based on semantic relations used by Walton et al. (2008) and Macagno et al. (2018). Accordingly, the schemes "argument from cause to effect," "argument from effect to cause," and "argument from correlation to cause" structured based on causal reasoning were grouped under the title of "causal argumentation schemes." Argument from consequences is based on practical reasoning (Macagno et al., 2018; Walton, 2013; Walton et al., 2008) and, therefore, is not classified as a causal argumentation scheme. And, slippery slope type of argument is clearly a subtype and special instance of argument from negative consequences (Macagno et al., 2018, p. 552). Thus, different varieties of slippery slope argument such as the causal slippery slope argument and the precedent slippery slope argument were addressed under the title "argument from consequences."

The lesson plans prepared by the participants for the micro-teaching practices in the monitoring phase I and for the teaching experiences in the real school environment in the monitoring phase II were also examined by the researchers. The participants shared their lesson plans with the first researcher before the practices. The first researcher used the prepared lesson plans as a reference while making observations in monitoring phases I and II. The lesson plans prepared by the participants were evaluated based on the methods they contained, the nature of the activities, their appropriateness for the learning outcome, and their inclusion of argumentation elements.

Interviews To assess the participants' oral argument construction skills, a semi-structured interview form was developed by the researchers to be used before and after the IM. The IM interview consists of three sections. The first section contains questions about demographic characteristics (age, reading habits, professional competencies, content knowledge competencies, communication, and group work skills). In the second section, there are eight questions aimed at determining the participants' levels of knowledge about argumentation (definition and characteristics of argument and argumentation, science-argumentation relationship, characteristics of argumentation-based learning environments, teacher roles, student roles, advantages and disadvantages, and integration into the learning environment). The last section includes four scenarios related to four different socio-scientific issues (gene therapy, the establishment of nuclear power plants, GMOs, and cloning), along with questions requiring participants to construct arguments and counterarguments for these scenarios. In the last section of the interview form, it was aimed for the participants to critique the scenarios given to them and to construct arguments for their own standpoint and alternative standpoint. Although the topics of the introductory scenarios in the interview form were different, the questions asked at the end of the scenarios were the same. During the interview, the participants were read the first scenario and then asked the question "Do you think such practices should or should not be implemented? Why?" to construct their own argument for the scenario. Secondly, with the question "Assume you have a friend who is undecided on this matter. How would you convince them?", the participants were encouraged to defend the arguments they constructed in the first question. Thirdly, with the question "What could be the argument of those who oppose your opinion?", the participants were made to construct an argument about the alternative standpoint. Finally, the question "How would you rebut the argument for the alternative standpoint?" was asked to encourage the participants to try to rebut the alternative standpoint.

This process was carried out with all participants separately for all four scenarios through oral interviews both before and after the IM. One of the scenarios in the third section of the interview form is as follows:

> Scenario 4: Rapid developments in cloning technology raise the question of whether extinct species can be recreated. What do you think about the recreation of ancient life forms in the future if suitable conditions are met with this technology?
>
> Questions for scenarios:

1. Do you think such practices should or should not be implemented? Why?
2. Assume you have a friend who is undecided on this matter. How would you convince them?
3. What could be the argument of those who oppose your opinion?
4. How would you rebut the argument for the alternative standpoint?

The questions in the third section of the IM interview form were asked again to all participants after the IM was completed, aiming to reveal the improvement in their oral argument construction competencies during the IM process. The procedures used in the analysis of argumentative essays were repeated in the analysis of the answers given to the scenarios related to different socio-scientific issues in the pre- and post-interviews. In the analysis of oral arguments, the structural components used in the analysis of written arguments were taken into consideration. In the analysis of oral arguments, argumentative elements were identified, too. Elements of oral arguments are divided into genre-specific sub-goals (standpoint(s), reasons for the standpoint, counterarguments, rebuttals of the counterarguments, alternative standpoint(s), reasons for the alternative standpoint, rebuttals of the alternative standpoint), referred to as functional elements (Fan, 2019; Ferretti et al., 2009; Song, 2012; Song & Ferretti, 2013). The arguments that the participants constructed within the scope of the scenarios in the pre-IM and post-IM interviews were divided into functional components as in the written arguments. Statistical analyses were made by determining the frequencies of the components in the arguments constructed by the participants for each scenario, in an attempt to reveal the improvement of the participants from pre-IM to post-IM.

Then, the argumentation schemes used by the participants in the context of the scenarios were identified, and it was tried to reveal whether the argumentation schemes used varied according to the scenarios or between pre- and post-interviews.

In the monitoring phases I–II interviews, the participants who were monitored in micro-teaching practices and the teaching practice course were asked questions aimed at prompting them to critique their teaching practices and improvements in argumentation.

Observation For the structured observations in the monitoring phases I and II, the researchers reviewed the literature (Boyer, 2012; Harlow & Otero, 2004; Simon et al., 2006) and identified the behaviors that teachers should demonstrate in argumentation-based learning environments and the characteristics of argumentation-based learning environments. Based on these characteristics, a 16-item "argumentation-based learning environment observation form" (ABLEOF) was created. The items included in the observation form are related to (1) patterns of discourse, (2) encourages discussion, (3) encourages listening, (4) encourages positioning, (5) encourages providing evidence, (6) encourages

further justification, (7) encourages anticipating counterargument, (8) encourages evaluation, (9) encourages asking questions, (10) waiting time, (11) questions type, (12) feedback-correction, (13) appropriateness for the learning outcome, (14) appropriateness for the grade level, (15) appropriateness for the nature of argumentation, and (16) applicability of the activities.

While creating the observation form, the item about the direction of the interactions in the classroom was prepared by turning each of the categories of classroom interaction in Harlow and Otero (2004) into an item. While writing the item about the questions that the PsSTs asked the students during the practices, the talk moves used by Boyer (2012, p. 22) were utilized. Finally, an item was added to this heading about whether the PsSTs asked questions about the critique of the arguments in the process. The items in the observation form such as encourage discussion, encourage listening, encourage positioning, encourage providing evidence, encourage further justification, encourage anticipating counterargument, and encourage evaluation were prepared based on the items in Simon et al. (2006). The last four items were prepared to determine whether the learning environments created by the participants were appropriate for the nature of argumentation. ABLEOF consists of two sections: (1) statements describing the participant behaviors in graded form, (2) explanations of why the observer chose that item. The form item prepared for (7) encourage anticipating counterargument in ABLEOF is given below. The participant's practice was observed and whether they were able to encourage students to anticipate counterarguments in the process was rated as adequate (item A), partially adequate (item B), or adequate (item C).

7. What kind of behavior does the pre-service teacher exhibit during the lecture **to encourage** students **to anticipate counterarguments**? (Choose one of the following items and explain your reason for choosing the item by giving an example)	
A. The pre-service teacher did not prepare activities to encourage students to anticipate counterarguments within the context of the subject and did not address this in their discourse throughout the practice	**Explanation**
B. The pre-service teacher attempted to encourage students to anticipate counterarguments through the activities they prepared and their discourses within the context of the subject but was not successful	
C. The pre-service teacher attempted to encourage students to anticipate counterarguments through the activities they prepared and their discourses within the context of the subject throughout the class and was successful	

The form item prepared for (9) encourage asking questions in ABLEOF is given below. The participant's practice was observed and whether they were able to encourage students to ask questions to each other in the process was rated as adequate (item A), partially adequate (item B), or adequate (item C).

9. What kind of behavior does the pre-service teacher exhibit to **encourage** students to **ask questions** during the lecture? (Choose one of the following items and explain your reason for choosing the item by giving an example.)

	Explanation
A. The pre-service teacher did not prepare activities to encourage students to ask questions to one another within the context of the subject and did not address this in their discourse throughout the practice	
B. The pre-service teacher attempted to encourage students to ask questions to one another through the activities they prepared and their discourses within the context of the subject but was not successful	
C. The pre-service teacher attempted to encourage students to ask questions to one another through the activities they prepared and their discourses within the context of the subject throughout the class and was successful	

After the observation form was prepared, the opinions of three field experts were taken, and necessary corrections were made. Subsequently, the observation form underwent a pilot implementation phase where the micro-teaching practices of a different group were evaluated with a field expert using the prepared form. The final version of the form was then created by incorporating the necessary corrections. The practices of the participants in the monitoring phases I and II were evaluated in the context of the items in the form. In the monitoring phase I, the first researcher observed the micro-teaching practices using ABLEOF. After the micro-teaching practices were completed, the first researcher shared their notes with the relevant participant in the short-term interviews held for the participants' self-evaluation, and the notes were evaluated to ensure member checking. In the monitoring phase II, the mentor teacher participated in the observations as well. The first researcher and the mentor teacher evaluated the participants' practices separately using ABLEOF. Then, the two observers compared their rating of the items in the form and reached a consensus by making evaluations on the items they rated differently. This was repeated for the eight observations made within the monitoring phase II.

3.4 Validity and Reliability of the Study

Data triangulation, member checking, and prolonged engagement were employed to ensure the credibility and the confirmability of the qualitative data obtained in the study. Different data collection techniques were used to assess the improvement of the PsSTs (triangulation). In addition, the sources were revisited for the findings obtained from the interviews, and it was confirmed whether the findings reflected the truth or not (member checking). Finally, the researcher's familiarity with the PsSTs since the beginning of their undergraduate education, their previous direction of different courses, and the main implementation process occurring over a period of 1 year (prolonged engagement and persistent observation) can enhance the meaningfulness and credibility of the collected data.

To ensure transferability, the entire implementation process was described in detail, including the structure of the study group, the development and implementation of data collection tools, the development and implementation of the IM, and the structure of monitoring phases.

In the study, stepwise replication and inter-rater reliability criteria were considered to ensure confirmability. Data collection tools and sessions were piloted, and revisions were made in IM sessions and data collection tools based on the data obtained from pilot implementation. In addition, the researchers collaborated to analyze the collected data. Furthermore, observations were made together with the mentor teacher in the monitoring phase II, and their codings in the process were compared and evaluated. Direct quotations were used to support the findings.

4 Findings

4.1 Findings for the First Research Question

The first research question was aimed at revealing the improvement of the pre-service science teachers' argumentation competencies from before to after the IM. Argumentation competencies were analyzed in two dimensions: argumentative writing skills and oral argumentation skills.

The argumentative essays written by the participants before and after the IM were analyzed based on the functional elements and argumentation schemes they contained. The functional elements in the essays written by the participants are presented in Table 5.

As shown in Table 5, while 118 reasons (62 level-1 reasons, 56 reasons below level 1) were formed for the participants' standpoints in the essays written before the IM, 157 reasons (88 level-1 reasons, 69 reasons below level 1) were formed after the IM. When explaining their standpoints in the essays they wrote, the participants constructed more reasons in the post-implementation phase than in the pre-implementation phase.

In the pre-implementation phase, 10 participants included an alternative standpoint alongside their own standpoint in their argumentative essays and attempted to rebut that alternative standpoint. In the post-implementation phase, however, the number of participants critiquing the alternative standpoint was eight. While PsST2, PsST10, and PsST12 critiqued both standpoints in the essays they wrote in the pre-implementation phase, they did not include the alternative standpoints in their essays in the post-implementation phase. In their argumentative essays written after the IM, PsST2, PsST10, and PsST12 constructed more reasons for their own standpoints and tried to explain their standpoints in more detail instead of critiquing the alternative standpoints. PsST4, on the other hand, did not include any alternative standpoint in her essay in the pre-implementation phase but critiqued both standpoints in the post-implementation phase. The 10 participants who included alternative standpoints in their essays in the pre-implementation phase created 43 reasons for the alternative standpoint and 39 rebuttals against the alternative standpoint. In the post-implementation phase, 8 participants created 30 reasons for the alternative standpoint and 37 rebuttals against the alternative standpoint.

A Wilcoxon signed-rank test was performed to determine whether there was a significant difference between the total number of functional elements in the argumentative essays written by the participants before and after the IM (Table 6).

As a result of the Wilcoxon signed-rank test, the change in the total number of functional elements used by the participants in their argumentative essays was found to be statistically significant ($z = -2.195$, $p < 0.05$). According to Cohen (1988, as cited in Pallant, 2010, p. 232), the effect size is moderate ($r = 0.45$). The median values of the argumentative essays increased significantly from the pre-test (Md = 17.83) to the post-test (Md = 20.83).

The argumentation schemes used by the participants in their argumentative essays before and after the IM were identified. The argumentation schemes used by the participants to explain their standpoint, those used to explain the alternative standpoint, and those used to rebut the alternative standpoint were determined separately in the essays they wrote. The argumentation schemes in the argumentative essays written by the participants before and after the IM are given in Table 7.

While explaining their standpoints in the pre-implementation phase, the participants generally addressed the causal relationships between the establishment of hydroelectric power plants and the need for energy and justified their standpoints accordingly. PsST1,

Table 5 Functional elements in the argumentative essays written by the participants before and after the IM

Functional elements	PsST1		PsST2		PsST3		PsST4		PsST5		PsST6		PsST7		PsST8		PsST9		PsST10		PsST11		PsST12	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Author's standpoint	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Level-1 reason	7	10	9	9	1	3	5	9	6	4	9	4	2	7	5	12	3	9	4	5	6	8	5	8
Reason below level 1	0	1	4	9	2	4	6	3	3	6	9	6	4	1	6	14	1	0	7	13	11	5	3	7
Counterargument	0	0	0	1	0	0	0	0	0	0	2	0	1	0	0	0	0	4	0	0	0	0	0	0
Rebuttal of the counterargument	0	0	0	1	0	0	0	0	0	0	3	0	0	0	0	0	0	2	0	0	0	0	0	0
Reason for the rebuttal of the counterargument	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	4	0	0	0	0	0	0
Alternative standpoint	1	1	1	0	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	1	0
Reason for the alternative standpoint	9	8	2	0	6	0	0	4	1	3	10	9	1	3	3	1	2	2	6	0	0	0	3	0
Rebuttal of the alternative standpoint	11	10	4	0	3	3	0	4	4	5	2	11	2	1	6	1	2	2	3	0	0	0	1	0
Reason for the rebuttal of the alternative standpoint	3	3	0	0	0	0	0	2	5	2	0	3	0	4	5	0	0	1	2	0	0	0	0	0

Table 6 Wilcoxon signed-rank test for the scores obtained from argumentative essays

Pretest–posttest	*N*	Mean rank	Sum of ranks	*Z*	*p*
Negative ranks	2	4.25	8.50	−2.195	0.028*
Positive ranks	9	6.39	57.50		
Ties	1	-	-		

*$p < 0.05$

PsST8, and PsST9 constructed their arguments with reference to different classifications. PsST9 considered renewability as a classification criterion, while PsST8 considered environmental friendliness as such. PsST6, PsST11, and PsST12 built their standpoints on negative consequences and accordingly constructed their arguments based on possible risks (ecosystem degradation, fish deaths, migration of people, etc.).

The participants mostly constructed their arguments for the alternative standpoint on possible negative consequences (fish deaths, reduction in agriculture, disruption of the natural balance, migration, deforestation, etc.) and causal relationships (working principle of the hydroelectric power plant-quality of water, energy needs-economy of the country, etc.).

The rebuttal against the alternative standpoint were, on the other hand, mostly constructed based on classification (laws, EIA reports, written agreements, etc.), causal relationships, or negative consequences (ecosystem degradation, fish deaths, etc.).

While explaining their standpoints in the essays they wrote after the IM, the participants focused mainly on negative consequences (people having to migrate, ecosystem degradation, fish deaths, wastes, reduction in plant and animal species, decreased soil fertility, etc.), causal relationships (the working principle of hydroelectric power plants and their effect on nature, Türkiye's geographical situation and energy needs etc.), different examples (habitats of the red-spotted trout, the condition of the Fırtına Valley, the effectiveness of alternative energy sources, etc.), and different classification criteria (clean energy, renewability).

The participants provided similar reasons for the arguments they constructed for both the alternative standpoint and the rebuttal against the alternative standpoint.

After determining the quality of the written arguments of the participants, the quality of their oral arguments was also analyzed. In this regard, the functional elements of the arguments constructed for the scenarios related to four different socio-scientific issues in the interviews conducted before and after the IM are given in Table 8.

Considering the functional elements that the participants constructed in the context of different socio-scientific issues before and after the IM, while the number of reasons constructed for the standpoint before the IM was 32 in the first scenario, this number increased to 56 after the IM. Before the IM, 21 reasons were constructed for the alternative standpoint, with 13 rebuttals and 15 supporting reasons for these rebuttals. After the IM, 28 reasons were constructed for the alternative standpoint, with 21 rebuttals and 27 supporting reasons for these rebuttals.

For the second, third, and fourth scenarios, the number of reasons for the standpoint, reasons for the alternative standpoint, and rebuttals and supporting reasons for these rebuttals were also higher after the IM than before the IM.

A Wilcoxon signed-rank test was performed to determine whether there was a significant difference between the total number of functional elements in the arguments the participants constructed in the pre- and post-interviews (Table 9).

Table 7 Argumentation schemes used by the participants in their argumentative essays

	Argumentation diagrams	Participants	
		Before IM	After IM
Argumentation schemes for the standpoint	Argument from classification	PsST (1, 8, 9)	PsST (3, 7, 9)
	Argument from consequences	PsST (6, 11, 12)	PsST (2, 5, 6, 8, 9, 10, 11, 12)
	Causal argumentation schemes	PsST (1, 2, 3, 4, 5, 7, 8, 9, 10, 11)	PsST (1, 2, 3, 4, 6, 7, 9, 11)
	Argument from example	PsST (1, 7, 8, 10)	PsST (1, 2, 3, 4, 6, 8, 9, 12)
	Argument from waste	-	PsST (5, 8)
Argumentation schemes for the alternative standpoint	Argument from consequences	PsST (1, 2, 3, 5, 7, 8, 9, 10)	PsST (6, 7, 9)
	Causal argumentation schemes	PsST (1, 6, 8)	PsST (1, 5, 6, 8)
	Argument from example	PsST (1, 6, 12)	PsST (1, 4)
Argumentation schemes to rebut the alternative standpoint	Argument from classification	PsST (2, 3, 8, 9, 10)	PsST (3, 4, 7 9)
	Argument from consequences	PsST (6, 12)	PsST5
	Causal argumentation schemes	PsST (1, 5, 7, 8, 9)	PsST (1, 3, 5, 6, 7, 8)
	Argument from example	-	PsST (1, 6)

Table 8 Elements of the arguments constructed for socio-scientific issues-based scenarios in the pre- and post-interviews

Functional elements		PsST1		PsST2		PsST3		PsST4		PsST5		PsST6		PsST7		PsST8		PsST9		PsST10		PsST11		PsST12	
		Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Scenario 1	Standpoint	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Level-1 reasons	3	4	1	2	1	3	2	1	1	1	1	2	1	2	2	2	3	2	2	3	1	2	1	2
	Reasons below level 1	3	2	2	3	0	2	1	2	1	2	3	2	0	2	0	2	1	4	1	3	0	3	1	3
	Alternative standpoint	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Reason for the alternative standpoint	2	1	2	2	1	2	2	1	2	2	2	2	1	2	2	3	2	4	2	3	2	3	1	3
	Rebuttal of the alternative standpoint	1	2	1	2	1	2	1	2	1	1	1	1	1	1	1	2	1	3	2	2	1	1	1	2
	Reason for the rebuttal of the alternative standpoint	2	3	1	2	2	2	1	3	1	1	1	2	1	2	2	2	2	3	2	4	0	2	0	2
Scenario 2	Standpoint	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Level-1 reasons	1	3	3	3	1	4	2	3	3	3	2	4	1	3	4	2	2	2	2	5	2	4	3	4
	Reasons below level 1	2	2	0	2	0	3	1	4	1	2	2	2	2	5	0	3	1	5	3	6	1	6	2	5
	Alternative standpoint	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1
	Reason for the alternative standpoint	2	5	1	2	2	3	2	2	3	3	3	5	2	3	1	3	2	2	3	5	0	4	1	7
	Rebuttal of the alternative standpoint	1	3	1	1	1	4	2	1	2	1	2	1	1	2	1	2	1	3	2	3	0	2	1	3
	Reason for the rebuttal of the alternative standpoint	2	3	2	2	2	3	2	2	1	2	3	3	1	3	2	2	2	5	1	4	0	2	1	6
Scenario 3	Standpoint	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Level-1 reasons	2	4	2	3	1	2	1	2	2	4	2	2	2	2	2	3	1	1	3	3	2	2	1	3
	Reasons below level 1	0	1	2	2	0	2	2	3	0	2	0	2	2	2	0	4	2	5	1	2	0	2	0	6
	Alternative standpoint	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Table 8 (continued)

Functional elements		PsST1		PsST2		PsST3		PsST4		PsST5		PsST6		PsST7		PsST8		PsST9		PsST10		PsST11		PsST12	
		Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
	Reason for the alternative standpoint	2	3	2	5	1	4	1	2	3	3	1	5	2	3	2	3	2	3	3	4	1	3	1	5
	Rebuttal of the alternative standpoint	2	3	2	2	1	4	1	1	1	2	1	2	1	3	1	2	1	2	1	4	1	2	1	2
	Reason for the rebuttal of the alternative standpoint	1	3	0	3	1	3	1	1	3	3	1	2	1	2	0	2	1	2	2	3	0	0	1	3
Scenario 4	Standpoint	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Level-1 reasons	2	1	2	2	2	2	1	5	1	3	1	3	2	2	1	2	2	2	2	4	2	2	1	4
	Reasons below level 1	1	3	2	1	0	1	2	3	1	2	0	2	0	1	2	2	1	5	0	4	0	3	1	2
	Alternative standpoint	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Reason for the alternative standpoint	1	2	1	2	2	2	1	2	1	2	2	2	1	2	1	4	2	6	2	6	1	3	2	4
	Rebuttal of the alternative standpoint	2	2	1	1	1	1	1	2	1	2	1	2	1	2	1	2	1	2	1	3	1	2	1	2
	Reason for the rebuttal of the alternative standpoint	0	3	2	2	2	2	2	1	2	1	1	2	1	2	2	0	1	5	0	2	0	2	1	3

Table 9 Wilcoxon signed-rank test for the scores obtained from argumentative elements

Scenario number	Pretest–posttest	N	Mean rank	Sum of ranks	z	p
Scenario 1	Negative ranks	-	0.00	0.00	−3.065	0.002
	Positive ranks	12	6.50	78.00		
	Ties	-				
Scenario 2	Negative ranks	-	0.00	0.00	−3.063	0.002
	Positive ranks	12	6.50	78.00		
	Ties	-				
Scenario 3	Negative ranks	-	0.00	0.00	−3.063	0.002
	Positive ranks	12	6.50	78.00		
	Ties	-				
Scenario 4	Negative ranks	-	0.00	0.00	−2.938	0.003
	Positive ranks	11	6.00	66.00		
	Ties	1				

*$p < 0.05$

The Wilcoxon signed-rank test revealed statistically significant changes in the total number of functional elements in the arguments, counterarguments, and rebuttals constructed by the pre-service teachers participating in the IM for the first ($z = -3.065$, $p < 0.05$), second ($z = -3.063$, $p < 0.05$), third ($z = -3.063$, $p < 0.05$), and fourth scenarios ($z = -2.938$, $p < 0.05$). The effect size is high for all scenarios ($r_{1,2,3} = 0.63$; $r_4 = 0.59$), according to Cohen (1988, as cited in Pallant, 2010, p. 232). The median values of the scores obtained from the arguments constructed in the context of the scenarios in the interviews showed a significant increase from the pre-interview to the post-interview.

The argumentation schemes of the participants in the scenarios in the pre- and post-interviews are given in Tables 10 and 11.

In the interviews conducted prior to the IM, the participants often provided arguments from consequences and causal relationships when explaining their standpoints. Most of the participants justified their arguments based on consequences in scenarios 3 and 4, while in scenarios 1 and 2, most participants justified their arguments by establishing causal relationships. In the context of the scenarios in the pre-interview, the participants also constructed arguments based on classification, referencing religious beliefs, ethical or social rules, or their own criteria.

In the pre-interview, the participants provided reasons using the same schemes when explaining the alternative standpoint as well. When explaining the alternative standpoints in scenario 1 and scenario 2, the participants particularly mentioned the consequences of such practices, whereas in scenario 4, they constructed arguments based on causal relationships. In rebutting the alternative standpoint, the reasons were based on consequences, causal relationships, gradualism, example, and classification.

When explaining their standpoint in the first scenario on gene therapy, PsST1 stated that she is against such practices and based her argument on three different argumentation schemes: argument from classification (I would not accept this because of my beliefs), argument from consequences (even if it is not a problem now, it will be a problem in 3–4 generations...), and causal argumentation scheme (our knowledge of the structure of genes is not sufficient for this type of research...). When the participant was asked to construct

Table 10 Argumentation schemes used by the participants in the sample scenarios in the pre-interview

	Schemes	Standpoint				Alternative standpoint				The rebuttal of the alternative standpoint			
		Scenarios				Scenarios				Scenarios			
		S1	S2	S3	S4	S1	S2	S3	S4	S1	S2	S3	S4
Argumentation schemes	Argument from classification	PsST1, PsST8, PsST9, PsST10	PsST7, PsST11	PsST8, PsST11	PsST3, PsST6	PsST3, PsST10	-	PsST1	PsST9	PsST9, PsST10	PsST10	PsST3	PsST4, PsST5
	Argument from consequences	PsST1, PsST2, PsST7, PsST9	PsST1, PsST4, PsST5, PsST6	PsST1, PsST2, PsST4, PsST5, PsST6, PsST7, PsST 8, PsST9, PsST10	PsST1, PsST2, PsST3, PsST4, PsST5, PsST7, PsST8, PsST10, PsST11, PsST12	PsST2, PsST4, PsST5, PsST6, PsST8, PsST10, PsST11, PsST12	PsST1, PsST3, PsST7, PsST8, PsST9, PsST10, PsST12	PsST1, PsST3, PsST6, PsST9, PsST12	PsST1, PsST6, PsST7, PsST9,	PsST1	PsST2, PsST4, PsST5, PsST6	PsST2, PsST4, PsST5, PsST9, PsST10, PsST11	PsST2, PsST3, PsST5, PsST7, PsST8, PsST10, PsST11, PsST12
	Causal argumentation schemes	PsST1, PsST2, PsST3, PsST4, PsST5, PsST8, PsST11, PsST12	PsST1, PsST2, PsST8, PsST9, PsST10, PsST12	PsST3, PsST6, PsST12	PsST1, PsST2, PsST7, PsST9, PsST10,	PsST1, PsST7, PsST9	PsST1, PsST2, PsST4, PsST5, PsST6, PsST7	PsST2, PsST4, PsST5, PsST7, PsST8, PsST10, PsST11	PsST2, PsST3, PsST4, PsST5, PsST8, PsST10, PsST11, PsST12	PsST2, PsST3, PsST6, PsST7, PsST10, PsST11, PsST12	PsST1, PsST2, PsST3, PsST7, PsST8, PsST9, PsST10, PsST12	PsST1, PsST2, PsST6, PsST7, PsST8, PsST12	PsST1, PsST3, PsST4, PsST9,
	Argument from gradualism	PsST6	PsST3, PsST9	PsST1	-	-	-	-	-	PsST4, PsST5, PsST8	PsST8, PsST9,	PsST1	PsST1, PsST6

Table 10 (continued)

Schemes	Standpoint				Alternative standpoint				The rebuttal of the alternative standpoint			
	Scenarios				Scenarios				Scenarios			
	S1	S2	S3	S4	S1	S2	S3	S4	S1	S2	S3	S4
Argument from example	PsST10	PsST6	PsST9	-	PsST3, PsST9, PsST10	-	-	-	PsST3	-	-	-
Argument from expert opinion	-	PsST6	-	-	-	-	-	-	-	-	-	-

Table 11 Argumentation schemes used by the participants in the sample scenarios in the post-interview

	Schemes	Standpoint				Alternative standpoint				The rebuttal of the alternative standpoint			
		Scenarios				Scenarios				Scenarios			
		S1	S2	S3	S4	S1	S2	S3	S4	S1	S2	S3	S4
Argumentation schemes	Argument from classification	PsST1, PsST3, PsST6, PsST10	PsST9, PsST12	PsST1	PsST4, PsST5, PsST10	PsST6, PsST7, PsST9, PsST10, PsST12	PsST6, PsST8		PsST1	PsST1, PsST5, PsST9, PsST10, PsST12	PsST1	PsST1, PsST2	PsST4
	Argument from consequences	PsST1, PsST2, PsST7, PsST8, PsST12	PsST2, PsST5, PsST6, PsST7, PsST8, PsST10, PsST11	PsST1, PsST2, PsST3, PsST5, PsST6, PsST7, PsST8, PsST11, PsST12	PsST2, PsST4, PsST5, PsST6, PsST8, PsST10, PsST11, PsST12	PsST3, PsST4, PsST5, PsST9, PsST10, PsST11	PsST1, PsST3, PsST4, PsST9, PsST10, PsST12	PsST4, PsST9, PsST10	PsST6, PsST7, PsST9	PsST1, PsST2, PsST7, PsST8	PsST6, PsST7, PsST8, PsST11	PsST2, PsST3, PsST6, PsST7, PsST8, PsST12	PsST2, PsST3, PsST5, PsST6, PsST10, PsST11, PsST12
	Causal argumentation schemes	PsST3, PsST4, PsST5, PsST6, PsST9, PsST10, PsST11, PsST12	PsST1, PsST3, PsST4, PsST5, PsST9, PsST10, PsST11, PsST12	PsST4, PsST5, PsST7, PsST9, PsST10, PsST11, PsST12	PsST1, PsST2, PsST3, PsST7, PsST8, PsST9, PsST12	PsST1, PsST2, PsST7, PsST8, PsST12	PsST2, PsST5, PsST7, PsST8, PsST11	PsST1, PsST2, PsST3, PsST5, PsST6, PsST7, PsST8, PsST11, PsST12	PsST1, PsST2, PsST3, PsST4, PsST5, PsST6, PsST8, PsST9, PsST10, PsST11, PsST12	PsST2, PsST3, PsST4, PsST6, PsST8, PsST9, PsST10, PsST11, PsST12	PsST2, PsST3, PsST4, PsST5, PsST7, PsST9, PsST10, PsST12	PsST1, PsST5, PsST9, PsST10, PsST11, PsST12	PsST1, PsST4, PsST7, PsST8, PsST9
	Argument from gradualism	-	-	-	-	-	-	-	-	PsST3, PsST4, PsST9	PsST1, PsST9	PsST4, PsST6, PsST9	-

Table 11 (continued)

Schemes	Standpoint				Alternative standpoint				The rebuttal of the alternative standpoint			
	Scenarios				Scenarios				Scenarios			
	S1	S2	S3	S4	S1	S2	S3	S4	S1	S2	S3	S4
Argument from example	PsST1	PsST5, PsST6, PsST7, PsST10, PsST11	PsST1, PsST2, PsST6, PsST8	PsST5, PsST6, PsST9, PsST10, PsST11	PsST1, PsST11	PsST6, PsST7, PsST10, PsST12	PsST6, PsST7, PsST10	-	PsST1, PsST3, PsST8, PsST9, PsST10, PsST11, PsST12	PsST10	PsST9, PsST10, PsST12	-
Argument from expert opinion	-	PsST6	-	-	-	-	-	-	-	-		-
Argument from analogy	-	PsST11	-	-	-	-	-	-	-	-	-	-
Argument from waste	-	-	-	PsST12	-	-	-	-	-	-	-	-

an argument for the alternative standpoint, she constructed her counterargument based on causal relationships (if we can eliminate diseases, why not eliminate them? This will lead to new scientific discoveries...). When asked to rebut the alternative standpoint, she again justified it based on consequences (we cause new diseases when we try to cure diseases). In the context of the first scenario, the participant justified her standpoint using multiple schemes and used some argumentation schemes as alternatives to each other.

In the post-interviews, the participants frequently made reasons based on consequences and causal relationships when explaining their standpoints, whereas the arguments for the alternative standpoint were generally based on consequences or causal relationships.

For example, PsST5, when explaining his standpoint for scenario 4, stated that he is against cloning. The participant justified his argument for his standpoint based on classification (cloning is against the law in Türkiye …), negative consequences (clones will disrupt the natural balance …), and example (Dolly cloning raises many questions …). The same participant justified his argument for the alternative standpoint based on causal relationships (cloning practices can inform us of theories about the origin of living things) and rebutted the alternative standpoint through reasons based on negative consequences (continual cloning will negatively affect the natural balance and genetic diversity …). In the context of the fourth scenario in the post-interview, the participant justified his standpoint using multiple schemes and used some argumentation schemes as alternatives to each other.

4.2 Findings Related to the Second Research Question

The second research question of the study investigated how effective the prepared IM was in providing the pre-service teachers with the knowledge and skills necessary for them to create an argumentation-based learning environment. In the pre-interview, 10 of the participants (PsST2, PsST3, PsST5-PsST12) did not answer the question about how argumentation could be integrated into learning environments, stating that they lacked knowledge on the topic. PsST1 described the integration of argumentation into learning environments as follows: (1) teachers constructing their own arguments well, (2) teachers identifying students' opinions, and (3) teachers persuading students based on their own opinions in a discussion environment directed by them. PsST4 described the integration of argumentation into learning environments as follows: (1) teacher starting the lesson with a question, (2) teacher using worksheets to determine students' opinions, and (3) teacher facilitating the groups to persuade each other or reach consensus through competition of different opinions on the issue.

The same question was asked again after the IM, and detailed answers were obtained from all participants. The answers given by the participants to the question on how argumentation can be integrated into learning environments are given in Table 12.

Before the IM, all but one of the participants had no knowledge of how to create argumentation-based learning environments. After the IM, on the other hand, all of the participants gave detailed explanations about the steps that can be followed in argumentation-based learning environments (see Table 12). All participants indicated that when creating argumentation-based learning environments, the first step is to determine whether the learning outcome aligns with the nature of argumentation, and if so, appropriate pedagogical strategies should be identified to match the outcome, and activities should be designed accordingly. The participants stated that the integration process should include elements

Table 12 Participants' post-IM views on the integration of argumentation into learning environments

	Participant			
Integrating argumentation into the learning environment	PsST1	PsST2	PsST3	PsST4
	1. Determining the appropriateness for the learning outcome 2. Designing activities appropriate for the learning outcome 3. Determining the appropriate time for each phase of the class 4. Collection of appropriate data sources 5. Monitoring the discussion groups 6. Asking critical questions when necessary, giving feedback and reinforcement 7. Asking follow-up questions when necessary 8. Enabling everyone to express their opinions 9. Checking the evidence 10. Making an overall evaluation	1. Determining the appropriateness for the learning outcome 2. Choosing techniques appropriate for the learning outcome 3. Making an engaging introduction 4. Identifying appropriate discussion groups 5. Choosing an appropriate topic for discussion 6. Giving students enough time 7. Providing classroom management 8. Asking critical questions 9. Enabling everyone to express their opinions 10. Making an overall evaluation	1. Determining the appropriateness for the learning outcome 2. Choosing techniques appropriate for the learning outcome and student level 3. Identifying appropriate discussion groups 4. Giving students enough time 5. Integrating critical questions into the process 6. Making an overall evaluation	1. Determining the appropriateness for the learning outcome 2. Identifying appropriate techniques 3. Informing the student about the subject 4. Identifying discussion groups 5. Providing classroom management 6. Setting the timing 7. Small group and large group discussion 8. Making an overall evaluation
	Participant			
	PsST5	PsST6	PsST7	PsST8
	1. Determining the appropriateness for the learning outcome 2. Determining student level 3. Preparing appropriate activities 4. Identifying groups 5. Enabling everyone to express their opinions 6. Small group and large group discussion 7. Making an overall evaluation	1. Determining the appropriateness for the learning outcome 2. Preparing appropriate activities 3. Identifying groups 4. Using different materials 5. Use of different discussion techniques 6. Reaching a consensus 7. Making an overall evaluation	1. Determining the appropriateness for the learning outcome 2. Designing activities appropriate for the learning outcome 3. Large group and small group discussion 4. Monitoring discussion groups 5. Asking critical questions when necessary 6. Enabling everyone to express their opinions 7. Making an overall evaluation	1. Determining the appropriateness for the learning outcome 2. Designing activities appropriate for the learning outcome 3. Large group and small group discussion 4. Monitoring the discussion groups 5. Asking critical questions and giving feedback when necessary 6. Making an overall evaluation
	Participant			
	PsST9	PsST10	PsST11	PsST12
	1. Determining the appropriateness for the learning outcome 2. Designing activities appropriate for the learning outcome 3. Large group and small group discussion 4. Monitoring the discussion groups 5. Making an overall evaluation	1. Determining the appropriateness for the learning outcome 2. Selecting appropriate techniques 3. Asking critical questions 4. Revising techniques according to student circumstances 5. Large group and small group discussion 6. Enabling everyone to express their opinions 7. Making an overall evaluation	1. Determining the appropriateness for the learning outcome 2. Selecting appropriate techniques 3. Asking critical questions 4. Large group and small group discussion 5. Enabling everyone to express their opinions 6. Making an overall evaluation	1. Determining the appropriateness for the learning outcome 2. Developing appropriate lesson plans 3. Asking critical questions 4. Large group and small group discussion 5. Enabling everyone to express their opinions 6. Making an overall evaluation

such as conducting small and large group discussions, monitoring discussion groups, asking critical questions, asking follow-up questions, allocating sufficient time for discussions, enabling everyone to express their opinions, and making a general evaluation at the end of the process.

In the monitoring phase I, the micro-teaching practices of all participants were monitored. In the monitoring phase II, PsST8, who had a successful performance in the monitoring-1 phase, and PsST5, who had a poor performance, were monitored for 3 months in their teaching practices in the real learning environment. In this way, an attempt was made to detail how they transferred the knowledge and skills they gained in the process to real learning environments, how their argumentation competencies developed with experience gained in real learning environments, and whether they could overcome the deficiencies observed in the micro-teaching practices.

The participants' practices in the monitoring phases I and II were evaluated according to the prepared observation form. Table 13 presents the findings obtained from the ABLEOF.

When the lesson plans prepared within the scope of the monitoring phase were analyzed, it was observed that all of the participants employed small group and large group discussions in micro-teaching practices, and four of the participants (PsST3, PsST6, PsST7, and PsST10) used the role playing technique, two of them (PsST2 and PsST8) the brainstorming technique and PsST4 and PsST5 the competing theories technique. PsST4 employed the opinion development technique in addition to the competing theories technique, and PsST5 applied the argumentative vee diagram following the competing theories technique. PsST9 used the jigsaw technique in the process and then had small group and large group discussions, while PsST11 and PsST12 structured the process around small group and large group discussions. PsST12 asked the group to write argumentative essay at the end of the practice he implemented.

As shown in Table 13, in the monitoring phase I, the interaction was not limited to a single dimension in any of the micro-teaching practices carried out by the participants. Multidirectional interactions emerged, including teacher-student, student–student, and student–teacher-student interactions. The participants tried to encourage the groups to engage in discussions through the different pedagogical strategies they preferred to use, the questions they asked, and the verbal instructions they employed. In this process, only PsST9 did not intervene in the discussion process. PsST5, PsST7, PsST11, and PsST12 were inadequate in some phases of their practices despite trying to encourage the group to engage in discussions through activities, instructions, and questions. PsST2 made remarks to encourage students to listen to each other and ensured that students listened to each other's opinions throughout the practices. PsST9 and PsST12 did not give verbal instructions to encourage students to listen to each other during the practices.

In the micro-teaching practices, PsST2 and PsST3 evaluated the evidence through their questions and instructions during the discussion process, whereas the other participants could not make sufficient moves in this regard. Six of the participants (PsST2, PsST3, PsST4, PsST6, PsST8, and PsST12) encouraged students to provide more reasons through their questions or instructions during the micro-teaching practices. Most of the participants gave students enough time to think and express their opinions. PsST1, PsST5, and PsST11 did not allocate enough time to students, particularly during the large group discussion phase, as they were rushing to complete their practices. PsST5, PsST6, PsST7, PsST10, PsST11, and PsST12 asked questions to compete students' opinions, while the other participants asked questions to encourage further justification. The participants encouraged student positioning in the discussion through the techniques they chose. In this context, various approaches were followed: assigning students different roles in the role-playing

Table 13 Evaluation of participants' teaching practices based on the findings obtained from the ABLEOF

Argumentation process	Codes	Monitoring phase I												Monitoring phase II							
		PsST1	PsST2	PsST3	PsST4	PsST5	PsST6	PsST7	PsST8	PsST9	PsST10	PsST11	PsST12	PsST5				PsST8			
														O1	O2	O3	O4	O1	O2	O3	O4
Patterns of discourse	Univocal-descriptive																				
	Univocal-model identification																				
	Dialogic-model establishment					√		√		√		√									
	Dialogic-model discussion	√	√	√	√		√		√		√		√	√	√	√	√	√	√	√	√
Encourages discussion	Inadequate									√											
	Partially adequate					√		√				√	√	√							
	Adequate	√	√	√	√		√		√		√				√	√	√	√	√	√	√
Encourages listening	Inadequate									√			√								
	Partially adequate	√		√	√	√	√	√	√		√	√			√	√					
	Adequate		√											√			√	√	√	√	√
Encourages positioning	Inadequate									√											
	Partially adequate					√						√	√	√				√			
	Adequate	√	√	√	√		√	√	√		√				√	√	√		√	√	√
Evaluates evidence	Inadequate					√		√		√	√	√	√					√	√		
	Partially adequate	√			√		√		√					√	√	√	√				
	Adequate		√	√																√	√
Encourages further justification	Inadequate									√											
	Partially adequate	√				√		√			√	√		√				√			
	Adequate		√	√	√		√		√				√		√	√	√		√	√	√
Encourages anticipating counterargument	Inadequate									√		√									
	Partially adequate					√							√	√				√			
	Adequate	√	√	√	√		√	√	√		√				√	√	√		√	√	√
Encourages evaluation	Inadequate	√								√											
	Partially adequate					√	√		√		√	√	√	√	√			√	√		
	Adequate		√	√	√			√								√	√			√	√
Question type	Questions to increase student participation									√											
	Questions for repetition																				
	Questions to compare ideas					√	√	√			√	√	√								
	Questions for the explanation of the reasons	√	√	√	√				√						√			√		√	
	Questions to critique opinions													√		√	√		√		√
Encourages asking	Inadequate	√								√		√	√					√			
	Partially adequate		√		√	√	√	√	√		√			√	√	√	√		√		√
	Adequate			√																√	

Table 13 (continued)

Argumentation process	Codes		Monitoring phase I											Monitoring phase II							
			PsST1	PsST2	PsST3	PsST4	PsST5	PsST6	PsST7	PsST8	PsST9	PsST10	PsST11	PsST12	PsST5				PsST8			
															O1	O2	O3	O4	O1	O2	O3	O4
Waiting time	Not allocating time																					
	Insufficient time		√				√				√		√									
	Sufficient time			√	√	√		√	√	√		√		√	√	√	√	√	√	√	√	√
Feedback-correction	Not responding																					
	Yes–no				√		√	√	√	√	√	√	√	√		√						
	Asking follow-up questions		√	√		√									√		√	√	√	√	√	√
Nature of activities	Appropriateness for the learning outcome	Not appropriate																				
		Should be improved					√	√	√		√		√									
		Appropriate	√	√	√	√				√		√		√	√	√	√	√	√	√	√	√
	Appropriateness for the grade level	Not appropriate																				
		Should be improved					√		√		√		√			√						
		Appropriate	√	√	√	√		√		√		√		√	√		√	√	√	√	√	√
	Appropriateness for the nature of argumentation	Not appropriate									√											
		Should be improved					√	√	√			√	√	√	√							
		Appropriate	√	√	√	√				√						√	√	√	√	√	√	√
	Transferability to different learning environments	Not appropriate									√											
		Should be improved					√	√	√			√	√							√		
		Appropriate	√	√	√	√				√				√	√	√	√	√	√		√	√

**O* Observation

technique, conducting small group discussions following the brainstorming technique, and ensuring the issue is evaluated in various contexts through the opinion development technique and six thinking hats techniques.

Considering the pedagogical strategies the participants chose for their micro-teaching practices, the instructions they used in the worksheets they prepared, and their moves during the practices, it can be said that the practices of PsST2, PsST3, PsST4, and PsST8 aligned with the nature of argumentation. The practices of PsST1, PsST5, PsST6, PsST7, PsST10, PsST11, PsST12 should be improved in terms of using the techniques appropriately, the quality and quantity of the instructions in the activities, structuring the discussions, and ensuring multidirectional interaction.

A detailed examination of the practices in the monitoring phase II (Table 13, Table 14) showed that PsST5 and PsST8 gave instructions, asked critical questions, and designed activities to ensure multidirectional interaction in all teaching practices. There were differences in encouraging students to engage in discussions during the participants' practices according to learning outcome and grade level. PsST5 experienced classroom management problems in the first practice and therefore was not successful enough in getting the whole group to participate in the discussion. PsST8, on the other hand, encouraged the group to participate in the discussion with various activities, instructions, and remarks in all the practices.

Both participants experienced problems in evaluating the content of the evidence put forward by students in learning environments. PsST5 tried to evaluate the evidence by asking follow-up questions in the introduction of the practices and critical questions during group discussions, but this did not extend to the whole process. While PsST8 did not take any action to evaluate the evidence in the first two practices, in the last two practices, she evaluated the evidence, especially with the critical questions she asked, and encouraged students to critique each other's evidence with their instructions.

Both participants asked a lot of critical questions and gave instructions for students to explain their reasons during their practices. PsST5 tried to encourage students to ask questions to each other by circulating around the groups especially during small group discussions, but she were not successful enough in getting students to ask questions to each other. Both participants gave students enough time to collect their thoughts, think about the answers to the questions, and construct their arguments.

The pedagogical strategies used by PsST5 and PsST8 in their practices in real learning environments in the monitoring phase II are given in Table 14.

The participants used various pedagogical strategies in the monitoring phase II. In the interview conducted with PsST5 at the end of the monitoring phase II, she explained the reasons for preferring the techniques she used during the practices as being experienced and believing that she would contribute to students.

> ... before the lesson, I thought a lot about what I could do, and brainstorming seemed the most effective. The students were not very successful, and perhaps not all of them could think of it, so it was very good to start with brainstorming. I had already liked it a lot while attending instruction module from you; I had said that I would definitely implement it. I saw that I could do it. (PsST5)

PsST8 used the brainstorming technique in the micro-teaching practice in the monitoring phase I, whereas she preferred to use techniques that she had no previous experience with in the monitoring phase II. She explained this preference as a desire to transcend themselves.

Table 14 Pedagogical strategies used by PsST5 and PsST8 in the monitoring phase II

	Techniques/activities used	Observation no	Techniques/activities used	
PsST5	Brainstorming, small group and large group discussion, poster preparation	Observation 1	Small group and large group discussion, poster preparation	PsST8
	Brainstorming, role playing, small group and large group discussion	Observation 2	Opinion development technique, KLEWS, small group and large group discussion	
	Pairs to fours discussion technique, project design, large group discussion	Observation 3	Six thinking hats, small group and large group discussion, question tickets	
	Large group discussion	Observation 4	Small group and large group discussion	

> ... we had not done KLEWS in the micro-teaching process, but you had shown an example. I was curious at the time, and when I researched it later, I saw that it was a lot of fun, and I said I should try it. I researched it. I also looked at your notes as well. I prepared and applied a worksheet. (PsST8)

In the short-term semi-structured interviews conducted during the monitoring phase II, the participants stated that through practice, they gained experience, became more adept at identifying key aspects, established a clearer connection between learning outcomes and strategies, formulated diverse questions, and improved the overall structuring of the process.

> ... the first time I did it, I didn't know much about what to pay attention to, but when I did it with the students, I first stumbled, but then I gained confidence. Although my first practice was not very good, the subsequent ones were much more successful. I said I could do this ... (after observation 3-PsST8)
> ... at first, I couldn't think of activities right away; I was thinking a lot. But now, when I think of outcomes, ideas come to my mind immediately. ... The more I practiced with the students here, the better I learned, and the more I realized how important it is ... (after observation 4-PsST5)

When the monitoring phase II is evaluated in general, it can be said that the lesson plans prepared by the pre-service teachers, the pedagogical strategies they used, the questions they asked, and their verbal instructions were useful for creating argumentation-based learning environments.

5 Discussion and Conclusion

The study aimed to reveal the improvement of the argumentation competencies of pre-service teachers participating in IM and how they transferred these competencies to learning environments.

When the argumentative essays written before and after the IM were evaluated in the context of their functional elements, it was determined that there was a significant difference in the scores of the essays, favoring the post-test results. Although argumentative writing is important for academic success and daily life, it is difficult to teach (Landrieu et al., 2023; Lee & Lee, 2024). This improvement of the participants' argumentative writing skills can be attributed to the IM. As a matter of fact, during the intervention, the participants frequently constructed arguments, competed their arguments, and gained experience in this skill. Especially the integration of argumentation schemes and critical questions into the process may have contributed positively to this improvement. Song (2012), examining the argumentative essay quality of university students, integrated argumentation schemes and critical questions into the process in one of the experimental groups. At the end of the experiment, it was found that the students participating in the training wrote much higher-quality essays. Similarly, Nussbaum et al. (2019) and Wissinger and De La Paz (2016) found that students wrote higher-quality arguments when critical questions from different argumentation schemes were used. During the IM, the participants gained knowledge and experience about the concept of argument, argumentation models, argumentation schemes, and critical questions about the schemes, which supported them in writing higher-quality argumentative essays (Ferretti et al., 2007; Ferretti et al., 2009; Song, 2012; Nusbaum & Edwards, 2011; Nussbaum et al., 2019).

When structuring their argumentative essays, the participants preferred to provide more reasons for their standpoints. While alternative standpoints were critiqued in ten of the essays written before the intervention, only eight of the essays written after the intervention included a critique of alternative standpoints. An examination of the essays from the participants who critiqued alternative standpoints before the intervention but did not include this section in their post-intervention essays revealed that these participants provided many more level-1 reasons and reasons below level 1 for their own standpoints compared to their pre-intervention essays. In the IM, particular emphasis was placed on presenting and critiquing alternative standpoints within the context of the topics, and the sessions were structured accordingly. The participants were encouraged to position themselves in the discussions during the sessions, and the selected topics were critiqued in different contexts. The participants provided many more reasons for both their own standpoints and alternative standpoints in their oral arguments (as shown in Table 8 and Table 9) compared to what was observed in their written argumentative essays. There may be different reasons why the participants preferred to focus more on their own standpoints when structuring their argumentative essays: (1) They may have thought that there is a linear relationship between the number of reasons for their standpoint and the persuasiveness of the essay. According to the literature, my-side bias is widely found in argumentative essays that focuses on the authors' own standpoints of the topic without consideration of alternative standpoints (Chase, 2011; Fan, 2019; Ferretti & Graham, 2019; Ferretti & Lewis, 2019; Nussbaum & Kardash, 2005; Song & Ferretti, 2013). The participants may have thought that the more reasons they provided to support their standpoint, the better quality their essays would be. Ferretti et al. (2000) state that the number of reasons for authors' standpoint in essays has a linear relationship with the persuasiveness of the essay. Therefore, it can be said that the participants adopted a strategy parallel to Ferretti et al.'s (2000) statement regarding the persuasiveness of the essay. (2) The lack of a dialogic nature in the argumentative essay writing process may cause the essays to contain bias: The participants continuously constructed and competed arguments through social interaction during the implementation process. Oral argumentation involves verbal exchanges between the proponent and the respondent, whereas argumentative writing is an individual activity in which the author has to assume both roles. In this regard, when writing essays, the participants may have used one of these two roles more actively. In this process, they may have gotten the idea that they do not have to consider alternatives and may have acted biasedly by considering it more accurate to include reasons for their own standpoint rather than incorporating alternative standpoints.

During the IM process, the participants' oral argumentation skills improved. The pre- and post-interviews included four different scenarios related to gene therapy, cloning, nuclear power plants, and GMOs. During the interview process, for each scenario, the participants constructed arguments for their own standpoint, the alternative standpoint, and the rebuttal of the alternative standpoint. In the oral arguments constructed for the four scenarios in the post-interview, the participants explained their own standpoint and alternative standpoint by using many more reasons. Additionally, they provided a substantially higher number of rebuttals against the alternative standpoints (see Table 8 and Table 9). This improvement of the participants' oral argumentation skills may be attributed to the experience they gained in argument construction and argument competition during the IM process.

The majority of the participants used multiple argumentation schemes for the scenarios in the post-interview, especially when constructing arguments for their own standpoints. In the pre-interview, most of the participants justified their arguments within the framework

of a single scheme, whereas after the IM, they justified their arguments using multiple schemes. This was especially the case in the arguments for their own standpoint, whereas less use of multiple schemes was found for the alternative standpoint and the rebuttal of the alternative standpoint.

At the end of the IM, the participants demonstrated a preference for incorporating a greater number of functional elements to enhance the quality of their standpoints in both written and oral argumentation. Additionally, they sought to enrich their standpoints by utilizing a more diverse array of argumentation schemes. They usually provided reasons for the alternative standpoint based on a single scheme.

When constructing their written and oral arguments, the participants preferred to use specific argumentation schemes according to their standpoint. For example, in the essays they wrote about the establishment of hydroelectric power plants, the participants mostly constructed their arguments based on arguments from example, causal argumentation schemes, and arguments from consequences. An important observation is that the participants who supported hydroelectric power plants explained their standpoints using causal argumentation schemes, whereas they addressed alternative standpoints through arguments from consequences. In parallel to this, those who were against the establishment of hydroelectric power plants explained their standpoints through arguments from consequences, while the alternative standpoint was explained based on causal argumentation schemes. These two argumentation schemes were frequently seen as alternatives to each other, depending on whether the participants supported the relevant issue. Similar argumentation schemes emerged in the participants' oral arguments regarding the sample scenarios. Oral arguments were justified based on arguments from example, arguments from consequences, causal argumentation schemes, arguments from classification, and arguments from gradualism. In oral arguments, as in written arguments, the participants mostly constructed their arguments through arguments from consequences and causal argumentation schemes depending on whether they supported the issue. This implies that the pre-service teachers considered some argumentation schemes as alternatives to each other in the context of standpoint and alternative standpoint.

It is crucial to understand how the participants transferred the knowledge and skills gained during the IM process to their learning environments. This is because it is not enough for teachers to have basic knowledge and skills to create argumentation-based learning environments; they must also be able to use effective techniques in classroom practices (Xie & So, 2012). In this regard, almost all participants (except PsST9) selected pedagogical strategies appropriate for the nature of argumentation. Considering the pedagogical strategies chosen by the participants within the scope of their practices and the way they structured them in the process, it can be said that the participants were inspired by the IM they participated in. Within the scope of the training received prior to starting micro-teaching practices, the participants were informed about how to transfer different pedagogical strategies to argumentation-based learning environments and what key considerations to focus on during this process. They also gained practical experience by engaging in various activities related to these topics. In particular, the pedagogical strategies such as brainstorming, role playing, opinion development technique, vee diagrams, and competing theories, which were used during different sessions in the IM, were successfully used by the participants in micro-teaching practices. In this context, the participants were able to transfer the knowledge and skills they gained in this field to learning environments. Similarly, Hiğde and Aktamış (2017) found that the participants preferred to employ the techniques they had practiced during their training within their learning environments. This suggests that the pre-service teachers felt more competent and self-confident about

the pedagogical strategies in which they had actively participated within the scope of their courses. This result proves that the prepared IM was effective in helping the participants gain competence in creating an argumentation-based learning environment.

After the micro-teaching practices of the participants were monitored, two PsSTs selected from the study group (PsST5 and PsST8) continued to be monitored within the scope of the "teaching practice" course which it is a compulsory course enrolled in the fall and spring semesters of the last year of the science teaching undergraduate program, where PsSTs gain professional experience in different middle schools with the assistance of a mentor. Long-term observation of the participants is crucial for understanding how they apply the knowledge and skills gained during the IM in a real environment over a long period of time. In the monitoring phase I after the IM, the participants preferred to use the techniques they had previously experienced in micro-teaching practices. However, as the process continued into the monitoring phase II, their preferences began to diverge. Namely, as the participants engaged in argumentation-based practices and gained experience, they started to employ different pedagogical strategies. For example, while PsST8 used brainstorming, a technique employed during the IM, in the micro-teaching practice she structured in the monitoring phase I, she chose to use techniques that they had no previous experience with in the monitoring phase II. During the interview, the PsST8 stated that she grew more confident in employing different pedagogical strategies as they accumulated experience. It is crucial for pre-service teachers to gain practical experience in argumentation in different learning environments, his enables them to develop proficiency in employing a different pedagogical strategies (Hiğde & Aktamış, 2017; Knight-Bardsley & McNeill, 2016; Martinez-Chico et al., 2019).

A review of the literature suggests that teachers' beliefs and perceptions may affect their engagement in new practices (Century, 2023), shape their decisions in the classroom (Martin-Gamez & Erduran, 2018), and impact argumentation instruction (Sampson & Blanchard, 2012). In this context, pre-service teachers' perceptions of argumentation and their own competencies are very important. As the pre-service teachers gained experience in teaching argumentation, their self-confidence in this field increased, and they believed in their own competencies more (McNeill et al., 2016). In this regard, it can be said that the IM developed within the scope of the study not only provides PsSTs with knowledge and skills about argumentation but also supports them in developing positive perceptions about their own competencies.

The participants employed different moves to encourage students to engage in discussion during the monitoring phases I and II. One of the most important of these moves is the questions they asked in the process. Whether classroom interaction is one-way or multi-way is related to the questions asked in the process (Chin, 2007). It was very important for the participants to ask different questions during the IM because appropriately structured open-ended questions support students to participate in the argumentation process and engage in multidirectional interaction (Günel et al., 2012; Sampson & Blanchard, 2012). Thus, it is important for the participants to pose different questions to groups, especially during small group discussions, and to ask guiding questions during large group discussions, as this enhances the quality of the argumentation process and facilitates participation.

In the argumentation process, it is crucial to present and critique alternative standpoints relevant to the subject. To achieve this, efforts should be made to encourage individuals with differing opinions to compete their standpoints in the argumentation process (Ferretti et al., 2000). In this direction, most of the participants encouraged positioning in the discussions during the micro-teaching practices. One of the significant problems that arose

during the micro-teaching practices conducted by the participants was their inability to ensure that students listened to each other adequately. PsST2 was the only participant who ensured that students listened to each other by employing various instructions during their practice. Yıldırır and Nakiboğlu (2014) found that both in-service and pre-service teachers encouraged listening by posing different questions and asking for opinions on previous comments. On the other hand, Hiğde and Aktamış (2017) and Simon et al. (2006) observed that while the majority of the participants encouraged discussions, they did not encourage listening. In this study, the participants tried to encourage students to listen through various instructions ("listen to your friends," "you cannot participate in the discussion if you don't listen to each other," "everyone should take turns," etc.), but these instructions were not sufficient for the whole process.

Critical questions in Walton's theory were introduced to the participants as part of the IM. They were given opportunities to use these questions in various activities, and information was exchanged on how these questions could be used in different activities and learning environments. In this context, throughout the micro-teaching practices, the participants were observed to ask critical questions at various phases of the process for different purposes, such as ensuring participation in the discussion, revealing reasons, evaluating evidence, creating counterarguments, and making evaluations.

In the monitoring phase II, PsST5 encountered difficulties in encouraging students to discuss during the first and second practices. To identify the cause, she spoke with students at the end of the class and learned the reason. Then, in the subsequent practices, she employed techniques such as designing posters, preparing projects, and role-playing—activities that students could enjoy—to encourage discussion, taking into account students' current situation. Meanwhile, she provided instructions and reinforcements to ensure participation in the process. The questions asked by PsST5, especially during the process, varied across the practices. In the first practice, the participant asked questions aimed at comparing students' opinions, such as "What do you think?", "Is there anyone who thinks differently from your friend?", and "What is your opinion?". However, in the later practices, the participant began asking questions like "Why do you support your friend's opinion?", "Would what you said be correct in every situation?", and "How can you prove that your friend's opinion is right or wrong?" In their practices, PsST8 effectively engaged students in discussions through the use of specific pedagogical strategies and critical questions, resulting in multidimensional interactions.

The participants' practices in the monitoring phase II were better structured than their first practices in monitoring phase-I. PsST5 and PsST8 stated that through practice, they gained experience, became more adept at identifying key aspects, established a clearer connection between learning outcomes and techniques, were able to formulate diverse questions, and improved the overall structuring of the process. In this context, it can be said that the participants became more successful in creating argumentation-based learning environments as they engaged in different practices and gained experience (Hiğde & Aktamış, 2017; Martinez-Chico et al., 2019; McNeill et al., 2016).

5.1 Limitations and Future Research

The study aimed to reveal the improvement of pre-service teachers' argumentation skills and how they transfer these skills to learning environments. Although significant findings were obtained, the study has some limitations.

In this study, the written and oral arguments constructed by the participants were evaluated based on the functional elements they contained. That is, a structural analysis was performed. It is noted that relying solely on structural analysis in evaluating the quality of written and oral arguments may not be sufficient for understanding how teachers and students distinguish between good and poor reasoning (Backman et al., 2023). For example, Backman et al. (2023) tried to demonstrate the potential of the Rational Force Model to improve argument analysis by focusing on the acceptability and relevance of argument elements. In this context, in future studies using the same IM, different analysis models can be employed to analyze arguments both structurally and according to acceptability and relevance, allowing for comparisons of results.

Ferretti and Lewis (2019) assessed the influence of writing goals and discourse knowledge on persuasive writing. In the study, students in both groups were asked to write the same essay. In the first group, students in the general goal condition were asked to take a position and write a letter to their teachers. In the second group, students in the elaborated goal condition were given the same general goal along with explicit sub-goals based on argumentative discourse elements. In Nussbaum et al.'s (2019) quasi-experimental study examining students' written and oral arguments, the experimental group students completed argumentative vee diagrams that included a critical questions box, while those in the control group were not provided with a critical questions box. At the end of the study, students in the experimental group were determined to form more rebuttals in the context of critical questions. Studies in the literature have generally focused on argument from consequences (Nussbaum et al., 2019; Song & Ferretti, 2013; Wissinger & De La Paz, 2016), argument from authority (Wissinger & De La Paz, 2016), or argument from example (Song & Ferretti, 2013). In Walton's theory, numerous argumentation schemes and corresponding critical questions are defined. It was considered that selecting some of these schemes and adding questions about them to the argumentative writing guide might limit the participants when writing argumentative essays. In this context, critical questions were not included in the argumentative essay writing guide, assuming that the participants would transfer the knowledge and skills they gained during the IM process. Through the analysis of the collected data in the study, the argumentation schemes frequently used within the scope of the IM were identified. In future studies using the IM prepared by researchers, comparative research can be conducted by adding critical questions related to the different argumentation schemes to the argumentative writing guide.

In phase 4 (implementation of the IM), the first four sessions (sessions 1, 2, 3, and 4) of the IM prepared and implemented in the study included theoretical information about argumentation. Sessions 5, 6, 7, and 8 were prepared to transfer the acquired knowledge into practice. In these sessions, the participants gained practical experience on how different pedagogical strategies can be used in argumentation-based learning environments. The activities prepared for sessions 5, 6, 7, and 8 were based on socio-scientific issues. In parallel to this, the scenarios in the interviews conducted before and after the IM were prepared in relation to these topics. The fact that only socio-scientific issues were taken into consideration in the four practice-based sessions in the IM process and in the data collection tool can be considered as a limitation of the study.

Following the completion of the IM, during the monitoring phase I, each participant underwent observation in one micro-teaching practice (see Table 13). In the monitoring phase II, two pre-service teachers were observed conducting four teaching practices each in real learning environments, spread across different weeks. Monitoring phase II was completed in 3 months. In the monitoring phase, the participants were evaluated in the context of the items in the ABLEOF. During the monitoring phase II, as the participants engaged in teaching practices in real learning environments and gained experience, they were able to transfer the knowledge and skills gained during the IM process to learning environments more easily, conducted higher-quality teaching practices, and demonstrated increased self-confidence in creating argumentation-based learning environments. Long-term observation of all participants in real learning environments could have provided more comprehensive data on how pre-service teachers transfer the knowledge and skills gained in the IM to learning environments and how they use these competencies. This is one of the important limitations of this study. In this regard, two recommendations can be made: (1) Long-term observations conducted after the IM will enable higher-quality conclusions regarding how participants transfer the skills they have gained. Thus, it is recommended that studies examining how pre-service teachers transfer any competencies to learning environments have longer observation periods. (2) Additionally, pre-service and in-service training programs that support pre-service and in-service teachers in creating argumentation-based learning environments through the preparation of various activities, the utilization of diverse techniques, and gaining relevant experiences may be implemented.

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Data Availability Data will be made available on request.

Declarations

Conflict of Interest The authors declare that they have no conflict of interest.

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