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The Effect of the Argumentation Method in Teaching Socio-scientific Issues on Elementary School Students' Critical Thinking Skills

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Abstract

This research focuses on revealing the effect of processing socioscientific issues via argumentation technique in 4th-grade primary school science teaching on students' critical thinking skills. This quantitative study, which adopted a semi-experimental design, included 66 elementary school students (2024-2025 academic year) from a district in the Southeastern Anatolia Region of Turkey. To determine the critical thinking profiles of the students, the four-point Likert-type scale developed by Akar and Uluçınar (2023) was utilized as the data collection tool. The relevant scale provided the opportunity to analyze the process through the dimensions of skepticism, curiosity, open-mindedness, and objectivity. When the analysis results are examined, it was determined that the experimental and control groups were at a similar level initially; however, the experimental group, where argumentation-based activities were applied, recorded a statistically significant improvement in terms of critical thinking skills at the end of the process. In light of these obtained data, it is recommended that educational programs be enriched with activities that support students' higher-order thinking skills.

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Introduction

In the information age, the impact of technological developments on education is increasing. Students can access information instantly; however, this convenience can lead to a weakening of inquiry-based learning processes. In particular, the decline in interest in questions that require establishing cause-and-effect relationships leads to students struggling to structure information, having difficulty establishing relationships between concepts, and forgetting the information they have acquired in a short time (Ayaz & Şekerci, 2014; Cin, 2013). This situation increases the need for learning environments where students can not only acquire knowledge but also transfer it to their daily lives, question it, and make sense of it.

Critical thinking is one of the basic skills necessary for individuals in the information age to make informed decisions, question information, and generate creative solutions. In this context, designing and implementing teaching programs aimed at developing critical thinking skills at all levels of education is of great importance (Alsaleh, 2019; Eğmir & Ocak, 2018; Karadeniz, 2006; Nor & Sihes, 2021; Önal & Erişen, 2019). When examining the 2018 Primary Education Teaching Programs and the 2024 Turkey Century Education Model in Turkey, it is seen that the mere inclusion of skills in the programs is not sufficient; these skills need to be effectively implemented and supported by holistic approaches (MNE, 2018, 2024).

International science education approaches, particularly shaped by the National Research Council Standards (NRCS) and 21st-century student skills, aim to nurture individuals who can think critically, research, question, inquire, and work collaboratively. In this regard, argumentation-based learning approaches are prominent in terms of developing students' scientific thinking processes and structuring knowledge. Methods such as the Toulmin Argument Model and Science Debate-Based Learning support meaningful learning in science education by enabling students to question and justify scientific knowledge (Aktamış & Hiğde, 2015; Berland & Reiser, 2009; Driver & Bell, 1986; Tezel & Günister, 2018).

Various studies have shown that argumentation develops students' problem-solving, critical thinking, and decision-making skills and provides a deeper understanding of scientific topics (Çetin, Kutluca & Kaya, 2013; Karakuş & Yalçın, 2016; Osborne, Erduran & Simon, 2004; Toulmin, 2003). Furthermore, this method keeps students active in the classroom, supporting their learning not only from the teacher but also through peer teaching, and enabling them to deepen their discussion skills and critical thinking processes (Apaydın, Cirit Gül & Omca Çobanoğlu, 2021; Okumuş, 2020; Şimşek & Yayla, 2016).

Social science topics hold a special place among the subjects where students can demonstrate their critical thinking skills and develop arguments. These topics, where scientific knowledge intersects with social and ethical issues, can be discussed from different perspectives due to their open-ended nature and require multifaceted evaluation rather than reaching a definitive answer. Topics such as climate change, artificial intelligence, and genetic engineering are supported by scientific data while also encompassing decision-making processes that involve individual and social values (Aydın & Kılıç Mocan, 2019; Ban & Mahmud, 2023; Çırak Zengin & Cebesoy, 2024; Sadler, 2004; Tezel & Günister, 2018).

Addressing socio-scientific issues in education enables students to critically evaluate scientific knowledge rather than memorize it, analyze different perspectives, and make informed inferences. Argumentation plays an important role in this process; it enables students to develop evidence-based arguments and understand how scientific knowledge is shaped in a social context (Karcılı, 2022; Sadler & Zeidler, 2005). In this context, the systematic application of argumentation in science education is critically important for strengthening students' scientific thinking processes and nurturing them as conscious individuals of the future.

Within this framework, the focus of the study is defined as "examining whether argumentation-focused teaching processes used in addressing sociological topics have a statistically significant effect on the critical thinking skills of fourth-grade elementary school students." In line with this primary objective, the effectiveness of the teaching method was tested by comparing the pre-test and post-test scores of the experimental and control groups. Furthermore, it was analyzed whether the change in critical thinking skills among students in both the experimental and control groups was significant at the intra-group and inter-group levels. During the process, it was also examined separately for each group whether the gender variable was a determining factor in students' critical thinking tendencies.

Method

Research Model

This study aims to examine the effect of argumentation-based teaching on the critical thinking skills of fourth-grade elementary school students in the teaching of social science topics. To this end, a pretest–posttest control group quasi-experimental design, one of the quantitative research methods, was used in the study. This model allows for a comparative assessment of the effect of argumentation-based teaching, the independent variable, on critical thinking skills, the dependent variable (Cohen & Manion, 1997; Gay & Airasian, 2000; Fraenkel & Wallen, 1996).

Two groups were formed within the scope of the research:

- The experimental group was taught using activities based on the argumentation method in science lessons.
- The control group continued the teaching process with activities included in the 2018 Science Teaching Program.

A pre-test was administered to both groups before the application, and a post-test was administered after the application to analyze the change in students' critical thinking levels. The decision to not match the experimental and control groups was made due to the difficulties of forming homogeneous groups in school and classroom conditions. This approach ensured that meaningful differences were identified by comparing the effect of the applied method with the control group.

Study Group

The study group for this research consists of a total of 66 fourth-grade students attending school in a district of a province in the Southeastern Anatolia Region during the 2024–2025 academic year. of these students, 33 were

assigned to the experimental group and 33 to the control group. Group selection was carried out using the convenience sampling method. This sampling technique is defined by the researcher's preference for a situation that is easily accessible and close to their immediate environment, and it makes the research process more efficient in terms of both time and resources (Yıldırım & Şimşek, 2016).

The distribution of the students participating in the study according to gender is presented in Table 1.

Table 1. Gender Distribution within the Working Group

	Group	Experimental group		Control group	
		n	%	*n*	%
Gender	Female	21	63.5	14	43.5
	Male	12	36.5	19	56.5
Total		33	100.0	33	100.0

Table 1 shows that 63.5% of the 33 students in the experimental group are female and 36.5% are male. 54.5% of the 33 students in the control group are female and 45.5% are male.

Data Collection Tool

In order to reveal the critical thinking profiles of the participants in the study, the ‘Critical Thinking Tendencies Scale for Primary School Students’ developed by Akar and Uluçınar (2023) was used. Designed to be appropriate for the 3rd and 4th grade elementary school curriculum and student level, the tool consists of 18 items. Participants' responses to the scale items were scored on a four-point rating scale ranging from ‘Never’ (1) to ‘Always’ (4) and prepared for analysis.

The scale has four subscales: curiosity, skepticism, objectivity, and open-mindedness. The Cronbach's Alpha internal consistency coefficient obtained in the reliability analysis of the scale was found to be .90 (Akar & Uluçınar, 2023). This coefficient indicates that the measurement tool has a high level of internal consistency and can be used reliably within the scope of the research. In the literature, a Cronbach's Alpha coefficient above .70 is considered good, while a coefficient between .80 and 1.00 indicates a high level of reliability (Yıldırım & Şimşek, 2016).

Data Collection Processes

In order to conduct the research, the necessary official permits were first obtained from the relevant Provincial Directorate of National Education. Following the approval process, the teacher and students at the primary school where the application would be carried out were informed about the purpose and process of the study.

Argumentation activities based on sociological topics to be used in the research were developed in line with the literature review. The activity contents were prepared using Ministry of National Education textbooks, academic

sources, and reliable digital content. The scope and appropriateness of the activities were evaluated based on the opinions of field experts and finalized. The implementation process was carried out over five weeks, with two class hours per week. Argumentation-based activities were applied to the experimental group, while the same social science topics were taught to the students in the control group in line with the 2018 Science Teaching Program. At the beginning of the research process, the "Critical Thinking Tendencies Scale for Elementary School Students" was used as a pre-test for students in both groups, and at the end of the process, the same scale was used again as a post-test.

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The argumentation activities used in the experimental group included structured learning tools such as concept cartoons, statement tables, and experiment design. Three fundamental sociobiological topics were addressed during the implementation period:

- Balanced nutrition
- Noise pollution
- Recycling

These topics were selected based on their alignment with 4th grade science learning outcomes and the recommendations of subject matter experts. Each topic was covered in two-week lesson plans; students actively participated in individual thinking, group work, and classroom discussion processes. During the activities, students were expected to justify their ideas, evaluate different perspectives, and design experimental processes. The data obtained at the end of the application was evaluated to analyze the development of students' critical thinking skills and group differences according to gender variables.

Data Analysis

IBM SPSS 27 software was used to analyze the data set, and the necessary statistical procedures were performed accordingly. First, the demographic profile of the study group was presented, followed by descriptive statistics (mean and standard deviation) of the pre- and post-intervention achievement scores for both groups. Since the sample size was over 30 in both groups, the Kolmogorov-Smirnov test was used to examine whether the data set met the assumption of normal distribution, using kurtosis and skewness coefficients (Bursal, 2019). Table 2 shows the normality analysis table comparing the participants' pre-test and post-test scores based on gender.

According to the analysis results obtained, Table 2 shows that a p-value greater than .05 indicates that the data set is normally distributed (Pallant, 2020). Furthermore, the normality of the distribution was confirmed by the skewness and kurtosis values between -1.5 and +1.5, which are accepted as the reference range (Tabachnick &

Fidell, 2013). Based on these findings, the independent samples t-test, a parametric method, was used to analyze the score differences between genders. The normality analysis data for the pre-test and post-test scores of the students separated into experimental and control groups are presented in Table 3 below.

Table 2. Normality Analysis Table for Pre-Test and Post-Test Scores by Gender

	Gender	*n*	*p*	Skewness	Kurtosis
Pre-test	Female	35	.09	-.67	.05
	Male	31	.20*	-.66	-.18
Post- test	Female	35	.20*	-.89	.11
	Male	31	.20*	-1.02	.09

When examining Table 3 regarding the distribution characteristics of the data set, the Kolmogorov-Smirnov test result being higher than .05 ($p > .05$) indicates that the data conform to a normal distribution. Additionally, the fact that the kurtosis and skewness values fall within the acceptable limits of -1.5 and +1.5 also strengthens the assumption of normality. In light of these statistical data, the dependent samples t-test was used to analyze the difference between the pre-test and post-test achievements of each group (Pallant, 2020).

Table 3. Normality Analysis Table for Pre-Test and Post-Test according to the experimental and Control Groups

	Group	*n*	*p*	Skewness	Kurtosis
Pre-test	Experimental	33	.07	-1.20	.20
Post-test	Control	33	.20*	-.81	.01
	Experimental	33	.20*	-.87	.01
	Control	33	.20*	-.48	.33

Findings

Findings Related to the First Research Question

The results of the statistical analyses conducted to determine possible differences in critical thinking skills between groups in the pre-test and post-test are presented in Table 4.

Table 4. Critical Thinking Skills Scale Control and Experimental Group Comparison Results

	Experimental group		Control group	
	$\bar{x}$	*ss*	$\bar{x}$	*ss*
Pre-test	46.54	4.20	44.39	5.27
Post-test	55.06	5.22	48.00	4.79

When examining the final test scores in Table 4, it is observed that the scores of both groups have increased. The pre-test average of the experimental group was 46.54, while it rose to 55.06 in the final test. In the control group, this increase was from 44.39 to 48.00. Although development was observed in both groups, the increase in the experimental group was more pronounced. This finding shows that argumentation-based teaching is more

effective than the control group in developing students' critical thinking skills.

Findings Related to the Second Research Question

Table 5 presents the results of the independent samples t-test conducted to examine whether there is a significant difference in the critical thinking scores of fourth-grade elementary school students based on the gender variable.

Table 5. Results of the İndependent Samples t-Test regarding the Relationship between Critical Thinking Skills Scale and Gender

	Gender	*n*	$\bar{x}$	*ss*	*t*	*p*
Pre-test	Female	35	45.00	5.13	-.833	.405
	Male	31	46.00	4.55		
Post- test	Female	35	51.94	7.01	.579	.557
	Male	31	51.06	4.99		

According to the t-test results examining the role of gender in critical thinking skills, presented in Table 5, there is no significant difference between the groups. When comparing the averages of female and male students, it was found that their critical thinking levels showed a similar distribution in both the pre-test phase ($t = -.833$, $p > .05$) and the post-test phase ($t = .579$, $p > .05$) and did not vary according to gender.

Findings Related to the Third Research Question

The results of the independent samples t-test analysis conducted to determine the difference between the pre-test and post-test mean scores related to the critical thinking skills of the experimental group are presented in Table 6.

Table 6. Results of the İndependent Samples t-Test regarding the Relationships between the Critical Thinking Skills Scale and the Gender of the Students in the Experimental Group

Experimental group	Gender	*n*	$\bar{x}$	*ss*	*t*	*p*
Pre-test	Female	21	46.80	4.89	.471	.589
	Male	12	46.08	2.74		
Post- test	Female	21	55.66	5.78	.878	.343
	Male	12	54.00	4.08		

Looking at the analysis results given in Table 6, there was no significant difference in critical thinking skills scores between female and male students in the experimental group. The gender variable did not play a decisive role in the effect of the argumentation-based teaching process. ($t = .471$, $p > .05$ [Pre-test]; $t = .878$, $p > .05$ [Post-test]).

Findings Related to the Fourth Research Question

The findings of the independent samples t-test applied to test whether the critical thinking skills of the students in

the control group showed a statistically significant difference according to the gender variable are presented in Table 7.

Table 7. Independent Samples t-Test Results regarding the Relationship between Critical Thinking Skills Scale and Gender in the Control Group

Control group	Gender	*n*	$\bar{x}$	*ss*	*t*	*p*
Pre-test	Female	14	42.28	4.33	-2.067	.040
	Male	19	45.94	5.47		
Post- test	Female	14	46.35	4.60	-1.742	.091
	Male	19	49.21	4.68		

When examining the analysis results presented in Table 7, although the p-value in the pre-test was at the .05 threshold, no significant gender-based difference was observed in the post-test since $p > .05$ ($t = -2.067$, $p > .05$ [Pre-test]; $t = -1.742$, $p > .05$ [Post-test]). This finding reveals that the female and male students in the control group showed similar development in terms of critical thinking skills.

Findings Related to the Fifth Research Question

The results of the dependent sample t-test conducted to determine whether there was a significant change in the critical thinking levels of the experimental group before and after the application of the argumentation method are summarized in Table 8.

Table 8. Results of the Dependent Sample t-Test comparing the Pre-Test and Post-Test of the Critical Thinking Skills Scale in the Experimental Group

Experimental group	*n*	$\bar{x}$	*ss*	*t*	*p*	*Cohen's d*
Pre-test	33	46.54	4.20	-14.95	< .001	1.41
Post-test	33	55.06	5.22			

Looking at the analysis results in Table 8, a significant and strong increase in the critical thinking skills scores of the experimental group students was recorded from the pre-test to the post-test. The dependent samples t-test ($t = –14.95$, $p < .05$) confirmed this difference statistically. Furthermore, the effect size calculated according to Cohen's (1988) classification ($d = 1.41$) indicates a large effect ($d \geq 0.80$). The findings show that the critical thinking skills level of the experimental group students had a significant and strong effect on their post-test scores compared to their pre-test scores.

Findings Related to the Sixth Research Question

The results of the dependent sample t-test analysis conducted to reveal the difference between the pre-test and post-test mean scores of the control group students' critical thinking skills are presented in Table 9.

Table 9. Dependent sample t-test Results for The Pre-Test - Post-Test Comparison of the Critical Thinking Skills Scale in the Control Group

Control Group	*n*	$\bar{x}$	*ss*	*t*	*p*	*Cohen's d*
Pre-test	33	44.39	5.27	-7.93	< .001	0.71
Post-test	33	48.00	4.79			

Looking at the analyses in Table 9, it is seen that there is not as significant and strong a difference between the pre-test and post-test scores on the critical thinking skills scale in the control group as there is in the experimental group ($t = -7.93$, $p < .05$). The effect size obtained ($d = 0.71$) corresponds to an effect between medium ($d = 0.50$) and large ($d = 0.80$) effect levels, based on Cohen's (1988) categorization.

Discussion and Conclusion

The primary objective of this study is to determine the effect of the argumentation method in teaching sociological topics on the critical thinking skills of elementary school students. In this regard, the critical thinking skills of fourth-grade elementary school students were evaluated through argumentation-based teaching activities. Findings related to the experimental group revealed that students' final test scores on the critical thinking skills scale increased significantly compared to their pre-test scores. This proves that the argumentation method contributes to the development of critical thinking skills. In contrast, no significant improvement in critical thinking skills was observed in the control group using the teaching methods employed in the 2018 Science Teaching Program. This highlights that the argumentation method stands out as an alternative approach that supports critical thinking in science education.

The argumentation activities implemented in the study encouraged students' active participation and deepened their thinking processes. In particular, the concept cartoon method attracted students' interest, engaging them in a fun learning environment while also encouraging them to question scientific information. This activity contributed to the development of students' critical thinking skills in a fun and interactive way. Concept cartoons, one of the argumentation tools used in the study, are an effective method that increases students' interest in the lesson and triggers the questioning process. Various studies in the literature support the success of this tool. For example, Yin and Fitzgerald (2017) reported in their study with secondary school students in Malaysia that peer interaction accompanied by concept cartoons increased critical thinking and academic achievement. Similarly, Demirci and Özyürek (2017) noted that using these materials in the 'Solar System and Beyond' unit made a meaningful contribution to students' thinking skills.

Chin and Teou (2009) point out that concept cartoons serve not only as teaching materials but also as formative assessment tools that track students' epistemological development. In their study, Balım, İnel & Evrekli (2008) found that while concept cartoons had a limited effect on academic achievement in science education, a significant difference in favor of the experimental group was detected in terms of the perception of inquiry-based learning skills. This finding supports the role of concept cartoons in triggering thinking processes in particular. Morris, Merritt, Fairclough, Birrell & Howitt (2007) examined how teacher candidates applied concept cartoons in

different schools and classrooms; they concluded that these tools made learning more effective and engaging in science education and early childhood education.

The statement table activity allowed students to discuss whether they accepted the given statements or not; it encouraged them to make logical inferences by providing an opportunity to evaluate different perspectives. This process supported students' ability to justify their thoughts and analyze opposing views. The study conducted by Demirel (2016) also concluded that various argumentation activities, such as statement tables, experimental design, theories competing with stories, prediction-observation-explanation, theories competing with cartoons, and theories competing with ideas and evidence, support students' conceptual understanding skills and learning motivation.

Using the experiment design method, students were divided into groups and took an active role in a collaborative learning environment. Thinking about the experiments they designed and discussing the sequence of operations helped them structure their scientific thinking processes. This activity both supported teamwork and contributed to the development of students' critical thinking skills. Anderson-Cook (1998) also noted that students designed experiments according to parameters set by the teacher, developed their experimental thinking skills using their prior knowledge, and critically evaluated their initial designs at the end of the lesson, proposing improved experiments in light of new information. This finding shows that the experiment design activity supports both critical thinking and scientific process skills.

In general, argumentation-based teaching activities contribute to the development of students' critical thinking skills; these activities enable them to question scientific knowledge, justify their reasoning, and analyze different perspectives. These findings are consistent with studies in the literature (Aktamış & Hiğde, 2015; Karakuş & Yalçın, 2016; Sadler & Zeidler, 2005). It can be said that argumentation, especially when addressed in conjunction with socio-scientific topics, strengthens students' scientific thinking processes and contributes to raising them as conscious individuals.

A review of the literature shows that teaching processes integrating socio-scientific topics (SST) and argumentation have positive effects on students' critical thinking tendencies (Acer, 2022; Aydın, 2021; Demiral & Çepni, 2018; Dolan, Nichols & Zeidler, 2009; Hacıoğlu 2022; Karcılı, 2022; Kuşdemir, 2023). For example, in a study conducted at the elementary school level during the pandemic, Acer (2022) found that SSI content contributed partially to students' critical thinking skills. However, the same study reported that no statistically significant progress was recorded in students' decision-making mechanisms. Nevertheless, the fact that both skills remained low in control groups that relied solely on textbooks highlights the potential of SSI-focused approaches.

In a similar context, another study conducted at the elementary school level by Dolan, Nichols, and Zeidler (2009) focused on how SSIs shape classroom dialogue. The research findings show that such topics transform students from mere consumers of information into individuals who examine events in their social and scientific dimensions, thereby supporting scientific literacy and critical thinking skills. Additionally, the effects of argumentation-supported SSI teaching were tested in a comprehensive 12-week study conducted by Karcılı (2022) with 7th grade

students. The data obtained prove that this method strengthens students' higher-level mental skills, such as problem solving and critical thinking, in addition to their academic achievement. This result confirms that argumentation is a critical tool not only in acquiring knowledge but also in structuring and effectively using it.

In a study conducted in the United States on teacher training programs, Robertshaw and Campbell (2013) examined the argumentation competencies of science teacher candidates within a sociological framework. Based on Toulmin's Argument Model, the study observed significant progress in teacher candidates' ability to justify scientific claims and present them with a critical eye. This highlights the importance of teachers first becoming proficient in argumentation skills in order to transfer them to students. Zohar and Nemet (2002) analyzed students' critical thinking processes by addressing an ethically controversial topic such as human genetics. The study found that the majority of students showed an increase in the quality of their scientific discussions. On the other hand, in a recent study on the teacher dimension, Kuşdemir (2023) revealed a strong link between preschool teachers' cognitive flexibility and their attitudes towards SHS. This finding indicates that the educational value of socioscientific topics is not limited to student gains but also shapes teachers' pedagogical and mental flexibility.

As in this study, some studies in the literature have directly integrated sociological topics into the argumentation process. In this respect, these studies share similar characteristics with the current research. However, there are also studies that address sociological topics using different teaching approaches and examine the impact of these approaches on critical thinking skills. For example, the study conducted by Aktaş (2022) examined the effect of teaching SSI using the Socratic question-and-answer method on BİLSEM students. In the study conducted with 20 fifth-grade students, the Socratic Inquiry Workshop was applied to the students, and all activities were structured according to this method. The research findings revealed that Socratic inquiry-based activities significantly improved students' critical thinking skills. This result provides an important indicator of how different teaching approaches can be effective in SSI-based teaching and complements the findings of the current study.

Similarly, in Arslan's (2022) study with 8th grade students, he presented socioscientific topics through storytelling and used an argumentation-focused teaching model; he examined the effects of this method on students' critical thinking, scientific attitudes, and argumentation levels. The study addressed the positive and negative aspects of establishing wind turbines, hydroelectric power plants, and nuclear power plants as socioscientific topics. The findings revealed that while no significant change was observed in the attitudes toward science among students in the control and experimental groups, there was a marked improvement in critical thinking skills in the experimental group. This result shows that the quality of the method used in teaching SSI can directly determine its effect on students' thinking skills; it also provides a framework that supports and expands on the findings of the current study.

The findings of this study indicate that there is no significant change in the pre-test and post-test scores of the critical thinking tendency scale for students in the control and experimental groups in terms of gender. This suggests that argumentation-based teaching practices do not vary according to gender when developing students' critical thinking skills. However, there are also studies in the literature that identify significant differences based

on gender in the context of critical thinking. For example, a study conducted by Shubina & Kulakli (2024) examined the relationship between critical thinking and creativity and evaluated the effect of gender on these skills. The research findings revealed significant differences in critical thinking levels between male and female students. A study conducted by Köksal & Çöğmen (2018) also examined the effect of gender on critical thinking skills and found that female students showed a significant advantage.

Similarly, Ay & Akgöl (2008) examined the effect of gender, age, and grade level on critical thinking skills in their study conducted on high school students. The results revealed that female students had higher levels of critical thinking than male students and that these skills increased with age. These differences indicate that the impact of individual and demographic variables on the development of critical thinking skills should not be overlooked; they also suggest that the findings of the current study may be limited to specific contexts.

The analyses show that the pre-test and post-test scores of the control group students on the critical thinking skills scale did not differ significantly. As a result, no significant change was observed in the critical thinking skill levels of the control group students who did not undergo the argumentation method. The lack of a significant difference between the pre-test and post-test scores on the critical thinking skills scale can be interpreted as indicating that the standard techniques included in the current 2018 curriculum are not sufficiently effective in developing students' critical thinking skills. This situation reveals that argumentation-based teaching is a superior approach to developing critical thinking skills.

Studies in the literature examining the effect of scientific argumentation on students' critical thinking skills support the findings of the present study. The study conducted by Puig, Bravo & Jimenez Aleixandre (2012) analyzed how students think during scientific argumentation processes and how they develop their critical thinking skills. The research revealed that argumentation is an effective tool in students' processes of interpreting and evaluating scientific data. Similarly, the study by Osborne, Erduran and Simon (2004) examined how scientific argumentation develops students' critical thinking skills; it was determined that students' active participation in scientific discussions makes important contributions in terms of making logical inferences and increasing their level of critical thinking. These findings demonstrate that argumentation-based teaching approaches have strong potential not only for knowledge transfer but also for the development of higher-order thinking skills.

In conclusion, studies conducted at different levels and in different disciplines show that argumentation-based teaching approaches significantly improve students' critical thinking skills. In the study by Hasnunidah, Susilo, Irawati and Suwono (2020), a positive correlation was found between science teacher candidates' levels of understanding basic concepts in biology and their critical thinking and argumentation skills. Similarly, research conducted by Aydın (2021) shows that examining socioscientific issues using an argumentation-based approach develops the analytical thinking and critical evaluation skills of secondary school students. When these findings are evaluated together with the results of the current study, they reveal that argumentation is a powerful teaching strategy that supports critical thinking skills both across disciplines and across age levels. In this context, the systematic integration of argumentation-based approaches into teaching programs will make an important contribution to the development of students' advanced thinking skills.

Recommendations

Based on the research findings, the following recommendations can be made:

- Considering the effects of applications such as concept cartoons, statement tables, and experiment design, which are among argumentation strategies, on critical thinking skills, new studies examining the effects of different argumentation strategies can be recommended.
- Including more argumentation activities such as concept cartoons, statement tables, and experiment design in elementary school textbooks may make lessons more effective and enjoyable. Such activities can support students' learning processes by contributing to the concretization of abstract concepts.
- Having too many students in groups during the implementation of activities made it difficult for students to express themselves. Therefore, dividing students into smaller groups in crowded classrooms can increase individual participation and contribute to the development of critical thinking skills.
- In teaching social science subjects, it is recommended to investigate not only the argumentation method but also the contribution of different teaching methods and techniques to students' critical thinking skills.
- Research results show that students' critical thinking skills are generally inadequate. In this context, more space can be given to activities aimed at critical thinking in teaching programs.
- It has been observed that students struggle particularly with tendencies such as questioning and modifying information, evaluating different perspectives, and approaching information with a critical attitude. Therefore, it may be recommended that structured activities aimed at developing these tendencies be added to teaching programs.
- Detailing explanations on how critical thinking can be fostered in teaching programs and supporting them with concrete examples may enable teachers to be more effective in the implementation process.

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