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# The effect of online argumentation activities workshop on pre-service science teachers' climate change awareness

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**ABSTRACT**

The aim of this study is to increase pre-service science teachers' awareness of climate change through online argumentation activities. The study prepared pre-service training content based on online argumentation to increase climate change awareness. For the training, activities were prepared based on online argumentation for the sub-dimensions of climate change, which are content knowledge, awareness of the effects of climate change, awareness of personal initiatives, awareness of industrial initiatives, and tendencies towards preventing climate change. Expert opinions were taken about the activities and then they were finalized. Data was collected through an open-ended questionnaire applied as pre- and post-test. 32 pre-service science teachers from 22 different universities across Türkiye participated in the online training. The climate change awareness form was applied before and after the training. Data was analyzed using a content analysis approach. As a result of the study, it was observed that there was a significant difference in the pre-service teachers' content knowledge of climate change, and they provided more justifications in the sub-dimensions of climate change awareness after the training, and their awareness increased.

**Keywords:** climate change awareness, online argumentation, pre-service teachers, socio-scientific issues

## INTRODUCTION

Forest fires, hurricanes, flooding, and other extreme weather events have become more common in recent years, emphasizing the severity of climate change (Field et al., 2012). The World Economic Forum (2021) has also identified climate change inaction as one of the most significant environmental risks for the coming decade. Despite recent initiatives to prevent climate change, universities have been limited in allocating time and resources to this issue (United Nations Educational, Scientific, and Cultural Organization [UNESCO], 2023a, 2023b). However, researchers have emphasized the importance of students and teachers participating in climate change adaptation and mitigation, with science education playing a critical role (Hess & Maki, 2019; Molthan-Hill et al., 2019; Strayer, 2012).

Increased awareness of climate change causes a significant change in individuals' behavior (Halady & Rao, 2010). Researchers emphasize the importance of students becoming aware of climate change at a young age to increase their agency toward climate change in the coming years and apply what they have learned in their lives. Despite initiatives to raise climate awareness, recent studies show that students' climate awareness is low (Owolabi et al., 2012). Oliver and Adkins (2020) examined the greenhouse gas awareness question from PISA exam of 540,000 15-year-old students from 52 countries and discovered that only 20.6% of the students reported knowing and being able to explain the phenomenon of the increase of greenhouse gases in the atmosphere. However, teacher and student awareness of climate change is not at the expected level. According to research, teachers are not prepared to integrate actions and content knowledge into climate change education (Oversby, 2015). According to Wise (2010), few teachers take climate science courses during their university years and learn the subject on their own to teach it in the classroom. Several studies have also revealed that teachers have misconceptions about climate change (Dawson, 2012; Herman et al., 2017). However, inadequate climate change education received by teachers during their university education is cited as one of the reasons for their lack of awareness (Wise, 2010).

The findings for pre-service science teachers are similar. According to studies, pre-service teachers confuse climate and weather and cite ozone depletion and air pollution as the primary causes of global temperature changes (Aksan & Celikler, 2013; Bleicher & Lambert, 2013; Lambert et al., 2012; Ocal et al., 2011). Although there are successful intervention studies to increase pre-service teachers' knowledge about climate change (e.g., Namdar, 2018), the advancement of understanding does not always positively transfer to behavioral change.

Furthermore, studies show that pre-service teachers are unaware of the need to take climate change precautions (Papadimitriou, 2004) and they are reluctant to change their actions (Tolppanen et al., 2020). However, researchers argue that teachers play a significant role for their students to take pro-environmental actions to fight against climate change (Tolppanen & Kärkkäinen, 2022). A recent study conducted with both students and pre-service teachers revealed that climate change education that they take was superficial and they did not feel prepared (Winter et al., 2022). Hence, it becomes critical to raise pre-service teachers' awareness of climate change for future change and it lays the foundation and rationale for this study.

Argumentation is a powerful tool for developing pre-service teachers' conceptual understandings and perceptions of climate change (Lambert & Bleicher, 2017). However, managing the consequences of climate change necessitates the participation of individuals in informed climate change decision-making (Nkoana, 2020). Argumentation has been identified as an effective medium for individuals to employ their content knowledge on socio-scientific issues as well as increasing their awareness by participating in informed decision-making processes. Furthermore, online argumentation environments proved to be effective in engaging students in decision making processes (Salih, 2020). However, the effect of online argumentation on climate change awareness has been unexplored.

The aim of this study is to enhance pre-service science teachers' climate change awareness by utilizing online argumentation activities. The study seeks to answer the following questions:

1. What effect do online argumentation activities have on pre-service science teachers' awareness of climate change content knowledge?
2. How do pre-service teachers' awareness of the effects of climate change, awareness of individual initiatives to prevent climate change, and awareness of industrial initiatives to prevent climate change differ after participating in the workshop?

### Climate Change Awareness

Even though it has an impact on people's daily lives, research has shown that teachers' awareness of climate change plays a significant role in the development of that awareness, albeit at a low level (Agboola & Emmanuel, 2016; Ekpoh & Ekpoh, 2011; Ezeudu et al., 2016). As a result, researchers advocate for intervention research to be conducted as part of environmental education programs to raise individuals' awareness of environmental risks such as climate change (Nkoana, 2020).

Climate awareness is divided into three sub-dimensions: awareness of the effects of climate change, awareness of individual climate change prevention initiatives, and awareness of industrial climate change prevention initiatives (Halady & Rao, 2010). Based on Halady and Rao (2010)'s study, Tok et al. (2017) adapted the questionnaire and added tendencies towards preventing climate change category. Awareness is defined broadly in this study as knowledge of subject-specific content as well as knowledge of desired behaviors (Onuoha et al., 2021). As a result, pre-service teachers are expected to develop both their climate change knowledge awareness and the awareness sub-dimensions, as identified by Halady and Rao (2010) and Tok et al. (2017), to develop a more holistic climate awareness.

Several recent studies have been conducted to raise awareness about climate change. Jeong et al. (2021), for example, used the flipped classroom approach to raise pre-service teachers' awareness of climate change. The findings of the study revealed that pre-service teachers' awareness of climate change favored the experimental group. Nkoana (2020) discovered that the environmental education course designed increased $7^{th}$ and $8^{th}$ grade students' climate awareness. In another study, Trott (2020) investigated the effect of a 15-week applied after-school program on the climate awareness of 10-12-year-old students. The study's findings revealed that students gained content knowledge on climate change and felt empowered to prevent the effects of climate change as they learned more about the subject.

There are studies on climate awareness in Türkiye. In these studies, it was discovered that learners lacked knowledge but had a high level of awareness and perception (Gulsoy & Korkmaz, 2020). In another study, Tok et al. (2017) found that pre-service primary school teachers were aware of the causes and effects of climate change, the importance of personal initiatives, and the need for behavioral change. However, pre-service primary school teachers were found to be less aware of industrial initiatives related to climate change than in other dimensions.

### Online Argumentation & Climate Change Education

In science education, argumentation can be defined as establishing links between data and claims through justification or evaluating claims with evidence (Jiménez-Aleixandre & Erduran, 2008). In this study, the claim, evidence, reasoning, and rebuttal model was used to introduce and engage pre-service teachers in argumentation (McNeill & Krajcik, 2012). When argumentation processes are structured online, students are exposed to different perspectives, allowing them to identify and structure counterclaim and rebuttal components, resulting in a higher quality argumentation process (Choi et al., 2014). Indeed, researchers claim that incorporating technologies such as augmented reality can increase individuals' climate awareness (Fauville et al., 2020). Furthermore, in the context of argumentation instruction, online activities have been shown to be effective in improving students' sustainability attitudes (Tsai, 2018) and developing content knowledge on socio-scientific issues (Kirbag Zengin et al., 2012).

Although argumentation increases students' understanding of climate change and argumentation levels (Dawson & Carson, 2020), research has shown that teachers cannot reach sufficient evidence in their climate change arguments (Liu & Roehrig, 2019). In a previous study conducted with pre-service teachers, argumentation improved pre-service teachers' understanding and perceptions of climate change (Lambert & Bleicher, 2017). However, little is known about how argumentation affects pre-service teachers' awareness of climate change.

Students' argumentation creation, sharing, and evaluation processes can be supported by online argumentation environments, which can be synchronous or asynchronous. Asynchronous argumentation environments, for example, allow for the presentation and development of informal reasoning through role playing (Salih, 2020), improve argumentation quality (Lin et al., 2012), increase scientific competencies (Tsai, 2015), and provide opportunities to explore and reason about natural science topics through asynchronous argumentation with scientists (Fauville, 2017). Synchronous argumentation environments, on the other hand, can lead to an increase in the quality and number of arguments, as well as conceptual understanding and conceptual change (Chen & She, 2012; Yeh & She, 2010). In this study both synchronous and asynchronous argumentation environments were utilized.

Online argumentation environments have also been used to teach socio-scientific issues in recent years. For example, Evagorou and Osborne (2013) used a tool called argue-WISE to engage 12-13-year-old students in argumentation processes about the government killing gray squirrels to protect red squirrels and discovered that the nature of students' participation in collaborative argumentation processes was related to the quality of their written arguments. Tsai (2018) investigated the impact of socio-scientific subject teaching based on flood detection ponds, tap water chlorination, technology factories, genetically modified mosquitoes, and nuclear energy scenarios on 127 high school and 68 undergraduate students' scientific skills and attitudes toward sustainability. Students used the online forum environment as a preliminary preparation for argumentation in the data collection and organization processes throughout the study. Ozturk et al. (2021) engaged pre-service teachers in Twitter debates about flu vaccine, homeopathy, sugar loading, chicken consumption, processed/raw milk, and child vaccination. The study's findings revealed that this practice improved pre-service teachers' argumentation skills. In another study, Foderaro and Lorentzen (2023) investigated Twitter discussions on climate change. Results revealed that users utilized various resources for justifying their arguments, but multiple audience used impromptu scientific artifacts and topics.

## METHOD

In this study one-group pre-/post-test design was employed to identify changes in pre-service teachers' climate change awareness (Bernard, 2013). The online workshop received 378 applications from 36 universities across Türkiye. We used criterion sampling method to identify the participants (Patton, 2002). The criteria included,

(a) a minimum GPA of 3.0,

(b) access to a computer at all times of workshop,

(c) interest in digital technology integration in education,

(d) equal number of male and female participation, if possible,

(e) maximum two participants from the same university, and

(f) being in the third or fourth year of their program.

Following the receipt of online applications, participants were contacted by phone in descending order, beginning with the students with the highest GPA and ending with the students with the lowest GPA. A total of 32 (30 female and two male) pre-service science teachers attended the workshop. The pre-service teachers were enrolled in 22 different public universities across Türkiye. The participants' ages ranged between 20-23. All the participants were studying science education to be middle school science teachers upon completing their degrees. They were in their third or fourth year of a bachelor's degree programs. All activities were carried out online.

### Procedures

When the participants attended the online workshop, science teacher education programs were prepared by the Higher Education Research Council (2023) and across the country only one bachelor's degree program was employed. The program did not offer a climate specific course, but the topic was covered only in earth science course (Higher Education Research Council, 2023). Pre-service teachers were given a four-day training course (**Table 1**). The researchers conducted a literature review and created the activity content. Furthermore, each activity incorporated various Web 2.0 tools and made them suitable for online argumentation. The tools included argument structuring environments, model-based inquiry environments, infographics creation environments, and canvas-type environments that are suitable for multiple representation creation and sharing. The relevant literature was reviewed during the process, and the necessary topics related to climate change content knowledge were incorporated into the activities. The activity plans were reviewed and finalized by two faculty members who are experts in the field of science education. For the training, 11 activities were created.

Following their selection, the participants were contacted and given the workshop schedule. The authors of this study conducted the workshop. The participants took part in the workshop virtually via their personal devices. Every participant was present for every activity. Following the workshop's introduction, the pre-tests were finished. At the conclusion of the workshop, the participants filled out the same open-ended questionnaire that had been prepared and distributed online. We paused the activities for fifteen minutes every 45 minutes. The Zoom system was employed. The participants worked in groups of Zoom breakout rooms or individually, depending on the nature of the tasks. The questions in each activity required the participants to provide arguments, either written or verbal.

**Table 1.** Activities, Web 2.0 tools used, & questions asked

| No | Activity name (Web 2.0 tools) | Sub-dimension | General question for which an argument is formulated |
|---|---|---|---|
| 1 | What is argumentation? (Padlet) | - | Should COVID-19 vaccinations be mandatory? (sample activity) |
| 2 | Climate & weather (Padlet*) | Content knowledge | What are arguments that those who are skeptical that climate change is not happening can put forward to show that it is not happening? |
| 3 | Greenhouse gases (WISE*) | Content knowledge | Are greenhouse gases real? |
| 4 | Melting glaciers (Miro) | Awareness of impacts | What would be your response to an article explaining that glaciers are not melting but that glaciers are forming at poles? |
| 5 | Endangered species (Parlay ideas*) | Awareness of impacts | Does it matter if living things become extinct due to climate change? |
| 6 | Extreme weather events (Infogram*) | Awareness of impacts | Florida is experiencing a high number of hurricanes due to climate change. How to plan for resettlement & climate mitigation? |
| 7 | Climate change & migration (Blendspace) | Awareness of impacts | A farmer named Mustafa's decision to migrate from his village to big city due to climate change |
| 8 | Individual consumption habits (JamBoard) | Awareness of personal initiatives | You have a child who is a climate activist & asks you to act on your personal consumption habits. |
| 9 | Climate friendly energy (Flip*) | Awareness of personal initiatives | How can we provide climate-friendly energy for our neighborhood? |
| 10 | Industrialization (Kialo*) | Awareness of industry initiatives | In addition to Paris Agreement, what other actions should be mandated for industrial activities in fight against climate change? |
| 11 | Use of climate friendly materials (Figma) | Awareness of industry initiatives | Explain by creating a business model canvas for your company to achieve highest profit by using climate friendly materials. |

## Data Collection

The data was collected with the same data collection tool at the start of the activities and after all activities were completed. Google Forms was used to create the items in the data collection tool. There were nine open-ended questions about climate change awareness in this data collection tool. The first set of questions, which determines content knowledge awareness, consisted of five questions:

1. What is the difference between climate and weather?
2. What is climate change?
3. What is global warming?
4. What are greenhouse gases?
5. What is the greenhouse gas effect?

The first set of questions were like the questions used in previous studies that determined the pre-service teachers' content knowledge about climate change (Namdar, 2018). The second set of questions consisted of four questions to determine participants' awareness of the effects of climate change, awareness of individual initiatives to prevent climate change, awareness of industrial initiatives to prevent climate change, and tendencies towards preventing climate change. The categories were found by Tok et al. (2017) in a Likert scale type question format. In this study, questions were reformatted as open-ended questions:

6. What are the consequences of climate change?
7. What can be done individually to prevent climate change?
8. How should industrial activities be structured to prevent climate change?
9. How do you evaluate your individual responsibility for preventing climate change?

The open-ended questionnaire was reviewed by two science education experts and based on expert opinions the questionnaire was revised and finalized.

## Data Analysis

The first five questions in the open-ended question form were scored between one and five using rubrics developed based on rubrics used in a previous study to determine the change in students' field knowledge about climate change awareness (Namdar, 2018). The researchers coded 50.0% of the data separately, and the Cronbach's alpha coefficient for inter-coder reliability was found to be between 0.82-0.91. A paired sample t-test was used to examine the change in students' climate change content knowledge for these items.

Question 6-question 9 in the open-ended question form were asked before and after the implementation. In the analysis of the written data, 20.0% of the answers in the data set were coded separately by the researchers and the inter-rater reliability Cronbach's alpha coefficient was found between 0.76-0.92. A content analysis method was used to analyze the data. Inductive coding processes utilized in which codes and categories were determined based on data. Therefore, the individual responses of the students to each question were coded, and then the codes were gathered and categorized based on the similarities of the content of the codes. The categories were reported in percentages before and after the application.

**Table 2.** Paired samples t-test results for content knowledge

| Tests | | t | df | p | MD | SED | d |
|---|---|---|---|---|---|---|---|
| Pre-test-1 | Post-test-1 | -7.44 | 31.0 | <.001 | -0.906 | 0.122 | -1.315 |
| Pre-test-2 | Post-test-2 | -2.88 | 31.0 | 0.007 | -0.500 | 0.174 | -0.508 |
| Pre-test-3 | Post-test-3 | -3.00 | 31.0 | 0.005 | -0.750 | 0.250 | -0.530 |
| Pre-test-4 | Post-test-4 | -5.64 | 31.0 | <.001 | -0.844 | 0.150 | -0.997 |
| Pre-test-5 | Post-test-5 | -5.57 | 31.0 | <.001 | -1.000 | 0.180 | -0.984 |
| Total pre-test | Total post-test | -11.22 | 31.0 | <.001 | -4.000 | 0.356 | -1.984 |

**Table 3.** Pre- & post-test mean scores for content knowledge

| Question | Mean pre-test (SD) | Mean post-test (SD) | d (ES) |
|---|---|---|---|
| Question 1 | 3.31 (0.74) | 4.22 (0.42) | 1.31 |
| Question 2 | 3.47 (0.76) | 3.97 (0.82) | 0.51 |
| Question 3 | 3.72 (0.92) | 4.47 (1.10) | 0.53 |
| Question 4 | 3.06 (0.71) | 3.91 (0.47) | 0.99 |
| Question 5 | 2.69 (0.69) | 3.69 (0.86) | 0.98 |
| Total | 16.25 (2.15) | 20.25 (2.05) | 1.98 |

**Table 4.** Awareness of impacts of climate change

| Categories | Pre-test (out of 72 total justifications) | Post-test (out of 128 total justifications) |
|---|---|---|
| Environmental impacts | 76.0% (55 justifications) | 77.0% (99 justifications) |
| Impacts on biodiversity | 22.0% (16 justifications) | 17.0% (23 justifications) |
| Direct impacts on humans | 2.0% (one justification) | 6.0% (six justifications) |

## FINDINGS

### Climate Change "Content Knowledge"

According to the results of the Shapiro Wilk test, the total scores of the questions on climate change content knowledge showed a normal distribution (W=0.97, p=0.40). The results of the study showed that the content knowledge of the pre-service science teachers who participated in the training increased significantly (**Table 2**).

Before the intervention, the mean score of all the questions related to the participants' content knowledge was 3.25 (standard deviation [SD]=0.43), and after the intervention, the mean score was 4.05 (SD=0.41) (**Table 3**). When all responses were analyzed, a significant difference was observed in the total scores of the participants' climate change content knowledge after the intervention for a total of five questions (t[32]=11.22, p<.001, α=0.05, d=1.98) (**Table 3**).

The data gathered for the question 6-question 9 in the questionnaire and the results based on the content analysis were reported in the next four subheadings regarding the changes in pre-service teachers' awareness on

(a) impacts of climate change,

(b) individual initiatives to prevent climate change,

(c) industry initiatives to prevent climate change, and

(d) tendencies towards preventing climate change.

### Awareness on "Impacts of Climate Change"

Pre-service teachers were most concerned about the environmental consequences of climate change. Among the environmental impacts mentioned were drought, sea level rise, glacier melting, disruption of seasonal balances, extreme weather events, forest fires, and water acidification. When the difference between pre and post activity responses was examined, it was discovered that pre-service teachers provided more valid reasons for climate change effects (**Table 4**). Pre-service teachers provided more than one justification for the effects of climate change in their responses. PST8, for example, offered the following explanations.

> "Glaciers melt, and this is not something that happens in the upper layer as we know it. The glaciers that break up because of melting in the lower layer melt even more and end up in the ocean.
>
> The sea level rises.
>
> Droughts occur due to increased temperatures.
>
> As there is more evaporation, extreme weather events such as excessive rainfall and subsequent floods increase.
>
> The cycle of the season's changes.

**Table 5.** Awareness of individual initiatives to prevent climate change

| Categories | Pre-test (out of 87 total justifications) | Post-test (out of 153 total justifications) |
|---|---|---|
| Reducing carbon footprint | 40.0% (35 justifications) | 28.0% (43 justifications) |
| Waste minimization | 24.0% (21 justifications) | 33.0% (51 justifications) |
| Changing eating habits | 6.0% (five justifications) | 8.0% (12 justifications) |
| Taking action to protect natural environment | 9.0% (eight justifications) | 7.0% (11 justifications) |
| Economical use of resources | 21.0% (18 justifications) | 24.0% (36 justifications) |

> It creates problems in life and reproduction of some living things. This means an increase in species in danger of extinction" PST8 (post-test).

Climate change has a variety of causes, according to pre-service teachers. Some participants appear to have considered the environmental impacts of climate change on biodiversity. Among the effects on biodiversity mentioned were ensuring the continuation of generation due to changes in environmental conditions, agricultural impact, and difficulties in the adaptation of living things to changing environmental conditions.

> "The polar ice caps are melting, seasonal transitions are not as smooth as they once were, and we are subjected to abrupt changes. Weather conditions may be much higher or lower than normal temperatures, which cannot be adapted to by all existing life forms, and many species may become extinct in the future. Plants, for example, cannot grow in arid environments" PST34 (post-test).

In terms of climate change consequences, only one student mentioned the effects of climate change on humans in the pre-test. PST31 stated that climate change would cause people to starve, but he provided no evidence to support his claim. When the post-test results were examined, it was discovered that a small number of justifications for migrations and the re-emergence of epidemics due to glacier melting (n=6) were presented.

> "People may be forced to relocate because of climate change. People who are exposed to many extreme weather events, such as hurricanes, because of climate change may perish and be forced to flee their homes. Again, adverse living conditions such as forest fires and drought may occur because of climate change. Many conclusions can be drawn, including the possibility that [agricultural] production will suffer" PST31 (post-test).

### Awareness of "Individual Initiatives to Prevent Climate Change"

The responses of pre-service teachers to what can be done at the individual level to prevent climate change were classified into six categories (**Table 5**). Under this theme, pre-service teachers most frequently provided reasons for reducing waste in the post test. It was stated that avoiding disposable materials, purchasing items with low environmental impact, and purchasing used items would help to reduce waste.

> "Environmentally friendly household appliances can be used, second-hand consumption can be used, old products can be repaired rather than discarded, we can increase the use of recyclable materials, we can reduce our waste, and we can turn off lights when not needed" PST37 (pre-test).

Along with waste reduction, one of the most frequently mentioned individual initiatives was the efficient use of resources to combat climate change. Individual initiatives mentioned included conscious resource consumption, reduced fuel consumption in manufacturing, preference for local products, and thermal insulation in buildings.

Taking actions to reduce one's carbon footprint was also one of the most frequently mentioned responses both in pre- (n=43) and post-test (n=35). Changing travel habits was mentioned as a method to reduce carbon footprint in most of these justifications, both in the pre- (n=20) and post-test (n=34). Travel habits included reduced use of airplanes, preference for walking or cycling over driving short distances, preference for public transportation, and reduction in frequency of travel. Furthermore, during the pre-test, some pre-service teachers mentioned the importance of installing filters on factory chimneys and ozone protection programs. The post-test, however, revealed neither of these two explanations. In the pre-test, seven pre-service teachers mentioned the importance of reducing one's carbon footprint, but they did not elaborate. The pre-service teachers explained how to reduce the carbon footprint by associating it with the outcomes of other actions after analyzing the post-test responses.

> "If we individually succeed in reducing our greenhouse gas emissions, we can significantly prevent climate change. For this, using public transportation rather than everyone at home using a separate vehicle contributes to reducing greenhouse gas emissions. Similarly, using solar panels, using energy-saving products (light bulbs, etc.), reducing food waste, consuming animal foods such as meat, milk, etc. at a minimum level, preferring local products instead of imported products, reducing air travel and electronic vehicle use, increasing the use of environmentally friendly products with recycling emblems on them are some of the individual practices we can do to prevent climate change" PST33 (post-test).

Justifications for forest protection and increased afforestation provided by pre-service teachers fall under the category of taking action to protect the natural environment. A small number of pre-service teachers, however, suggested environmental awareness-raising activities in addition to taking physical action to protect the environment. However, none of the pre-service teachers specified how they would raise awareness.

**Table 6.** Awareness of industry initiatives to prevent climate change

| Categories | Pre-test (out of 59 total justifications) | Post-test (out of 95 total justifications) |
|---|---|---|
| Reducing carbon footprint | 42.0% (25 justifications) | 24.0% (23 justifications) |
| Regulation of climatic impact | 22.0% (13 justifications) | 36.0% (34 justifications) |
| Waste control | 36.0% (21 justifications) | 40.0% (38 justifications) |

**Table 7.** Tendencies towards preventing climate change

| Categories | Pre-test (out of 27 total justifications) | Post-test (out of 94 total justifications) |
|---|---|---|
| Climate-friendly travel choices | 44.0% (12 justifications) | 19.0% (18 justification) |
| Climate-friendly individual consumption preferences | 48.0% (13 justifications) | 67.0% (62 justification) |
| Actions to reduce carbon footprint | 8.0% (two justifications) | 14.0% (14 justifications) |

Additionally, the pre-service teachers mentioned changing their eating habits to combat climate change. Twelve pre-service teachers mentioned their eating habits in the post-test, compared to five in the pre-test. While nine of the pre-service teachers justified a reduction in meat consumption, one advocated plant-based nutrition as a means of combating climate change. Two future teachers proposed lowering milk consumption and thus cattle production.

> "First and foremost, we must raise awareness about this issue. Furthermore, it is necessary to raise people's and our society's awareness. Individual actions should be taken to mitigate the effects of greenhouse gases, which cause climate change. In this context, calculating the carbon footprint allows an individual to determine how to calculate the use of carbon and direct his or her life to reduce it. Again, as we discussed in class, meat consumption can be adjusted on an individual basis because red meat products contribute to global warming and climate change. Another factor that contributes to climate change that can be mitigated mostly by individuals is the use of public transportation. Reduced fuel expenditures have a positive effect on climate change. These and many other measures can prevent climate change" PST1 (post-test).

### Awareness of "Industry Initiatives to Prevent Climate Change"

The number of justifications provided by pre-service teachers to the question of what industrial initiatives can be taken to prevent climate change increased in the post-test (**Table 6**). Lowering one's carbon footprint was a recurring answer in both the pre- and post-test. To reduce their carbon footprint, pre-service teachers suggested that industrial organizations use filtering systems, climate-friendly materials, and alternative energy sources in production.

> "Climate-friendly materials should be used. Thus, an environmentally friendly production is realized. They can obtain their energy through solar panels. Because the rate of electricity consumption in industry is very high. Filters should be installed on the factory legs" PST13 (pre-test).

Sanctions and penalties, the establishment of rewarding and incentive mechanisms, conducting awareness-raising activities for factory managers, and controlling industrialization were all mentioned as ways to control the climatic impact. When the responses of pre-service teachers in this category were analyzed, sanctions and penalties were mentioned only once in the pre-test but 11 times in the post-test.

> "We should encourage producers to use environmentally friendly materials; we can tax all products at the rate of their carbon emissions, so that producers and consumers prefer environmentally friendly materials; we should encourage industrial enterprises to reduce their carbon footprint; those who do not should be penalized; and we should reduce the rate of industrialization of all countries proportionally to their situation" PST21 (post-test).

Among the measures to combat climate change are those to ensure waste management from industrial activities. While only two pre-service teachers mentioned the use of environmentally friendly materials in industrial activities in the pre-test, it was the most frequently mentioned measure in the post-test (n=17). The following steps will be to recycle industrial materials and to use renewable energy sources in manufacturing processes. One of the measures not mentioned in the pre-test but mentioned in the post-test was the use of local raw materials in production.

> "Industrial activities should reduce the amount of carbon they emit into the environment, especially since they consume the most fossil fuels. They should prioritize recycling. Their energy use should be environmentally friendly, and the government should control and regulate it" PST23 (post-test).

### Awareness of "Tendencies Towards Preventing Climate Change"

To assess pre-service teachers' attitudes toward climate change prevention, they were asked to assess their own responsibilities in the matter. The post-test justifications showed an increase (**Table 7**).

When the post-test answers of the pre-service teachers were analyzed, six of them stated that although they were aware of their responsibilities, they could not implement them sufficiently.

> "I do not believe I'll be able to fully fulfill my responsibilities. The best I can do is take public transportation. In this case, I cannot claim to be able to fulfill my responsibilities. I now know what I need to do because of this activity" PST18 (post-test).

On the other hand, eight pre-service teachers stated that they already fulfill their responsibilities.

> "I believe that this is a universal problem with a personal solution. I believe that by paying attention to the environment and the use of energy resources, I am fulfilling my responsibility" PST29 (post-test).

However, one pre-service teacher mentioned the importance of contributing individually to the post-test while answering that individual efforts would not bring results in the pre-test.

> "I'm not someone who pays too much attention because I do not believe it's something that can happen with individuality, because I did pay attention once, but it did not go beyond limiting myself. For example, I saw on the news a few years ago that in a Middle Eastern country, there was a tire depot in an area of I do not know how many hectares that was set on fire. North Korea, on the other hand, is constantly testing missiles and bombs. It's extremely irritating. My contribution to climate change is insignificant in comparison, so I believe that if an effort is to be made, it should be on a national or global scale, considering people's freedoms" PST35 (pre-test).

> "I must do my part; this world belongs to all of us, and by changing our individual habits, we can achieve great things" PST35 (post-test).

Pre-service teachers who indicated a preference for environmentally friendly transportation preferred cycling, public transportation, and walking in their daily routines (n=12). In the post-test, four more pre-service teachers stated that it was their personal responsibility to prefer walking.

> "I believe we should do what we can without regard for the consequences of our actions. We all have a personal responsibility to our environment. I try to use less deodorant, eat less meat, keep my furniture for a long time, and do not leave electronic devices unplugged" PST30 (post-test).

According to pre-service teachers, climate-friendly individual consumption preferences are also their responsibilities in combating climate change. Buying used goods, recycling, favoring local products, being frugal with one's money, and favoring climate-friendly products are examples of these. Four pre-service teachers, on the other hand, identified reducing deodorant use as their individual responsibility in combating climate change.

> "Because climate change has always been a concern on our agenda, I have always been someone who tries to be environmentally conscious and aware of his/her responsibilities. As someone who has made it a point to protect nature and living things, I believe that we all bear a significant amount of responsibility in preventing climate change. I've learned that even the smallest changes in our daily lives can make a big difference. I've become more aware of my daily responsibilities, such as reducing my use of fossil fuels like gasoline, taking public transportation, or riding my bike, turning off unnecessary lights, not buying more than we need, and reducing waste, and how important these small steps are for the planet we live on and future generations. From this perspective, I will continue my life by expanding on these responsibilities and assisting everyone around me to act with awareness" PST33 (post-test).

When the pre-test responses were analyzed, no one claimed responsibility for reducing the carbon footprint. In the post-test, nine pre-service teachers mentioned their actions and responsibilities in combating climate change by reducing their carbon footprint. They also stated that they support afforestation activities to reduce their carbon footprint.

> "Every one of us has a significant annual carbon footprint. You do not do it, I do not do it, and we're still dealing with climate issues. We are all in peril. Just because a species in nature is becoming extinct does not mean that we are safe. Every living thing is a part of the ecosystem, and if we want to survive, we must be mindful of our carbon footprint. Furthermore, as a future teacher, I believe it is my responsibility to raise awareness among my students" PST15 (post-test).

## CONCLUSIONS & DISCUSSION

This study investigated the impact of online argumentation training on pre-service science teachers' climate change awareness. Examining previous studies in the literature revealed a scarcity of research and educational content for developing pre-service teachers' awareness of the subject. As a result, the study's goal was to raise pre-service teachers' awareness of climate change through online argumentation activities.

According to the study's findings, students' content knowledge was significantly influenced by their online argumentation practices. Previous research has discovered that argumentation processes improve students' understanding of climate change (Lambert & Bleicher, 2017). The ability of students to conduct research and access a variety of resources, particularly in technology-supported learning environments. Indeed, the Web 2.0 tools used by pre-service teachers in this study enabled them to instantly organize and access climate change information. It is possible to conclude that emphasizing the importance of supporting students' claims with data in their argument construction processes resulted in a positive change in pre-service

teachers' subject content knowledge. However, the absence of a control group prevents us from concluding that the results are entirely due to the training content (Bernard, 2013).

Following the online argumentation activities, the pre-service teachers provided more justifications in the other sub-dimensions of climate change awareness. Research on socio-scientific issues emphasizes the importance of students evaluating issues from various perspectives in decision-making processes (Fang et al., 2019). However, research has shown that pre-service teachers frequently use only one perspective when making decisions (Cebesoy, 2021). In this regard, it is suggested that various techniques be used in the teaching of socio-scientific issues. Recent research has shown that online argumentation and discussion environments, as well as techniques like role playing incorporated into these environments, can assist pre-service teachers in making decisions on socio-scientific issues from multiple perspectives rather than a single perspective (Salih, 2020). The current study supports previous research findings by showing that, in addition to role-playing in online argumentation processes, different techniques increase number of justifications in decision-making processes by exposing students to a variety of perspectives.

The study's findings also revealed that practices of online argumentation on the consequences of climate change resulted in a greater awareness of its effects on the environment and biodiversity. However, a small number of pre-service teachers' perceptions of its direct effects on humans have shifted. Climate change, however, has been shown in studies to have a negative impact on human health (McMichael et al., 2006; Patz et al., 2005). Deaths in the elderly because of extreme weather events such as hot air dives (thermal stress), infectious diseases that rise because of epidemics caused by various environmental impacts, and nutritional disorders that can arise because of food problems are examples of these. Ongoing studies on socio-scientific issues should be reflected in the course content, according to the socio-scientific issue-based learning and teaching framework used in the preparation of the educational content. As we followed this framework and discussed ongoing studies in various contexts, several pre-service teachers became more concerned about the effects of climate change on human health.

The number of reasons for pre-service teachers to be aware of individual initiatives increased. Students' socio-scientific responsibilities and feelings of individual responsibility in socio-scientific issues are regarded as prerequisites for 21st century citizenship, and the incorporation of socio-scientific issues into teaching processes is recommended in this direction (Choi et al., 2011). In this regard, studies with pre-service teachers show that they are unable to reason consistently when involved in reasoning processes on various issues, including climate change, and that they do not see themselves as the primary factor in solving these problems in solving comprehensive socio-scientific issues (Lee et al., 2012). In a study of 201 pre-service science teachers in Türkiye, Ozturk (2019) discovered that pre-service teachers' awareness of socio-scientific issues was the lowest in the dimension of sense of responsibility in socio-scientific issues. According to the current study, online argumentation practices can improve pre-service teachers' awareness of their individual responsibilities regarding climate change.

When pre-service teachers' awareness of their own responsibilities in relation to the subject was examined to determine their tendencies toward preventing climate change, it was discovered that they provided the least justification in this question prior to implementation. It demonstrates how argumentation practices help pre-service teachers become more aware of their roles. One reason for this is the combination of moral reasoning and argumentation processes. Individuals exposed to various points of view during argumentation processes may increase their socio-scientific responsibilities toward the issue (Namdar and Oğuz Namdar, 2021). Furthermore, research shows that people who are concerned about climate change engage in more climate-friendly behaviors, have more domain knowledge, and are more concerned (Kuthe et al., 2019).

When pre-service teachers' awareness of industrial developments aimed at mitigating the effects of climate change is examined, it is discovered that they developed an awareness of the use of sanctions and penalties, waste control, and the use of locally sourced raw materials. Previous research on industrial initiatives' awareness has identified energy savings, the use of environmentally friendly materials, and system improvement (Dal et al., 2014; Halady & Rao, 2010). This study's pre-service teachers were also aware of the importance of using environmentally friendly materials and conserving energy. In contrast to the literature, pre-service teachers frequently developed arguments for reducing carbon emissions through waste control and the use of sanctions and penalties.

When the literature is examined, it is seen that argumentation skills are developed from dialogic argumentation environments to individual written argumentation in the form of better justification of their own positions and the production of counterarguments. and transferable (Kuhn & Crowell, 2011; Kuhn et al., 2008). Students, on the other hand, were able to translate their online argumentation skills to face-to-face argumentation skills (Iordanou, 2013). According to the findings of this study, pre-service teachers reflected their online argumentation processes in their individual written arguments.

## Implications

Given the small number of pre-service teachers involved in this study, it is possible that the findings should not be generalized, particularly the relationship between climate awareness and argumentation processes and skills, which should be investigated further and with a larger sample size. Furthermore, the literature has shown that awareness of industrial initiatives is associated with environmentally friendly behaviors (Dal et al., 2015). However, only written argumentation processes were examined within the scope of the study. Given the difficulties people have in transferring verbal argumentation processes to written argumentation processes (Reznitskaya et al., 2007), future research could focus on pre-service teachers' verbal argumentation skills.

Pre-service science teachers' awareness of their skills for teaching climate change is one factor influencing effective climate change teaching in classrooms (Oppermann et al., 2019). It is recommended that teachers become more aware of climate change to develop these skills (Dupigny-Giroux, 2010). However, when the literature was reviewed, few studies were discovered to improve pre-service science teachers' climate awareness, and it was concluded that technology-assisted learning is a way to achieve this goal (Jeong et al., 2021). This study found that online argumentation practices had a positive effect on pre-service

teachers' climate change awareness, and that participation in online argumentation processes was one of the factors that positively developed climate change awareness.

There were several limitations to the study. First, some pre-service teachers had little experience with argumentation. We only had a limited amount of time in this study to introduce argumentation. This may have made it difficult for them to actively participate in online argumentation processes. As a result, future research can investigate the impact of pre-service teachers' prior argumentation skills on their effective participation in online argumentation. Second, due to the subject's complexity, time for activities was limited. Further design could consider increasing time devoted to activities and spreading the implementation over a longer period. Third, it had limitations in terms of participants' technological knowledge and abilities to participate effectively in online argumentation practices. This variable should be considered in future studies when designing an implementation.

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