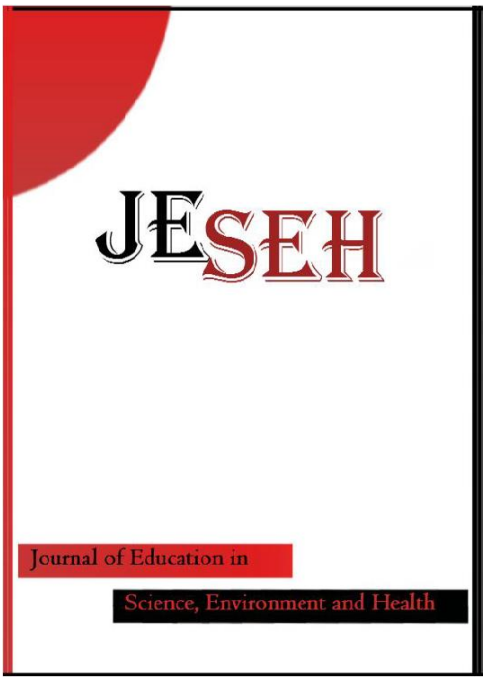

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Students' Belief Biases Concerning Climate Change and Factors Considered While Evaluating Informal Reasoning Arguments

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Abstract

This study determines whether 9th-grade students have belief biases about the cause of climate change. Furthermore, it determines the factors considered while evaluating the informal arguments about climate change. This study employs a case study, a qualitative research method. Participants included 137 9th-grade students (76 females, 61 males) from three different high schools located in the central district of the city of Aksaray, Turkey. Four types of arguments for climate change were considered: strong-believable, weak-believable, strong-unbelievable, and weak-unbelievable. Each argument contained two questions. One of the questions was related to the strength (strong, weak) of the argument, while the other was linked to the reason why students considered an argument to be weak or strong. The data were analyzed using descriptive statistics and content analysis. As a result, the findings showed that students evaluated various argument types in different ways. Students considered the strong-believable arguments to be the strongest. This was followed by weak-believable, strong-unbelievable, and weak-unbelievable arguments with diminishing strength. The students showed a weak tendency for the argument-based evaluation concerning the reasons for the strength and weak of arguments that included logical reasoning between premises and conclusions. Most of the students focused on the assertion-based evaluations that include the reality of premises and conclusion rather than the relationship between the premises and conclusions. This was followed by the arguments focusing on the relation between the conclusion and premise as well as alternative evaluations independent from the argument and those that considered the different aspects of the issue.

Introduction

In addition to simple decisions we make in our daily lives such as deciding which movie to watch, we have to make decisions about several socio-scientific issues. As individual, we are faced with several socio-scientific issues such as whether it is good to use mobile phones, to eat genetically modified foods, or to use embryonic stem cells in scientific research. Furthermore, we need to consider whether nuclear power stations should be installed or whether humans are having an effect on climate change. However, deciding on socio-scientific issues is difficult. This is because socio-scientific issues include open-ended, ill-structured, and debated problems, in addition to having numerous different viewpoints and multiple solutions (Sadler & Zeidler, 2005a). Moreover, socio- scientific issues often include ethical and moral values (Sadler & Zeidler, 2004).

Individuals undergo a reasoning process before making a decision on socio-scientific issues as well as on other issues. Reasoning is based on arguments, and it is the process of evaluating and constructing an argument (Shaw, 1996). Arguments are structures comprising premises and conclusions (Halpren, 1989; Cited in the study by Shaw, 1996), which should be supported by at least one reason (Angell, 1964; Cited in the study by Zohar and Nemed, 2002). For instance, imagine that you are watching a debate on television, in which two scientists are arguing about genetically modified organisms (GMOs). One scientist is claiming that GMOs are healthy, while the other is countering that they are unhealthy. Both scientists are presenting evidence in support of their claims. At the end of the debate, by considering the arguments of these scientists, the viewers reason to come to a decision whether GMOs are healthy. Their arguments comprise claims and evidences that support these claims.

Educators have proposed that numerous reasoning tasks in classes are informal in nature (Perkins, 1985). Informal reasoning is a type of thinking that especially emerges in socio-scientific issues (Means & Voss, 1996). It is highly effective in discussing socio-scientific issues and decision-making processes (Kuhn, 1993; Sadler,

2004). It differs from formal reasoning characterized by logic and mathematics. Formal reasoning includes well-defined problems with explicit and clear premises, whereas the problems in informal reasoning are not well-defined (Wu & Tsai, 2007). In general, informal reasoning involves the evaluation of complex problems that do not involve definitive solutions (Sadler, 2004). The process of formal reasoning often involves deductive reasoning, whereas the process of informal reasoning often involves inductive reasoning (Zohar & Nemed, 2002). In the process of formal reasoning, the premises supports the conclusion; in informal reasoning, the cause may or may not support the conclusion (Evans, 2002). Informal arguments are often used in situations for or against the conclusion (Shaw, 1996). These involve cognitive and emotional processes (Dawson & Venville, 2009; Sadler & Zeidler, 2005a; Topçu, Sadler &Yılmaz-Tüzün, 2010). Furthermore, informal reasoning is affected by social and ethical considerations as well as technological concerns (Topçu, Yılmaz-Tüzün & Sadler, 2011). It involves belief bias (Tompson & Evans, 2012).

Belief Bias

Reasoning independently of beliefs is a fundamental characteristic of critical thinking and scientific understanding. However, in some situations, beliefs may inhibit individuals' reasoning abilities (Stanovich & West, 1997; McCrudden, Barnes, McTigue, Welch & Macdonald, 2017). When people read ideas consistent with their beliefs, they often produce ideas that support or approve what they read. On the contrary, when they read the ideas that inconsistent with their beliefs, they tend to produce thoughts that refute or disapprove (Kardash & Howell, 2000; Sinatra & Broughton, 2011; Tompson & Evans, 2012). This situation leads to a cognitive bias, which is known as belief bias. Belief bias emerges when individuals accept more belief-consistent information than belief-inconsistent information (Stanovich & West, 1997). Individuals differently evaluate belief-consistent and belief-inconsistent arguments. Unfortunately, individuals more objectively evaluate the relation between premises and conclusion in belief-inconsistent arguments. In contrast, people respond more intuitively by refraining from focusing on the relation between premises and conclusion in belief-consistent arguments. Accordingly, belief-consistent arguments require less effort, whereas belief-inconsistent arguments require more effort (Baron, 1995; Tompson & Evans, 2012; Maier & Richter, 2013; McCrudden, Barnes, 2016). Individuals' belief biases have been noted in many controversial issues (Baron, 1995; Čavojová, 2015; Klaczynski, 2000; Klaczynski & Aneja, 2002; Maier & Richter, 2013; Plous, 1991, Wiley, 2005; Thompson & Evans, 2012; Toplak & Stanovich, 2003).

Climate change is one of the controversial issues, and prior studies have determined that individuals had belief biases in informal reasoning related to this issue. For instance, McCrudden and Barnes (2016) presented high school students with various arguments to reveal whether they had belief biases about climate change. Arguments were structured as "for the influence of humans on climate change" (belief-consistent) or "against the influence of humans on climate change" (belief-inconsistent). They found that high school students preferred belief-consistent arguments more than belief-inconsistent ones. Similarly, in their studies on climate change, Maier and Richter (2013) demonstrated that college students were prone to belief-consistent texts. They revealed that students had the opinion that the current acceleration in climate change resulted from human-made causes rather than natural causes. In the literature, prior studies revealed that belief biases exist not only in evaluation but also in the comprehension of controversial issues. For instance, Plous (1991) determined that after nuclear accidents, opponents of nuclear power drew different conclusions from proponents of nuclear power. In that study, the participants read many examples of nuclear accidents. After reading about the accidents, the proponents indicated that the likelihood of nuclear accidents was less than that expected. In contrast, the opponents indicated that the likelihood of nuclear accidents was greater than that expected. Similarly, Wiley (2005) determined that students remembered more belief-consistent arguments than belief-inconsistent arguments in controversial issues (e.g., whether abortion should be legal in the U.S.). Corner, Whitmarsh and Xenias (2012) provided strong evidence that college students internalized new and controversial information regarding climate change in a biased manner. The limited number of existing studies aimed at identifying students' belief biases about climate change underlies the importance of this study.

The literature review revealed that most of the studies on informal reasoning on socio-scientific issues focused on the styles of reasoning (Dawson & Venville, 2009; Sadler, Zeidler, 2005a; Wu & Tsai, 2007) and identification of argumentation qualities (Dawson & Venville, 2009; Demircioğlu & Uçar, 2014; Sadler & Zeidler, 2005b; Topcu, Sadler & Yilmaz- Tuzun,2010; Wu, & Tsai, 2007). The proposed study has key importance given that very few studies explored how individuals evaluated the quality of given arguments and the factors they take into consideration (Shaw, 1996; Topcu, Yilmaz-Tüzün & Sadler 2011). This study determines whether students have belief biases in their informal reasoning about climate change. In addition, it determines the factors that students consider while evaluating the informal arguments about climate change.

Method

Design

The qualitative research method was used in this study. Data were obtained using a case study, one of the qualitative research designs. The case study examines the researched phenomenon within its own framework of life. In the case study, the boundaries between the phenomenon and its environment are not clear. Used when multiple evidence or data sources are available (Yin,2009). The case study method was employed given that students' climate change phenomenon was addressed in the framework of their daily lives without any external educational interventions. The climate change phenomenon was broadly analyzed by considering a single analysis unit (one school), and therefore, a holistic single case study design was used (Yin,2009).

Participants

Participants included 137 9^{th}-grade high school students (76 females, 61 males) studying in three different high schools in the city of Aksaray, Turkey. Their mean age was 15.4. In Turkey, elementary school includes 1^{st}–4^{th} graders, middle school includes 5^{th}–8^{th} graders, and high school includes 9^{th}–12^{th} graders. The students who participated in the study were taught the subjects concerning climate, weather and climate change in the 8th-grade. Therefore, they had prior knowledge of these subjects. Their comprehensive knowledge of these concepts is important in terms of presenting the informal reasoning skill in the study.

Materials

Argument Evaluation Task

It includes four reason-based arguments concerning the source of climate change. As presented in table 1, the arguments were created using four imaginary characters were adopted from the study by McCrudden and Barnes (2016). An emphasis was put on choosing the names of the imaginary characters among basic and frequently used Turkish names.

Table 1. Strong and weak arguments about the source of climate change

	Believable	Unbelievable
Strong	Ahmet wonders whether the Earth's climate has changed with the industrial revolution. In his research, he determined that global warming has increased over the 150-year time span after the start of the Industrial Revolution. He indicated that large amounts of carbon dioxide were added to the Earth's atmosphere, which prevented heat from escaping, causing this change. Therefore, he decided that humans are affecting the climate.	Kerim wondered whether the Earth's climate has changed with the industrial revolution. In his research, he realized that global temperatures have changed over the 150-year time span before the start of the Industrial Revolution. He determined that the small variations in the Earth's orbit, which can change the amount of solar energy that the Earth receives caused these changes. Therefore, he decided that humans <u>are not</u> affecting the climate.
Weak	Esra wanted to learn whether humans are affecting the climate. In her research, she considered that temperatures are increasing from year to year. For instance, in Turkey, the average temperature in May 2016 was higher than the average temperature in May 2015. Therefore, she decided that humans are affecting the climate.	Derya wanted to learn whether humans are affecting the climate. In her research, she considered that the averages of temperature from year to year are not increasing. For instance, in Nevşehir, Turkey, the average temperatures in the recent year were the same. Therefore, she decided that humans <u>are not</u> affecting the climate.

Arguments comprise premises and conclusions. For instance, information such as global warming increased over the 150-year time span after the begining of the Industrial Revolution and large amounts of carbon dioxide which prevent escaping of heat released to the Earth's atmosphere, that causes global warming are premises of the argument. Considering these premises, the argument's conclusion is that "humans are affecting the climate." Arguments were created by considering the argument type (belief-consistent and belief-inconsistent) and the argument strength (strong and weak). Belief-consistent arguments coincide with the current scientific knowledge, which indicates that climate change is caused by human beings. In contrast, belief-inconsistent

arguments indicate that humans are not affecting climate change; therefore, these arguments do not coincide with the current scientific knowledge. Both belief-consistent and belief-inconsistent arguments were supported by strong or weak evidences. The arguments in which the conclusion was supported by the premises were defined as "strong," and the arguments in which the conclusion was not supported by the premises were defined as "weak." In the arguments, the time factor was considered as an evidence. In the strong arguments, the 150-year time span, sufficient to observe climate change, was given; in the weak arguments, the 1-year time span, not sufficient to observe climate change, was given. In the argument evaluation task (AET), two questions are related to each argument. The first question is related to the strength of the argument, and the second question is related to why they believe the argument is weak or strong. In the first question, there are "strong" and "weak" options about the argument's strength. The students respond to the question about the strength of the argument by choosing one of these two options. The second question seeks to explain the reason why they have chosen the option in the first question about the argument's strength.

Procedure

In the study, the 9th-grade students were asked to respond in the AET. This task included arguments about four imaginary characters and questions about these arguments. The AET began with an explanation about the difference between climate and weather. This explanation was as follows: "Climate and weather are two different concepts. Weather is used to explain the atmosphere's condition in a specific location for a shorter period of time. However, climate is the average weather pattern that does not change for many years. While the weather involves a period of time such as days, months or couple of years, climate involves a longer period of time such as several decades or even hundreds of years." Thereafter, the participants were asked to read the argument scenarios of four imaginary characters and answer the following questions. In the first question, the participants were asked to decide whether the argument was weak or strong. In the second question, they were asked to note the reasons for their decision about an argument's strength (strong/weak).

Analysis

Descriptive statistics were used to analyze the strength of the arguments, and content analysis was used to analyze the reason why arguments were rated as strong or weak by the students. The students' informal arguments about climate change were evaluated under three themes in the context of content analysis. The first was assertion-based evaluation that considered whether the premise or the conclusion was correct. For instance, about the reason for choosing the argument as weak or strong, one student may indicate that she or he approves or disapproves that humans are changing the climate. Similarly, it is applicable for the premises. The second was argument-based evaluation that indicated whether the conclusion was supported by the premises. For instance, one student may explain that the 150-year-time span is sufficient to infer whether humans are affecting the climate. The third was the alternative-based evaluation in which different aspects of the benefit and truth of the conclusion, which were not given in the argument, were indicated. For instance, students may indicate that climate change might depend not only on the industry but also on other reasons. Four codes about the assertion-based evaluations were determined (truth of the premises, unrealistic evidences, truth of the conclusion, and unrealistic conclusion). For the argument-based evaluation, one code (the relation between the evidence and conclusion) was determined. Similarly, for the alternative-based evaluation, one code (several factors influencing the conclusion) was determined. In the study, inter-rater reliability was used. To this end, the students' responses were analyzed using two content analyzers. The reliability score was calculated using the formula Agreement/(Agreement + Disagreement) × 100, which was suggested by Miles and Huberman (1994). The reliability score between the raters was determined as 0.86. Miles and Huberman (1994) indicated that the inter-rater scores of 80% and above are reliable. Incompatible codes were included in the study after consensus among the raters.

Findings

In this study, first, students' prior beliefs regarding whether the source of climate change is human agency were determined. Furthermore, 121 students (88,3%) had prior beliefs that the source of climate change is human, and 16 students (11,7%) had prior beliefs that the source of climate change is not human. Thereafter, students were required to determine the strength of the arguments they read. Table 2 presents the descriptive analysis results for the strength of the argument. As presented in table 2, most students agreed that strong-believable arguments were strong. This was followed by weak-believable, strong-unbelievable, and weak-unbelievable arguments.

Students accepted believable arguments more than unbelievable ones and strong arguments more than weak ones.

Table 2: Descriptive statistics on the strength of arguments

Arguments	Argument's strength	f (%)
Strong-believable argument	Strong	122 (89,1%)
	Weak	15 (10,9%)
	Total	137 (100%)
Strong-unbelievable argument	Strong	64 (46,7%)
	Weak	73 (53,3%)
	Total	137 (100%)
Weak-believable argument	Strong	78 (56,9%)
	Weak	59 (43,1%)
	Total	137 (100%)
Weak-unbelievable argument	Strong	22 (16,1%)
	Weak	115 (83,9%)
	Total	137 (100%)

Table 3. Descriptive statistics on the evaluation of arguments

	Assertion-based evaluation	Argument-based evaluation	Alternative-based evaluation	
	f(%)	f(%)	f(%)	Total
Strong-believable argument	118 (86,1%)	12 (8,8%)	7(5,1%)	137
Strong-unbelievable argument	123 (89,8%)	11 (8%)	3(2,2%)	137
Weak-believable argument	116 (84,7%)	18 (13,1%)	3(2,2%)	137
Weak-unbelievable argument	91 (66,4%)	39 (28,5%)	7 (5.1%)	137

Table 4. Reasons for the strength of the strong-believable argument

Strong-believable argument		f(%)	Student opinions
Assertion-based evaluation	Truth of premises	93 (67,9%)	S1:In Ahmet's view, humans are affecting the climate. This is because each year, negative aspects of industry sector are damaging our Earth in this way. S54: People are developing the technology with the impact of industrial revolution with each passing day; as a result of these developments, they are producing more industrial enterprises and vehicles. Therefore, CO2 emission is increasing.
	Non-realistic premises	4 (2,9%)	S12:Because he could find more reasons to decide. S20: He has not done enough research and has not reached a sufficiently strong source
	Truth of conclusion	18 (13,1%)	S3:This is because as humans are affecting the nature, climate changes occur. S9: This is because humans usually damage the atmosphere, and this causes climate change. S83:Only humans can disrupt the climate, even humans cannot restore the climate they have broken
	Non-realistic conclusion	3 (2,2%)	S7: Climate change is not caused by human beings. S23: Climate is not changeable; therefore, humans cannot affect it.
Assertion-based evaluation	Relationship between the evidence and the conclusion	12 (8,8%)	S98: This is because Ahmet made a research over the 150-year time span after the start of the Industrial Revolution, and in this time span, it becomes clear whether the Earth's climate has changed due to the Industrial Revolution. Therefore, Ahmet's conclusion is a strong conclusion. S104: Strong because he made a research about the subject and obtained information. As his research included the 150-year time span, he has reached the true information.
Alternative-based evaluation	Certain factors affecting the conclusion	7 (5,1%)	S47: This is because non-human organisms also harm the climate. S129: The Earth's climate cannot depend only on industry; therefore, this conclusion cannot be inferred by considering only one reason.

Table 3 indicates that while evaluating the arguments, students considered assertion-based arguments. Assertion-based evaluations were followed by argument-based and alternative-based evaluations. Argument-based evaluations that involved the relation between evidence and assertion were indicated by more students in weak arguments than in strong arguments.

As seen in table 4, while evaluating the strength of the argument in strong-believable arguments, most students made assertion-based evaluations based on the truth of the premises or the conclusion. Many students who made assertion-based evaluations focused on the evidence of the argument. The students indicated that they agreed with the evidence about the Industrial Revolution, and they decided that the argument was strong because these pieces of evidences were consistent with their thoughts. Some students focused on the conclusion of the argument and used expressions about the fact that the conclusion concerning human influence on climate was real. Few students focused on the relation between the evidence and conclusion and the other factors that affect the conclusion.

Table 5: Reasons for the strength of the strong-unbelievable argument

Strong-unbelievable argument		f (%)	Student opinions
Assertion-based evaluation	Truth of premises	44 (32,1%)	S651: In the world, an ice age occurred centuries ago and a great climate change occurred. S89: He is saying that there is the global warming due to small variations in the Earth's orbit. S109: I think it is a strong conclusion. Little variations in the Earth's orbit largely affect the climate; as humans, this is not in our hands.
	Non-realistic premises	39 (28,5%)	S58: I think the small variations in the orbit should be clearly explained; if they can change the climate, they are not small. S93: This is because factors other than humans may also cause climate change, but humans are also a great reason. S96: Humans play an important role in variations in the Earth's orbit. S99: It is a strong conclusion, but, in that period of time, the environmental damages caused by humans may again affect the climate.
	Truth of the conclusion	9 (6,6%)	S20: He arrived at the true conclusion. The effect of humans on the climate cannot be seen. Conditions in that period of time may not be the same in this period of time. S63: It is a strong conclusion because there was not so much mechanization and industrialization before the industrial revolution; they were not affected.
	Non-realistic conclusion	31 (22,6%)	S36: I think humans affect it. S97: The conclusion Kerim reached is a weak conclusion because humans affect the climate.
Argument-based evaluation	Inference between evidence and conclusion	11 (8%)	S18: It is a strong conclusion. By considering the 150 years after the Industrial Revolution, Ahmet concluded that humans are affecting the climate. Besides, Kerim concluded that the climate has changed 150 years before the Industrial Revolution. S108: Kerim conducted a long-term research and made an effort; therefore, it is a strong conclusion.
Alternative-based evaluation	Certain factors affecting the conclusion	3 (2,2%)	S129: This is because the only reason for the fact that it changed before the industrial revolution may not be these small variations.

As seen in table 5, while evaluating the strength of the strong-unbelievable arguments, assertion-based evaluations were mostly indicated by the students. In contrast with strong-believable arguments, the students' tendency to find conclusions as realistic decreased in weak-unbelievable arguments. Simultaneously, the number of those who did not find the conclusion as realistic increased. Students mostly indicated that changes other than human agency might affect the climate, but humans had a huge effect on climate change. Only 8 % of

the students could explain the relation between evidence and conclusions. Some students made alternative evaluations by saying that different factors other than the Earth's orbit might also affect the climate.

Table 6. Reasons for the strength of the weak-believable argument

Weak-believable argument		f (%)	Student opinions
Assertion-based argument	Truth of premises	33 (24,1%)	S5: This is because it proves that temperatures increase annually. S29: This is because seeing that the temperature increases year after year, I believe that humans are affecting the climate change. S77: Cosmetic products and the technology used by humans are polluting the nature, and the ozone layer depletes; thus, average temperatures increase year by year.
	Non-realistic premises	32 (23,3%)	S79: This is because there is no explanation for the reason why the temperature was higher in 2016 than that in 2015. It should not be said that 'it affects' without explanation. S95: Weak because it is not sufficient to evaluate only the temperature; thus, more data is needed. S123: Weak because of not doing enough research.
	Truth of the conclusion	49 (35,8%)	S114: I think it is a strong conclusion; humans may affect the climate because it should not be forgotten that everything affects and is affected by everything in the world; it is the law of nature. S122: Climate change emerges as long as humans are using things such as deodorants and perfumes, and this fact shows that humans are changing the climate. S130: This is because it is clearly stated that the factor that increases the temperature is human agency.
	Non-realistic conclusion	2 (1,5%)	S20: The reached conclusion might be possible, but it is a weak conclusion. The effect of each person may be seen even a little, but I think daily and yearly movements of the Earth lead more to this conclusion, so I think it is not related with humans. S119: Humans cannot affect the temperature.
Argument-based evaluation	Inference between evidence and the conclusion	18 (13,1%)	S35: I think a longer period of time can be considered. S55: It is clear that humans are affecting the climate; average annual temperatures may vary; the important thing is whether the average temperatures decrease compared with that in previous years. S77: According to this information, humans affect the weather. Information is insufficient.
Alternative-based evaluations	Certain factors affecting the conclusion	3 (2,2%)	S70: It is a strong conclusion because we are building huge buildings and skyscrapers, and this causes that the sun cannot reach to the ground. S117:I think it is weak because I think it is caused by the differences in the Earth's movements.

As seen in table 6, while evaluating the argument in which the relation between the premise and the conclusion was weak and the conclusion was believable, the students mostly made assertion-based evaluations. In their assertion-based evaluations, most students focused on the truth of the conclusion that "humans are affecting the climate." Contrary to the case of the strong arguments, more students focused on the relation between the premise and the conclusion. Not much difference was observed in the number of students who made alternative-based evaluations.

In the weak-unbelievable argument, the students mostly indicated that the argument was weak. As seen in table 7, most students made assertion-based evaluations. Most students who made assertion-based evaluations (about 34%) attributed the reason of argument's weakness to the non-realistic premises. In addition, some students frequently mentioned that they did not agree with the conclusion that "humans are not affecting the climate." The weak-unbelievable argument was the argument in which the relation between the premise and the conclusion was the most evaluated argument among all arguments. The number of students who made alternative-based evaluations is as much as that stated in other arguments.

Table 7: Reasons for the strength of the weak-unbelievable argument

Weak-unbelievable argument		f (%)	Student opinions
Assertion-based evaluation	Truth of premises	11 (8%)	S1: Each year, temperature variations occur due to the Earth's orbit. S19: It is a strong conclusion because she has found that the annual temperature has not changed but remained the same. S30: Climatic conditions and factors affecting climate has remained the same.
	Non-realistic premises	46 (33,6%)	S11: The fact that the annual temperature is the same cannot explain whether humans negatively affect the climate; it may be that it occurs because they both affect in the same degree. S14: Derya should not remain limited to Nevşehir and Aksaray. She should look at other cities. In the nature, many usable materials are destroyed by humans, and this is negatively affecting the climate. Because there is not much industrialization in Nevşehir and Aksaray, there is no temperature change, but she should have investigated other cities as well. S110: Research done in a restricted area does not reflect the truth
	Truth of the conclusion	9 (6,6%)	S3: I also agree that is true; humans do not have any effect on it. S17: It is difficult for humans to do actions that affect the climate.. S20: The research is correct. Because humans have no effect on climate. Climate has an impact on humans. Even the climate is one of the immigration causes of humans
	Non-realistic conclusion	25 (18,2%)	S75: This is because the things that humans do affect the climate; the explanation is not sufficient. S111: This is not a reason why humans do not affect the climate. I think humans absolutely influence the climate.
Argument-based evaluation	Inference between evidence and conclusion	39 (28,5%)	S81: This is because in Derya's example, there are outcomes of one year; this is weather, and climate cannot change in such little time; it is a weak conclusion. S82: Climate is the average temperature in a wide region that does not change for long years. As Derya did, it cannot be decided by looking at two to three regions and with the average temperature of the one last year.
Alternative-based evaluation	Certain factors affecting the conclusion	7 (5,1%)	S54: It makes no sense to evaluate human's effect on the climate and make decisions accordingly without knowing conditions and industries in the region. S136: Because the construction of these 2 cities may affect the climate (factory, etc.). So their climates can be the same.

Discussion

The main conclusions of the study indicated that students evaluated various argument types in different ways. In terms of the reason for climate change, the students agreed that believable arguments were stronger than unbelievable arguments and that strong arguments were stronger than weak arguments. In particular, the strong-believable argument was found to be strong by most students. This was followed by the weak-believable, strong-unbelievable, and weak-unbelievable arguments in order of diminishing strength.

Similar studies conducted on climate change showed that students evaluated belief-consistent information more positively than belief-inconsistent information (Corner et al., 2012; Maier & Richter, 2013; McCrudden & Barnes, 2016, McCrudden & McTigue, 2019). This implies that belief bias may influence evaluation of informal arguments. The fact that the premises or the conclusions in argument were consistent with students' prior beliefs indicates that the arguments will be more accepted as strong ones.

Most students correctly determined the strength of the arguments. However, in terms of why the arguments were strong or weak, the students showed a weak tendency to the argument-based evaluation, which involves logical reasoning between the evidence and the conclusions. Most students focused on assertion-based evaluations, which involve the truth of premises or the conclusion, rather than focusing on the relation between the premises

and the conclusion. Assertion-based evaluation is followed by argument-based evaluations and alternative-based evaluations. Shaw (1996) determined that while evaluating the informal arguments, individuals make more objections to the truth of the conclusion rather than to the relation between the premise and the conclusion.

The argument-based evaluations were indicated in weak arguments compared with those in strong arguments by more students. Especially in weak-unbelievable arguments, the tendency to focus on logical relationships becomes prominent. Studies indicated that individuals approach more objectively to the arguments inconsistent with their prior beliefs, and they focus more on the logical relation between the evidence and the conclusion (Beatty & Thompson, 2012; Thompson & Evans, 2012). In strong arguments, there is no logical basis for rejecting the conclusion, whereas there are logical responses that prevent individuals' emotional reactions in weak arguments (McCrudden et al, 2017). Reasoning may weaken when individuals evaluate the information by considering whether it is consistent with their prior beliefs rather than its qualification (McCrudden & Barnes, 2016). The existing literature showed that there is a need for a more detailed approach beyond teaching the "fundamental components' of a scientific discussion or a scientific method. In general terms, presenting the argumentation language and particularly certain argumentation schemes may help students to improve their reasoning skills (Nussbaum, Sinatra, & Owens, 2012).

The other result of this study is that while evaluating the informal arguments, students considered assertion-based, argument-based, and alternative-based arguments in order. In the strong-believable argument, most students focused on the truth of the arguments' premises. The students who believed that humans affects the climate have based the strength of the argument on strength of the premises by considering the strong evidence in their evaluations. Some students focused on the argument's conclusion. Although they stated that the conclusion that humans are affecting the climate change was true, they could not provide a logical basis about why they agreed with the truth of the conclusion. The students who believed that humans are affecting the climate may agree with the premises and conclusions consistent with their prior beliefs. The premises and conclusions that coincide with prior beliefs may support the agreement that the argument is strong and may explain why the arguments were agreed as strong. Strong evidence may provide strong agreement without providing a logical basis.

In cases when the argument's conclusion conflicts with individuals' prior beliefs, the premise-conclusion relation may not always provide strong agreements, even if they are strong. In the strong-unbelievable argument, the tendency of believing the truth of the conclusions or premises decreased for the students who encountered with the conclusions that conflicted with their prior beliefs. The students who encountered with the conclusions that conflicted with their prior beliefs excluded strong evidence without searching for a logical basis.

In the weak-believable argument in which weak premises were presented, the students' tendency to believe the truth of the conclusion increased. The students who believed that humans affect the climate accepted the conclusion that was consistent with their prior beliefs without providing a logical reason. Weak evidences may cause the students to focus on the conclusion while evaluating the argument. In their evaluations, the students considered weak evidences that were consistent with their prior beliefs. Believability of an argument's conclusion may cause the students to evaluate the weak evidences that positively support their opinions as true.

In the weak-unbelievable argument, the students objected to the premises and the conclusions. The weak evidence and unbelievable conclusions may cause the argument to be evaluated as weak. With regard to all arguments, few students indicated the fact that climate change may be related to different factors other than human agency. The lack of sufficient knowledge concerning the causes of climate change can be cited as the reason for indicating a smaller number of alternative arguments. Consequently, it was determined that the students had belief biases about the reasons for climate change. Besides, it was found that in terms of the reasons for climate change, the students made assertion-based, argument-based, and alternative-based evaluations in order.

For future studies, the following suggestions can be made: in some prior studies, it was determined that the belief bias may significantly decline with education (Baron, 1995; Toplak & Stanovich, 2003). In this context, experimental studies showing the effect of in-class and extracurricular practices on belief biases may be conducted. McCrudden et al. (2017) indicated that perspective-taking is a potential way of decreasing the belief bias. By constructing arguments with different viewpoints, their effect on the belief bias may be tested. Furthermore, similar studies in many socio-scientific issues (global warming, GMOs, ecological footprint, environmental issues, energy sources, etc.) may be conducted on a large scale. Thus, whether belief bias varies across various socio-scientific issues may be investigated. Furthermore, argument examples that were used in

this study may be extended and made available for science teachers. Thus, students' argumentation abilities development can be supported.

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