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Prediction of students' argumentation skills about controversial topics by epistemological understanding

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Abstract

This study focuses on the contribution of overall epistemological understanding to argumentation skills, after controlling for topic knowledge and interest, in eighth graders. Students were introduced to two controversial topics, global warming and genetically modified food, through the reading of a two-sided text on each topic. After reading, students were asked to generate an argument, a counterargument, and a rebuttal for each topic. Findings from hierarchical regression analyses show that epistemological understanding was a significant predictor of all three components of argumentation skills for both controversies. In addition, participants at the evaluativist level of overall epistemological understanding generated arguments, counterarguments, and rebuttals of a higher quality than participants at the multiplist level. Findings were substantially replicated by a domain-specific analysis of epistemological understanding. Topic knowledge moderately, but significantly, contributed to the production of rebuttals about transgenic food only, while topic interest did not play a significant role.

1. Introduction

An issue of increasing interest from both theoretical and educational perspectives is the relevance of argumentation skills in and out of school. Argumentation skills involve reasoning about the advantages and disadvantages, pros and cons, causes and consequences, of alternative perspectives. As such, they are crucial for participation in a democratic society.

In school subjects, such as the social sciences and humanities, students often encounter issues and positions that need to be developed, defended or evaluated (Means & Voss, 1996). Practice in argumentation has recently been considered a central need for science education as well (e.g. Driver, Asoko, Leach, Mortimer, & Scott, 1994; Duschl & Osborne, 2002; Kuhn, 1993; Sandoval & Millwood, 2005; Zohar & Nemet, 2002), at least to the extent that science is conceived as a historical, cultural, and social practice (e.g. Latour & Woolgar, 1979). In this regard, Duschl and Osborne (2002) posited that scientific understanding requires understanding argument.

In their everyday lives out of school, students also deal with debatable issues which are inherent in the popular messages of science they often encounter. They are asked to be able to interpret them critically, especially in order

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to make informed decisions. To do this, they must recognize whether arguments are supported by evidence, the quality and quantity of that evidence, as well as the pragmatic meaning of messages, or their intention (Norris & Phillips, 1994). The study reported below was aimed at examining factors which affect students' argumentation skills, specifically epistemological understanding in relation to topic knowledge and interest.

Argumentation has been studied from different perspectives outside psychology, such as the logico-philosophical (Toulmin, 1958), new rhetorical (Perelman & Olbrechts-Tyteca, 1969), pragma-dialectical (van Eemeren & Grottendorst, 1992) perspectives. It is not within the scope of this article to review them but rather to refer to argumentation in educational psychology research, which considers the relevance of argumentation skills to classroom learning as well as the possible enhancement of these skills via instruction. Students' argumentation skills are examined through the factor of epistemological understanding, and we refer to the psychology of views about knowledge and the knowing process (Hofer & Pintrich, 1997, 2002). The issues regarding argumentation skills and epistemological understanding we are concerned with will be introduced in the next two sections.

2. Argumentation skills

Arguing about different positions is an essential part of informal reasoning, that is, reasoning applied outside the formal contexts of symbolic logic and mathematics. Informal reasoning is a goal-dependent process that implies argument generation and evaluation. An argument is a conclusion sustained by at least one reason (Angell, 1964). Informal reasoning assumes importance when the problems are complex, controversial or ill-structured with no definite solution (Halpern, 1989; Kuhn, 1991; Means & Voss, 1996; Perkins, Faraday, & Bushey, 1991; Voss, Perkins, & Segal, 1991; Walton, 1989). It is activated, for example, when an individual considers evidence related to an issue in order to arrive at a conclusion and make a decision or provide reasons for maintaining a particular claim.

The search for reasons related to both sides of an issue has been recognized as crucial in good informal reasoning (Baron, 1991; Kuhn, 1991; Means & Voss, 1996). Arguments can be elaborated in a number of ways and at different levels. Unlike categorical syllogisms in formal logic, the content of informal arguments is important for their evaluation. They are indeed evaluated in terms of their soundness, which refers to two criteria: the acceptability of the supporting evidence per se and its relevance in terms of the extent to which it supports the conclusion (Fisher, 1988; Means & Voss, 1996).

An empirical study has revealed that the need for cognition and assertiveness predicts a disposition to engage in argument, while a desire to maintain warm relationships as well as assertiveness predicts argument avoidance. Further, epistemological beliefs significantly predict argumentativeness, but not in the expected manner, since they are related more to the disposition to avoid argument (Nussbaum & Bendixen, 2003). It has also been found that individuals differ in their preparedness to learn from argumentation (Duschl & Osborne, 2002).

As far as argumentation skills in individuals of different ages are concerned, there is evidence that even young children have some competence in generating arguments to support claims (e.g. Anderson, Chinn, Chang, Waggoner, & Yi, 1997; Orsolini, 1993; Stein & Miller, 1993) and in understanding the structure of an argument (Chambliss & Murphy, 2002).

On the other hand, research has documented that argumentation skills are not highly developed in young people and adults, who may have difficulty producing relevant evidence to support their positions, counterarguments, and rebuttals (Kuhn, 1991) or be guided by belief bias when evaluating arguments (Klaczynski, 2000). The ''my-side bias'' has been found to affect college students' production and evaluation of arguments (Baron, 1995). Most of them evaluated arguments that were one-sided as better, even when the side was opposed to theirs. Students who were in favor of one-sidedness also tended to produce one-sided arguments. Moreover, it has been documented that even when high school students pay attention to the need to cite data as warrants of their explanatory claims, they often fail to provide sufficient explicit evidence for them (Sandoval & Millwood, 2005). However, awareness of general argumentation norms facilitates the identification of reasoning fallacies in middle and high school students (Weinstock, Neuman, & Tabak, 2004).

Perkins (1985) and Means and Voss (1996) also found that argumentation skills did not increase with school grade, suggesting that schooling does not significantly affect the development of this aspect of informal reasoning. Science education researchers have indeed documented that science teachers do not give students opportunities to refine their argumentation skills, since they dominate classroom discourse leaving very little room for whole-class discussions and students' engagement in the construction of arguments (Newton, Driver, & Osborne, 1999).

Yet, there are a number of studies that show that engagement in constructing arguments enhances knowledge in college students (Wiley & Voss, 1999). Engagement in argumentative small- or large-group discussions has also been found to improve conceptual understanding (Alexopoulou & Driver, 1996; Duschl, Ellenbogen, & Erduran, 1999; Mason, 1996, 2001; Zohar & Nemet, 2002) and reasoning (Chinn & Anderson, 1998) in school-age students.

Argumentation as a central aspect to scientific practice has also been proved to promote conceptual change in university students (Nussbaum & Sinatra, 2003). Argumentation and collaborative debate are the core of the SCOPE (Science Controversies Online: Partnerships and Education) project that aims at facilitating students in learning science concepts, and also in understanding the nature of scientific inquiry by dealing with current scientific controversies (Bell & Linn, 2000). It has also been documented that arguments can enhance students' epistemic motivation and engagement (Hatano & Inagaki, 2003), and help them detect and resolve errors (Schwartz, Neuman, & Biezuner, 2000). In addition, two recent studies, one developmental and the other educational, have documented the effectiveness of interventions implemented at school to develop argumentation skills. The former was successful with American academically at-risk 13–14 year olds who participated in a number of sessions to exercise argumentative thinking (Kuhn & Udell, 2003). They showed an increased usage of powerful argumentative discourse strategies, such as counterarguments, and a decreased usage of less effective ones, as well as an improvement in the quality of their arguments. The latter was effective in fostering Israeli ninth graders' argumentation and biological knowledge skills through dilemmas regarding human genetics (Zohar & Nemet, 2002). Furthermore, it has been indicated that argument quality in college students may be enhanced through scaffolding (Nussbaum, Hartley, Sinatra, Reynolds, & Bendixen, 2004; Nussbaum, Kardash, & Graham, 2005).

3. Epistemological understanding

According to the model of cognitive development proposed by Kuhn (1999, 2000), epistemological understanding is the third level of meta-knowing, following cognitive (to know what) and strategic (to know how). It concerns a wider understanding of what knowledge and knowing are, in general (''How does one come to know?'') and personally (''What do I know of what I know?''). The developmental sequence of epistemological understanding encompasses the stages from childhood to adolescence to early adulthood, when individuals move from an absolutist to a multiplist to an evaluative view of knowledge and knowing, although at different individual rates. At the absolutist level, individuals believe that knowledge is absolute, certain, non-problematic, right and wrong, and does not need to be justified since observations of reality or authorities are its sources. At the multiplist level, individuals believe that knowledge is ambiguous, idiosyncratic, and each individual has his or her own views and truths. At the evaluativist level, individuals have an epistemology grounded on the belief that there are shared norms of inquiry and knowing. Thus, some positions are reasonably more justified and sustainable than others. This sequence of development is characterized by a progressive integration and coordination of the objective and subjective dimensions of knowing. Only at the evaluativist level are these dimensions balanced, without one dominating the other (Kuhn & Weinstock, 2002).

A number of studies have shown that beliefs about knowledge and knowing are associated with performances in reading comprehension (Schommer, Crouse, & Rhodes, 1992), metacomprehension (Ryan, 1984; Schommer, 1990; Schommer et al., 1992), transfer of learning (Jacobson & Spiro, 1995), and conceptual change (Mason, 2002, 2003; Qian & Alvermann, 1995; Southerland & Sinatra, 2003).

What is more pertinent to the study reported below is that assumptions about knowledge and knowing are also implied when individuals deal with ill-structured problems that have no single and definitive solution (King & Kitchener, 1994; Kuhn, 1991; Schraw, Dunkle, & Bendixen, 1995). Asking participants to reason on everyday, ill-structured problems that have no definitive solution, Kuhn (1991) also indirectly elicited their beliefs about knowledge. In the analysis of their argumentative reasoning, she identified three different underlying epistemological perspectives – absolutist, multiplist, and evaluativist. However, to our knowledge, only one study has empirically investigated the contribution of epistemological understanding to everyday reasoning by involving prospective jurors (Weinstock & Cronin, 2003). Representations of the nature of knowledge and knowing were assessed with an interview about the nature and source of the discrepant knowledge claims of two historical accounts. Outcomes showed that epistemological understanding underlies specific juror-reasoning skills and the overall production of arguments. Argumentation skills may indeed be enhanced or constrained by epistemological understanding, that is, by more or less advanced representations about the nature, source, justification, validation, and appropriation of knowledge. In fact, to be able to produce and evaluate arguments, alternative perspectives and evidence should be contemplated, reasoned, and judged. A study by Mason

and Boscolo (2004) has documented that students' level of epistemological understanding affects their writing of a conclusion to a text they had read, which presented a debated topic and contained no overall concluding paragraph or statement. They also documented students' changes in topic-specific beliefs.

A crucial consideration is needed here. Epistemological understanding is considered in terms of a dispositional rather than a competence factor or general intelligence (Weinstock & Cronin, 2003). As indicated by Stanovich (1999), on the basis of experimental outcomes (Stanovich & West, 1997, 1998), individual differences in performance on argument evaluation and various reasoning tasks must by explained by reference to epistemological dispositions – for instance disposition to think flexibly and to change one's beliefs in the face of contradictory evidence – as well as knowledge and cognitive ability. General intelligence has been found to be only weakly related to juror reasoning (Becker, 1997).

4. Research questions and hypotheses

The aim of this study was to examine further the contribution of epistemological understanding to argumentation skills. We extended the previous investigation by involving participants younger than those who participated in the two above-mentioned studies, and took into account epistemological understanding in relation to other personal variables such as knowledge of, and interest in the topic to be argued. These two variables should be controlled, given the findings of previous research. It emerged that grade level and ability levels seem to play a role in argumentation. The influence of these two factors can be explained in terms of knowledge about the topic under consideration. Presumably, older students have greater knowledge as do gifted students (Means & Voss, 1996, experiment 1). Knowledge of the topic was found to be related to the number of arguments generated and types of reason supporting them (Means & Voss, 1996, experiment 2).

In the study introduced below, not only was participants' prior knowledge about the topic taken into account but also their interest in the topic, that is, their relatively stable evaluative orientation toward it (Hidi, 1990). Although the effects of topic interest on argumentation were not examined, we expected that this motivational variable would play a role, on the basis of previous research on learning from text. It has been documented that knowledge and interest are both significant predictors of comprehension of a technical physics text (Alexander, Kulikowich, & Schulze, 1994). It has also emerged that highly interested students develop a deeper representation of a text's meaning, whereas low interested readers assimilate a text superficially (Schiefele, 1996). Strong interest in the domain as well as willingness to pursue understanding discriminates highly successful from less successful college students (Alexander & Murphy, 1999). It has also been found that topic interest interacts with topic knowledge and affects learning from text according to the degree of student knowledge (Boscolo & Mason, 2003). Given these findings, it was legitimate to assume that attentional arousal and willingness to persist in the task, stimulated by interest in a topic, may also help construct arguments about it.

In the study reported below, arguments are considered as cognitive constructions of individuals who reason on controversial topics. Unlike Kuhn (1991), who studied argumentation about the causes of social phenomena by asking participants to offer evidence for a causal phenomenon (e.g., school failure or unemployment), we examined reasons or justifications provided to sustain one position against a competing one, which is apparent, given the controversy of the topic. In other words, in Kuhn's study participants had to formulate a theory and offer evidence, in our study participants had to argue in favor of one of two competing views, which were both introduced to them in the text that they read. We explicitly asked participants to formulate arguments, counterarguments, and rebuttals, and justify them on the basis of what they had read.

Two controversial topics were introduced, both the object of currently heated debates, global warming and genetically modified food. They had not been dealt with at school, so students would have had little prior knowledge, although the topics were not unfamiliar. This allowed us to examine better the role of the other variables, epistemological understanding and topic interest. Two controversies, instead of one, were introduced to be able to test better the reproducibility of the findings and exclude that they may be related to specific content. The controversies are described in two texts of different length but of the same structure. They were chosen because both regard scientific phenomena that may be of some interest, also to eighth graders, for their strong social implications as they also pertain to our everyday life. Both global warming and genetic modification of food could have an impact on individual human behavior. To exemplify, if global warming is due to an increase in greenhouse gases in the atmosphere, as a result of human activity, one could decide to try to contribute to reducing the emission of carbon dioxide by changing individual habits. If genetically modified food does not resolve the food requirements in poor

countries, and if its harmlessness is far from being proven, one could decide to be careful to buy GMO-free products and ask that consumers should always be informed about the presence of transgenic ingredients in products. To some extent, the debate concerning genetically modified food, however, could be considered a scientific question closer to people's everyday lives because it regards a fundamental need – to eat. People, as consumers, may believe that they have some control over the phenomenon and impact the production of transgenic food by boycotting its sale.

The purpose of the study was to answer the following three questions:

(1) Is there a relationship between overall epistemological understanding and the different aspects of argumentation skills, that is, the skills of producing arguments, counterarguments, and rebuttals about a controversy read in a text while controlling for topic knowledge and interest?
(2) Do levels of overall epistemological understanding differentiate the different aspects of argumentation skills?
(3) Is the pattern of results (from the two points above) the same when arguing about two different controversial topics?

For research question 1 we hypothesized that the overall level of understanding about knowledge and knowing would be significantly related to the different aspects of argumentation skills. This component skill requires an ability to consider alternative arguments and reasons. We also expected the limited prior knowledge of the topic before text reading not to be significantly related to argumentation. Text information would be the common base for their argumentation. Moreover, we hypothesized that topic interest would be significantly related to argumentation. The more participants were curious about the topic and attributed importance, the better their argumentation skills.

For research question 2, we hypothesized that levels of overall epistemological understanding would significantly differentiate the counterargument and rebuttal skills. Participants who believe that different knowledge claims can compete and be evaluated, so that a position can be reasonably judged as more justified and sustainable than others, would be facilitated in these components of argumentation skills. If a multiplist level of epistemological understanding would be sufficient to generate arguments, an evaluative epistemology would facilitate the production of counterarguments. This assumption was based on the findings of previous studies showing that people are less likely to produce counterarguments even when they can produce arguments and perform other argument skills (e.g. Baron, 1991; Weinstock & Cronin, 2003).

For research question 3 we hypothesized the same pattern of findings in arguing about controversial topics, independently of the specific content. Whether participants argue about global warning or genetically modified food, their beliefs about knowledge and the knowing process would be activated, helping them or not, to produce arguments, counterarguments, and rebuttals.

5. Method

5.1. Participants

Sixty-two eighth graders, 32 boys and 30 girls attending two public middle schools in the province of La Spezia (north western Italy) read one of the two texts about the controversial topics, global warming. Fifty-two of these students also read the text about the other controversial topic, genetically modified food. This group was smaller since 10 students were absent from school in the session when the text about transgenic food was introduced. About half the students read the text on global warming first, while the other half read the text on transgenic food first. All participants were Caucasian native speakers of Italian and shared a homogeneous middle-class social background. There were no students with learning difficulties and none had particularly low achievement. They all had at least moderate reading ability. On the 10-point scale (1–10) used in Italy for assessment, all students were between 6 and 9 in reading comprehension, which is mostly part of Italian language classes. The tasks carried out by the very few students with reading difficulties were not included in the statistical analyses.

5.2. Pre-reading tasks and coding

5.2.1. Epistemological understanding

The 15-item instrument developed by Kuhn, Cheney, and Weinstock (2000) to measure epistemological understanding was administered. Each item consists of a pair of contrasting statements in five domains (judgments of

personal taste, aesthetics, values, truth about the social world and truth about the physical world) attributed to two individuals. There are three pairs of statements for each judgment domain. Following each pair of statements, participants were first asked to answer the question ''Can only one of their views be right, or could both have some rightness?''. There were two options: ''Only one right'' and ''Both could have some rightness'' (p. 316). The following question, depending on the response to the first (''If both could be right''), was ''Could one view be better or more right than the other?'' (p. 316). Participants had to choose one of two options: ''One could be more right'' and ''One could not be more right than the other''. The order of domains was randomized. This instrument was chosen because, unlike others (such as the Epistemological Questionnaire by Schommer, 1990), it only concerns beliefs about knowing and knowledge – and not learning or intelligence – which is the focus of the present study. Scoring reflected the authors' three-level model of development. Absolutist answers (''Only one right'') were scored 1, multiplist answers (''One could not be more right than the other'') were scored 2, and evaluativist answers (''One could be more right'') were scored 3.

This instrument was developed to identify the transitions from absolutist to multiplist and from multiplist to evaluativist positions, by assuming that an individual can be at different levels of epistemological understanding according to the judgment domain. The aim of our study was to examine the effects of students' general level of epistemological understanding on their argumentation about controversial topics, and not to investigate patterns of epistemological understanding, across judgment domains to arrive at a profile of the students' transitions from one level to the next. We therefore considered it appropriate to compute a total score in epistemological understanding for each participant, made up of the scores for the five judgment domains. The mean (inter)correlation between the five scores was 0.37. The resulting alpha reliability coefficient of the total score was 0.72.

Total scores could range from 15 (absolutist positions in all judgment domains) to 45 (evaluativist positions in all judgment domains). A total score of 15 would reflect ''pure'' consistently absolutist positions across all five judgment domains, a score of 30 multiplist positions and a score of 45 evaluativist positions. Following Kuhn et al. (2000), for each judgment domain, a participant was categorized as conforming to the absolutist (score 1), multiplist (score 2), or evaluativist (score 3) level if responses to two of the three items assessing judgments in the domain conformed to the pattern characterizing that level. In a very few cases in which no patterns dominated, as all types of patterns appeared across the three items, the intermediate multiplist level was assigned. Thus, a score ranging from 15 to 25 would reflect absolutist positions for all judgment domains, a score ranging from 25 to 35 would reflect multiplist positions, and a score ranging from 35 to 45 would reflect evaluativist positions. It should be pointed out that the total score of 25 could be obtained, in each judgment domain, both in the case of two absolutist and one evaluativist position, and in the case of two multiplist and one absolutist position. However, in the former case a participant was categorized as conforming to the absolutist level, in the latter to the multiplist level. Similarly, the total score of 35 could be obtained both in the case of two multiplist and one evaluativist position, and in the case of two evaluativist and one absolutist position, in each judgment domain. However, in the former case a participant was categorized as conforming to the multiplist level, in the latter to the evaluativist level. Participants' total scores ranged from 25 to 42 with a mean score of 33.24. Overall absolutist positions did not emerge. Of the 62 participants, 46 (74.2%) expressed overall multiplist positions and 16 (25.8%) evaluativist positions.

The single variable, reflecting a general epistemological understanding, was used as the study was not intended to explore domain differences in epistemological understanding. However, we also considered domain specificity to show that the choice of a single variable was valid. For instance, differences in the domains of truth judgments about the social and physical world would be the most relevant with reference to arguments intended to establish truthful claims about phenomena that are both scientific and social.

5.2.2. Topic knowledge of global warming

Nine questions were asked to measure students' knowledge about the greenhouse effect and global warming, one open-ended question (''What is the greenhouse effect? Explain the mechanism that produces it.'') and 8 multiple-choice questions. The open ended questions were scored 0–2, on the basis of their correctness and completeness, by the second author and an independent judge. Inter-rater reliability as indicated by percentage agreement was 95%. Disagreement was resolved in conference by discussion in the presence of the first author. The possible score-range was 0–10. The alpha reliability coefficient of the questionnaire was 0.80.

5.2.3. Topic knowledge of genetically modified food

Eleven questions were asked to measure students' knowledge about genetically modified food, one open-ended question (''What is genetically modified food?'') and 10 multiple-choice questions. Open ended questions were scored 0–5 on the basis of their correctness and completeness by the second author and an independent judge. Inter-rater reliability as indicated by percentage agreement was 98%. Disagreement was resolved in conference by discussion in the presence of the first author. The possible score-range was 0–15. The alpha reliability coefficient of the questionnaire was 0.82.

5.2.4. Topic interest in global warming

An 11-item interest questionnaire, devised by the authors, with items to be rated on a 5-point scale, was used to measure participants' degree of interest in the topic of global warming. Its alpha reliability coefficient was 0.94. Examples of items are: ''I would like to know more about the greenhouse effect''; ''The question of the greenhouse effect is complex but interesting''; I like to be updated on issues such as global warming''. The minimum and maximum possible scores were 11 and 55, respectively.

5.2.5. Topic interest in genetically modified food

An 11-item interest questionnaire was also devised and used to measure participants' degree of interest in the topic of genetically modified food. Its alpha reliability coefficient was 0.89. Examples of items are ''I am curious about how science and technology can transform natural food''; ''The topic of genetically modified food is complex but interesting''; ''I think that we should learn much more about genetically modified organisms''. Also for this measure the minimum and maximum possible scores were 11 and 55, respectively.

5.3. Reading task

For each topic, the authors prepared an expository text to introduce participants to neutral, informative aspects of the examined phenomenon first, and then two different perspectives on it. Half the students read a text with one of the two perspectives first, and half the students a text with the other perspective, to avoid any interference due to the order of presentation.

5.3.1. Text on global warming

The two-sided text, comprising 1277 words and 49 sentences, was divided into three parts. The first part was a neutral introduction to the global warming. The second part of the text, comprising 490 words and 18 sentences, introduced the position that explains global warming as a consequence of human activity which causes the accumulation of carbon dioxide and other greenhouse gases in the atmosphere. The third part, comprising 493 words and 18 sentences, introduced an opposing position that considers global warming as a natural phenomenon and not the effect of an increase in carbon dioxide. Both parts supported their respective views with evidence. The text prepared for the present study was used after being evaluated in terms of difficulty, familiarity and strength of argument of the two positions by four high school science teachers and four university biology students. According to both teachers and students, the two positions were introduced in a balanced manner for the aspects examined.

5.3.2. Text on genetically modified food

The two-sided text, prepared by the authors comprised 2727 words and 89 sentences, and was divided into three parts, like the text on global warming. The first part was a neutral introduction to genetic engineering and biotechnology, and its application to food production. The second part of the text, comprising 1006 words and 35 sentences, introduced a position in favor of the production of genetically modified food. The third part, 1008 words and 35 sentences, presented an opposing position, arguing against this kind of food. In this text too, both parts supported their respective views with evidence. This text, already used in a previous study (Mason & Boscolo, 2004), had also been evaluated in terms of difficulty, familiarity and strength of argument of the two positions by four university professors in the field of biology and a group of university psychology students. All found that the two positions were introduced in a balanced manner for the aspects examined.

5.4. Post-reading tasks and coding

5.4.1. Argumentation skills

For each topic students were asked to formulate arguments, counterarguments, and rebuttals providing justifications. Counterarguments are arguments that contradict one's original position. Rebuttals are arguments that refute the counterarguments. For the topic of global warming the participants were asked the following:

- "Do you think that global warming is caused by an increase in the emission of greenhouse gases due to human activity? Explain your position as clearly and completely as possible by referring to all reasons that support it." (Argument);
- "One of your classmates disagrees with your position. How could she/he explain her/his position to illustrate the reasons supporting it and convince you?". (Counterargument);
- "What would you reply to your classmate to explain as clearly and completely as possible that your position is right?" (Rebuttal).

For the topic of genetically modified food, the participants were asked the following:

- "Do you think that genetically modified food should be produced and marketed? Explain all reasons that support it as clearly and completely as possible." (Argument);
- Your friend disagrees with your position. How could she/he explain her/his position to illustrate the reasons supporting it and convince you that she/he is right?". (Counterargument);
- "What would you reply to your classmate to explain as clearly and completely as possible that your position is right?" (Rebuttal).

For each topic, therefore, a student could argue in favor of one or other view. Taking into account argument scoring in previous studies (Means & Voss, 1996; Zohar & Nemet, 2002), the quality of argumentation (for arguments, counterarguments, and rebuttals) produced by the participants was scored according to the number and content adequateness of the reasons (justifications) given to support conclusions. The number of reasons provided was considered in accordance with Means and Voss (1996), who maintained that although more reasons do not necessary mean better argumentation, arguments with a greater number of acceptable reasons are to be considered as stronger. The content adequateness of reasons refers to their acceptability per se and whether they support the conclusion. The argumentation produced was scored 0–4 in the following way:

- 0 points: No argument, that is, no justifications provided: "I disagree with him, he is not right"; "I would repeat my explanation about the cause of global warming";
- 1 point: No completely valid argument (justification) provided: "I think that OGM products should be marketed as they are good things";
- 2 points: Valid argument provided with no entirely correct reason supporting it: "Global warming is not due to human activity because also between the years 1000 and 1500 there was an increase in temperature";
- 3 points: Valid argument provided, supported by one reason; "I think that it is good to produce genetically modified food because the organisms, resistant to insects, grow easily and plentifully".
- 4 points: Valid argument provided, supported by two or more reasons: "I could even agree that it has not been clearly demonstrated that transgenic food is harmful, but it is not true that it would help the developing countries because they are poor because of the inefficient distribution of natural resources and not because of agricultural underdevelopment. For instance, Brazil is the third country in the world for the export of agricultural products, yet 18% of its population is malnourished. Therefore it is not a matter of lack of food in the country. Moreover, the multinational companies would make the poor countries "slaves" as they would totally depend on those who know how to produce the new organisms".

This simple analysis does not cover the full set of criteria for argument quality indicated in the literature (e.g. Kuhn, 1991; Means & Voss, 1996; Zohar & Nemet, 2002). However, it measures the quality of students' arguments for three main reasons: (1) no simple assertions were accepted but rather arguments supported by justifications; (2) only

acceptability and relevance of justifications for supporting the conclusion were considered; and (3) arguments with a greater number of acceptable reasons were considered as stronger. Moreover, it should be pointed out that a rebuttal was considered valid if it used reasons different from those provided in the initial argument, or, at least, if a reason already mentioned was further elaborated. There were no cases of participants who did not generate a counterargument and provide an answer to the rebuttal question.

The second author and an independent judge scored all written responses. Inter-rater reliability as indicated by percentage agreement was 94%. Disagreement was resolved in conference by discussion in the presence of the first author. For each topic, a score for argument, counterargument, and rebuttal was calculated.

5.5. Procedure

Participants were administered the epistemological understanding instrument in the first session that lasted about half an hour. Each topic was dealt with in three sessions. In the first session participants, tested in their classrooms, were given unlimited time to carry out the pre-reading tasks. They were administered the topic interest questionnaire and the open-ended and multiple-choice questions on prior knowledge. The first session lasted 45–55 min. The second session took place a week later. The order of tasks in the second session was (a) reading the text on one of the two topics, (b) argumentation task, (c) multiple-choice questions, (d) open-ended questions. Students were given unlimited time to carry out the post-reading tasks. The third session, devoted to reading the text about the other topic, took place a week later and the order of post-reading tasks was the same as in the second session, as was the session length, which lasted from 1 h 50 min to 2 h 15 min.

6. Results

6.1. Global warming

The first analysis to be carried out was correlational, examining the variables that could be associated with argumentation skills. Table 1(a) shows the means and standard deviations of all variables used in the analysis. Table 2(a) displays the zero-order correlations between all variables and indicates that the three components of argumentation skills correlated positively with epistemological understanding, as well as each other. Multiple regression analyses were then carried out to see whether epistemological understanding would predict argumentation skills while other variables, that is, topic knowledge and topic interest simultaneously included in the first step, were controlled. The first hierarchical regression analysis with argument generation as the criterion variable revealed that only

Table 1
Means and standard deviations of variables used in regression analyses for the topics of global warming ($N = 62$) and genetically modified food ($N = 52$)

Variable	*M*	SD
(a) Global warming		
Argument (0–4)	3.04	0.99
Counterargument (0–4)	2.16	1.11
Rebuttal (0–4)	2.09	1.19
Topic knowledge (1–7)	3.19	1.75
Topic interest (16–55)	38.29	9.75
Epistemological understanding (25–42)	33.24	3.55
(b) Genetically modified food		
Argument (0–4)	3.15	0.82
Counterargument (0–4)	2.86	0.76
Rebuttal (0–4)	2.40	0.97
Topic knowledge (3–15)	8.83	2.40
Topic interest (20–54)	38.96	9.08
Epistemological understanding (25–42)	32.96	3.43

Numbers in parentheses indicate the actual score-range.

Table 2
Intercorrelations between the examined variables for the topics of global warming ($N = 62$) and genetically modified food ($N = 52$)

Variable	1	2	3	4	5	6
(a) Global warming						
1. Argument	–					
2. Counterargument	0.38**	–				
3. Rebuttal	0.44**	0.50**	–			
4. Topic knowledge	0.06	−0.10	0.18	–		
5. Topic interest	0.07	0.10	−0.39	0.09	–	
6. Epistemological understanding	0.36**	0.31*	0.37**	0.03	−0.07	–
(b) Genetically modified food						
1. Argument	–					
2. Counterargument	0.34*	–				
3. Rebuttal	0.45**	0.44**	–			
4. Topic knowledge	0.28*	–	0.39**	–		
5. Topic interest	0.13	0.29*	0.042	0.24	–	
6. Epistemological understanding	0.41**	0.51**	0.39**	0.06	0.04	–

**$p < 0.01$, two-tailed; *$p < 0.05$, two-tailed.

epistemological understanding significantly predicted it, accounting for 13.8% of the variance [$R = 0.38$, $R^2 = 0.14$, $F(3, 58) = 3.34$, $p < 0.05$]. The second hierarchical regression analysis revealed that the criterion variable of epistemological understanding was also the only significant predictor of counterargument generation, accounting for 10.3% of the variance [$R = 0.35$, $R^2 = 0.12$, $F(3, 58) = 2.81$, $p < 0.05$]. Finally, the third hierarchical regression analysis with rebuttal generation as the criterion variable revealed again that only epistemological understanding significantly predicted it, accounting for 13.6% of the variance [$R = 0.41$, $R^2 = 0.17$, $F(3, 58) = 4.06$, $p < 0.05$]. A summary of all regression analyses is reported in Table 3. To illustrate higher and lower levels of argumentation skills, examples showing no argument, single and simple, as well as more complex and elaborated structures for each component (argument, counterargument, and rebuttal) are introduced in the Appendix.

To analyze further if the two different levels of participants' overall epistemological understanding, that is the multiplist and the evaluativist, differentiated the three examined components of argumentation skills, a multiple analysis of covariance (MANCOVA) was performed. In this analysis the epistemological understanding level was used as the independent variable, the three scores of argument, counterargument, and rebuttal scores as dependent variables, and topic knowledge and topic interest as covariates. The MANCOVA revealed the significant main effect of epistemological understanding, $F(3, 56) = 3.61$, $p < 0.05$. The univariate tests showed that the independent variable affected the generation of arguments, $F(1, 58) = 5.27$, $p < 0.05$, MSE = 0.95, counterarguments $F(1, 58) = 6.04$, $p < 0.05$, MSE = 1.16, and rebuttals, $F(1, 58) = 8.77$, $p < 0.01$, MSE = 0.126. For all three components of argumentation skills, participants at an overall evaluativist level outperformed participants at an overall multiplist level (Table 4(a)).

As mentioned above, we also considered domain differences in epistemological understanding to ensure that the choice to use a single variable to represent general epistemological understanding was valid. As an illustrative example, we refer here to the domain of judgment of truth about the social world, which is partially relevant to the controversies examined. Three regression analyses were performed with arguments, counterargument, and rebuttals as criterion variables, and epistemological understanding in judgments of the truth about the social world as predictor (controlling for topic knowledge and topic interest). It emerged that the latter significantly predicted ($\beta = 0.37$, $p < 0.01$) the generation of counterarguments, accounting for 13.3% of the variance [$R = 0.37$, $R^2 = 0.14$, $F(3, 58) = 3.19$, $p < 0.05$]. In addition, an ANCOVA revealed a significant difference in the quality of counterarguments by level of epistemological understanding about the truth of the social world, $F(1, 58) = 5.99$, $p < 0.05$, MSE = 0.94. The quality was higher in those formulated by participants at the evaluativist level ($M = 3.28$, SD = 0.72) than at the multiplist level ($M = 2.65$, SD = 1.26). No participants were at the absolutist level.

6.2. Genetically modified food

The same analyses were also carried out for the topic of genetically modified food. Means and standard deviations of all variables considered in the analyses are reported in Table 1(b), and their correlations in Table 2(b). In this case

Table 3
Summary of regression analyses for variables predicting argument, counterargument, and rebuttal skills about global warming ($N = 62$), with epistemological understanding entered separately

Variable	*B*	SE *B*	β
Argument			
Step 1			
Topic knowledge	0.03	0.07	0.06
Topic interest	0.00	0.03	0.06
Step 2			
Topic knowledge	0.03	0.06	0.05
Topic interest	0.01	0.01	0.09
Epistemological understanding	0.10	0.03	0.37*
Counterargument			
Step 1			
Topic knowledge	−0.07	0.08	−0.11
Topic interest	0.01	0.01	0.11
Step 2			
Topic knowledge	−0.07	0.07	−0.11
Topic interest	0.01	0.01	0.14
Epistemological understanding	0.10	0.03	0.32*
Rebuttal			
Step 1			
Topic knowledge	0.13	0.08	0.19
Topic interest	−0.00	0.01	−0.05
Step 2			
Topic knowledge	0.12	0.08	0.18
Topic interest	−0.00	0.01	−0.02
Epistemological understanding	0.12	0.04	0.37*

Argument: $*p < 0.01$; $R^2 = 0.009$ for Step 1, $p > 0.05$; $R^2 = 0.147$ for Step 2, $\Delta R^2 = 0.138$, $p < 0.05$.
Counterargument: $*p < 0.05$; $R^2 = 0.023$ for Step 1, $p > 0.05$; $R^2 = 0.127$ for Step 2, $\Delta R^2 = 0.103$, $p < 0.05$.
Rebuttal: $*p < 0.01$; $R^2 = 0.038$ for Step 1, $p > 0.05$; $R^2 = 0.174$ for Step 2, $\Delta R^2 = 0.136$, $p < 0.05$.

too, the three components of argumentation skills correlated positively with epistemological understanding, as well as each other. It also emerged that scores for argument and rebuttal generation correlated positively with topic knowledge, and the score for counterargument correlated positively with topic interest.

The first multiple hierarchical regression analysis with argument generation as the criterion variable revealed that only epistemological understanding significantly predicted it, accounting for 15.8% of the variance [$R = 0.49$, $R^2 = 0.24$, $F(3, 48) = 5.08$, $p < 0.05$]. The second hierarchical regression analysis revealed that the criterion variable

Table 4
Means and standard deviations of scores for argument, counterargument, and rebuttal by level of epistemological understanding for the topics of global warming ($N = 62$) and genetically modified food ($N = 52$)

	Multiplist	Evaluativist
	M (SD)	*M* (SD)
(a) Global warming		
Argument	2.89 (1.07)	3.50 (0.51)
Counterargument	1.97 (1.08)	2.68 (1.07)
Rebuttal	1.84 (1.15)	2.81(1.04)
(b) Genetically modified food		
Argument	3.00 (0.84)	3.66 (0.49)
Counterargument	2.77 (0.80)	3.16 (0.57)
Rebuttal	2.22 (1.02)	3.00 (0.42)

of epistemological understanding was also the only significant predictor of counterargument generation, accounting for 24.4% of the variance [$R = 0.58$, $R^2 = 0.34$, $F(3, 48) = 8.30$, $p < 0.001$]. Finally, the third hierarchical regression analysis with rebuttal generation as the criterion variable revealed that in the first step topic knowledge was a significant predictor, while interest was not [$R = 0.40$, $R^2 = 0.162$, $F(2, 49) = 4.72$, $p < 0.05$]. In the second step epistemological understanding made a significant contribution as a predictor of rebuttal quality, accounting for 13.4% of the variance [$R = 0.54$, $R^2 = 0.29$, $F(3, 48) = 6.72$, $p = 0.001$]. A summary of all regression analyses is reported in Table 5. To illustrate higher and lower levels of argumentation, examples showing no argument, single, simple and more, as well as complex and elaborated argument structures for each component (argument, counterargument, and rebuttal) are introduced in the Appendix. These results indicate that participants' level of epistemological understanding contributes to argumentation skills over and above topic knowledge effects.

For this topic too, a multiple analysis of covariance (MANCOVA) was performed to analyze whether participants at the multiplist level significantly differentiated from those at the evaluativist level in their generation of arguments, counterarguments, and rebuttals. Again, the epistemological understanding level was used as the independent variable, the three scores of argument, counterargument, and rebuttal as dependent variables, and topic knowledge and topic interest as covariates. The MANCOVA revealed only the significant main effect of epistemological understanding, $F(3, 46) = 3.66$, $p < 0.05$. Univariate tests showed that the independent variable affected the generation of arguments, $F(1, 48) = 7.53$, $p < 0.01$, MSE = 0.57, counterarguments $F(1, 48) = 5.37$, $p < 0.05$, MSE = 0.50, and rebuttals, $F(1, 58) = 5.08$, $p < 0.05$, MSE = 0.70. Participants at an overall evaluativist level of epistemological understanding attained higher scores than participants at an overall multiplist level for all three components of argumentation skills (Table 4(b)). Two illustrative examples of higher and lower levels of argumentation skills are included in

Table 5
Summary of regression analyses for variables predicting argument, counterargument, and rebuttal skills about genetically modified food ($N = 52$), with epistemological understanding entered separately

Variable	*B*	SE *B*	*β*
Argument			
Step 1			
Topic knowledge	0.09	0.04	0.26
Topic interest	0.00	0.01	0.07
Step 2			
Topic knowledge	0.08	0.04	0.23
Topic interest	0.00	0.01	0.06
Epistemological understanding	0.10	0.03	0.39*
Counterargument			
Step 1			
Topic knowledge	0.03	0.04	0.10
Topic interest	0.02	0.01	0.27
Step 2			
Topic knowledge	0.02	0.03	0.07
Topic interest	0.02	0.01	0.23
Epistemological understanding	0.11	0.02	0.49*
Rebuttal			
Step 1			
Topic knowledge	0.16	0.05	0.41*
Topic interest	−0.00	0.01	−0.06
Step 2			
Topic knowledge	0.15	0.05	0.39*
Topic interest	−0.00	0.01	−0.07
Epistemological understanding	0.10	0.03	0.36*

Argument: *$p < 0.01$; $R^2 = 0.084$ for Step 1, $p > 0.05$; $R^2 = 0.241$ for Step 2, $\Delta R^2 = 0.158$, $p < 0.01$.
Counterargument: *$p < 0.001$; $R^2 = 0.098$ for Step 1, $p > 0.05$; $R^2 = 0.342$ for Step 2, $\Delta R^2 = 0.244$, $p < 0.001$.
Rebuttal: *$p < 0.01$; $R^2 = 0.162$ for Step 1, $p < 0.05$; $R^2 = 0.296$ for Step 2, $\Delta R^2 = 0.134$, $p = 0.001$.

the Appendix to give an example of no arguments, simple, and more complex and elaborated structures for the three components.

Furthermore, for this topic also, we carried out a domain-specific analysis regarding the relationship between levels of epistemological understanding for judgments of truth about the social world and the skills of argument, counterargument, and rebuttal. The first regression analysis revealed that the domain epistemological understanding significantly predicted ($\beta = 0.27$, $p < 0.05$) the generation of argument, accounting for 10.2% of the variance [$R = 0.39$, $R^2 = 0.15$, $F(3, 48) = 2.98$, $p < 0.05$]. The second regression analysis revealed that the domain epistemological understanding also significantly predicted ($\beta = 0.32$, $p < 0.05$) the generation of counterarguments, accounting for 16.7% of the variance [$R = 0.45$, $R^2 = 0.20$, $F(3, 48) = 4.06$, $p < 0.05$]. Finally, from the third regression analysis it emerged that the domain epistemological understanding also significantly predicted ($\beta = 0.30$, $p < 0.05$) the generation of rebuttals, accounting for 16.2% of the variance [$R = 0.47$, $R^2 = 0.22$, $F(3, 48) = 4.58$, $p < 0.01$]. In this last case, prior knowledge was also a significant predictor ($\beta = 0.39$, $p < 0.01$) in the first step [$R = 0.40$, $R^2 = 0.16$, $F(2, 48) = 4.72$, $p < 0.05$]. Furthermore, a MANCOVA showed the main effect of epistemological level, $F(3, 46) = 3.48$, $p < 0.05$. In particular, it differentiated the component of counterargument skills, $F(1, 48) = 10.81$, $p < 0.01$, MSE = 0.50. Evaluativist ($M = 3.10$, SD = 0.66) positions about knowledge and knowing led to counterarguments of a higher quality than multiplist positions ($M = 2.40$, SD = 0.79).

7. Discussion

Our research question 1 asked if overall epistemological understanding could contribute significantly to the quality of eighth graders' argumentation skills while controlling for topic knowledge and interest. Argumentation skills were considered as skills in producing arguments, counterarguments, and rebuttals. As hypothesized, findings from the regression analyses show that epistemological understanding, the third and more abstract level of meta-knowing according to Kuhn's (1999, 2000) model of cognitive development, is a significant predictor of all three components of argumentation skills. This main finding is in line with previous research carried out by Kuhn (1991), which, although not aimed at addressing levels of epistemological thinking, identified absolutist, multiplist and evaluativist positions about knowledge and knowing underlying individuals' argumentative reasoning about the causes of social phenomena. A correspondence between epistemological reasoning and juror-reasoning skills was also pointed out (Kuhn & Weinstock, 2002; Weinstock & Cronin, 2003).

In addition, the domain-specific analyses of epistemological understanding regarding judgments of truth about the social world, substantially confirmed that our main variable matters. More specifically, for both topics it was related to the eighth graders' counterargument skills, while for the topic of transgenic food it was also related to their argument and rebuttal skills.

Our research question 2 asked if the overall levels of epistemological understanding differentiated the different components of argumentation skills. Findings from a MANCOVA revealed that participants at an overall evaluativist level produced arguments, counterarguments, and rebuttals of a higher quality than those at the multiplist level. Rather than believing that each knowledge claim is as valid as any other, believing that competing knowledge claims are legitimate, and can be compared and evaluated to judge which can reasonably be considered more justified, sustainable and plausible than the other, led participants to show better argumentation skills for each of the aspects examined. This outcome for the component of counterargument skills was replicated when domain-specific analyses were performed.

It should be pointed out that absolutist positions about knowledge and knowing, which could differentiate the three aspects of argumentation skills even more, were not found among the participants of this study.

Our research question 3 asked if the same pattern of results would emerge in argumentation skills about both controversial topics under consideration. As hypothesized, for both controversies, that is, for scientific phenomena that have to do with people's everyday life to some extent, the same substantial pattern of results emerged. Epistemological understanding contributed to the quality of participants' argument, counterarguments, and rebuttals for both debatable questions. In addition, students at the evaluativist level outperformed those at the multiplist level in the three components of argumentation skills. Only for the topic of genetically modified food was the generation of rebuttals also related to prior knowledge about the question.

Some considerations must be made regarding the role of the two variables that have been controlled in this study, topic interest and topic knowledge. Contrary to our expectations, regression analyses revealed that topic

interest did not relate with our dependent measure. Several interpretations of this finding are possible. First, participants who showed a high degree of topic interest may have expressed it only as a desirable aspect from the researcher's point of view, masking an actual low degree of topic interest. Second, the instrument we used to measure topic interest was not able to capture participants' orientation toward the topics well enough. Unlike situational and text-based interests, which have been analyzed in terms of situation dimensions (e.g. Mitchell, 1993; Schraw & Lehman, 2001), topic interest has been investigated less (Ainley & Hidi, 2002). In this study we measured topic interest in terms of curiosity about the topic and interest in the debate about it. Topic interest was therefore conceptualized as the will to know more about a topic and as appreciation of it. Other components of this motivational variable could be implied. A deeper analysis of the construct to identify other possible components is needed to measure its different facets. Third, participants' prior knowledge was not sufficient to be able to reliably indicate topic interest. However, as prior knowledge was limited only for the topic of global warming, this interpretation is less plausible.

The role of prior knowledge of the topic does not emerge clearly in this study. On the one hand, the association of topic knowledge about transgenic food with the skill of generating rebuttals about the transgenic food controversy, read by the participants, is in line with previous research showing that knowledge is related significantly to the number and types of reason generated by arguing (Means & Voss, 1996). On the other hand, the other two aspects of argumentation skills about the same topic and all three aspects of global warming were not significantly associated with prior knowledge of the topic. This finding could be explained by referring to different degrees of topic knowledge regarding the two topics. On transgenic food, their topic knowledge before reading the text was more differentiated (minimum score 3, maximum 15) and therefore this might have helped participants generate and elaborate reasons to refute the counterarguments. Regarding global warming, the participants overall had rather low prior knowledge (minimum score 1, maximum 7). They may not have been able to rely on the little information they already had, thus the text was the common base for the generation of an argument, alternative argument, and rebuttal.

Finally, this study supports Kuhn's (1991) claim that epistemological understanding and argumentation are related. Her position has been challenged by Brem and Rips (2000) who argued that participants in Kuhn's study produced poor arguments because they were asked to generate their own evidence, therefore, they did not have enough data to work with. In their study with college students, the two authors found that the quality of informal argument about several social issues varied according to the availability of evidence. Our study supports Kuhn's position as variation in the eighth graders' argumentation skills cannot be explained by lack of available evidence, given that they were provided with an information-rich text on each controversial topic.

8. Conclusion and implication

A clear outcome of this study is that the skill of generating a valid and supported argumentation about a controversy is associated with higher levels of representation about knowledge and knowing. Further research will help us understand whether other factors are related to argumentation, either individual, such as personality characteristics, or sociocultural differences in valuing debates and ways of expressing disagreement. Argumentation needs also to be investigated as collaborative cognition produced in dialogues with a peer or in a group. An implication of our findings leads to highlighting the importance of fostering students' epistemological thinking. Scholars who have proposed models for the development of this kind of thinking (e.g. King & Kitchener, 1994; Kuhn & Weinstock, 2002) have underlined the need to provide students with opportunities to deal with ill-defined problems for which there is no single right answer. In this way they would have practice gathering, analyzing, and weighing up evidence from multiple sources, and making and defending claims. Fostering epistemological thinking in an instructional context means teaching students to value thinking and judgment, and helping them acquire and refine the skills of producing and evaluating reasoned arguments. Therefore, there could be a two-fold advantage in presenting students with controversial topics to introduce disciplinary knowledge (Bell & Linn, 2002). Understanding controversies requires epistemological thinking to deal with source, structure, and credibility of knowledge. At the same time having to deal with these aspects of the knowing process may stimulate and sustain the refinement of epistemological understanding.

Appendix

Examples of higher and lower levels of argumentation skills on global warming

Higher level

Argument. Yes, I think that the increase in the earth's temperature is caused by pollution. Scientists have proved that from 1856 to 2000 the temperature has increased from 0.4° to 0.8°. This rise may be due to two factors: (1) destruction of the rainforests and (2) combustion of fossil fuels. Scientists have proven that about 50% of the increased temperature is due to the combustion of fossil fuels. The greenhouse effect, in fact, works in this way: solar radiation hits the earth, which sends this radiation upward as infrared radiation. This radiation, in turn, is absorbed by carbon dioxide and water vapor. Therefore, we could say that the more carbon dioxide there is, the greater the absorption of heat. We can also say that we, human beings, issue a large amount of carbon dioxide into the atmosphere, which remains in the air and absorbs heat.

Counterargument. No, I do not think that the rise in temperature is due to an increase in carbon dioxide. Some scientists think that an increase from 0.4° to 0.8° is almost nothing, that is, a natural rise in temperature. Climatic changes also occurred in the past like nowadays, for instance between 1000 and 1300, during the so-called ''hot middle ages''. Some scientists think that the cold oceans will absorb additional heat first, slowing down the atmospheric warming. Then, when their temperature is balanced with the heat due to the large amount of carbon dioxide in the atmosphere, global warming will increase rapidly. Special tools, such as radio-probes and satellites to measure temperature not on the surface but above, in the atmosphere, have proved that the global temperature is not increasing as it seems from measures taken on the surface. Therefore, the increase in global warming from 0.4° to 0.8° is only a natural climatic change.

Rebuttal. First of all an increase from 0.4° to 0.8° is not small. Then, how do you explain that the earth's temperature has increased at the same rate as the increase in the production of carbon dioxide? Yes, the oceans are not getting warmer, but scientists say that global warming regards the terrestrial part first and then the oceans. Moreover, if carbon dioxide is a greenhouse gas and traps heat, and the amount of carbon dioxide in the atmosphere has increased, how can you maintain that it is not the cause of global warming?

Lower level

Argument. I believe that the cause of global warming is the pollution caused by human beings, in particular by the gases in the atmosphere.

Counterargument. The increase in the earth's temperature is a natural event as some scientists maintain.

Rebuttal. My theory is right and his theory is not.

Examples of higher and lower levels of argumentation skills on genetically modified food

Higher level

Argument. I am against both the production and marketing of genetically modified food. Nowadays, there are many GM foods, for example transgenic corn, tomatoes, chicory. I am against it because when a foodstuff is grown, for example corn, the wind can transfer pollen containing genes of transgenic organisms to other natural organisms. In this way, many problems are created because of the contamination of a natural field with transgenic material. Further, since transgenic food has been marketed, the number of allergies has increased. Furthermore, scientists say that when a foreign gene is inserted in an organism, it is also necessary to introduce a promoter, which is something like a switch that activates that gene. These promoters force the genes to be even 1000 times more productive than they would

normally be, which can influence other genes. Finally, it is necessary for people to know that there are GM organisms when they buy food, so that they can choose if they want to buy it or not.

Counterargument. I am in favor of genetically modified food because in developing countries it makes it possible to have enough food to feed the population. By inserting some genes in the seeds, corn, for example, can be made resistant to insects and pesticides, so genetically modified corn can grow more easily with all the advantages. Further, there is no evidence that GM foods are harmful or that they cause allergies. Furthermore, if wind transfers pollen containing transgenic material, it is not harmful to natural seeds and plants.

Rebuttal. In my opinion your argument that allergies have not increased because of transgenic food is wrong, since I have been told by an expert that due to the marketing of genetically modified food, no child is born nowadays without some allergy. This is evidence that transgenic food is harmful. Further, it would not solve the problem of starvation in the world since this problem depends on an unbalanced distribution of natural resources. Finally, a person should not be forced to buy GM food without knowing it, but rather he or she should free to choose what to eat.

Lower level

Argument. No, I think that GM food should not be marketed because it can be harmful to health and cause allergies.

Counterargument. In my opinion more genetically modified food should be produced and marketed since there are starving people in the world and they could eat more because GM seeds are more resistant to bad atmospheric conditions.

Rebuttal. I do not agree with him because GM food can be harmful.

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