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The Effect of Argumentative Task Goal on the Quality of Argumentative Discourse

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Abstract

In argumentative discourse, there are two kinds of activity-dispute and deliberation-that depend on the argumentative task goal. In dispute, the goal is to defend a conclusion by undermining alternatives, whereas in deliberation, the goal is to arrive at a conclusion by contrasting alternatives. In this study we examine the impact of these tasks goals on the quality of argumentative discourse. Sixty-five junior high school students were organized into dyads to discuss about sources of energy. Dyads were formed by members who had differing viewpoints and were distributed to one of two conditions: 31 dyads were asked to discuss with the goal to persuade the partner and 34 were asked to reach consensus. Argumentation was analyzed using a schema based on Toulmin (1958). Eleven different argumentative structures resulted from the combination of Toulmin's basic elements. Students in the consensus group scored significantly higher than students in the persuasion group in 5/6 argumentative structures that included rebuttals. The major implication of the present work is that, similar to Mercer's (2000) claim about types of classroom conversation, not all classroom argumentation tasks promote scientific reasoning equally.

Keywords: argumentation, deliberation, persuasion, scientific reasoning, quality of discours

The international educational community has shown an increasing interest in argumentation in the last two decades. This interest has been especially visible in science education policy, research and practice. Consider, for example, the wide range of curricular policy initiatives (e.g. OECD, 2010; NGSS, 2012), research studies (e.g. Driver, Newton, & Osborne, 2000; Erduran & Jimenez-Aleixandre, 2012) and school-level implementation (e.g. Zohar & Nemet, 2002) that have advocated the incorporation of argumentation in science teaching and learning. The epistemological shift that has taken place in the scientific community has contributed to this fact. Science is no longer viewed as individual empirical processes from which conclusive claims to truth are drawn, as positivists once claimed. Instead, science is now understood as a social construction that results not only from inquiry processes, but also from the discourse and public scrutiny used to resolve controversies and reach consensus (Latour & Woolgar, 1986; Rheinberger, 1997). The science education community has mirrored this epistemological shift by looking at science learning as participation in scientific practices (Berland & Reiser, 2010), and making argumentation a key component of teaching in science classrooms. For example, Duschl, Schweingruber, and Shouse (2007, p. 36) have proposed four goals for science education: (1) Know the scientific explanations of the natural world; (2) Generate and evaluate scientific evidence and explanations; (3) Understand the epistemic nature of scientific knowledge; (4) Participate in scientific practices and discourse.

In the present paper, we are particularly interested in the relationship between the first, second and fourth of these goals. Kuhn's notion of "science as argument" (Kuhn, 1993; 2010), or the view that science education should address "not only mastery of scientific concepts but also the appropriation of scientific discourse" (p.

810) is a widely accepted frame for science education (Berland & Reiser, 2009; Bricker & Bell, 2009; Driver, et al.,, 2000; Duschl, 2008; Jimenez-Aleixandre & Erduran 2008; Lehrer, Schauble, & Lucas, 2008; Naylor, Keogh, & Downing, 2007; Nussbaum, Sinatra, & Poliquin, 2008; Osborne, Erduran, & Simon, 2004; Sampson & Clark, 2008; Zohar & Nemet, 2002). The view is compelling not only because it addresses the process by which scientific knowledge is generated and evaluated in the scientific community, but also because it suggests a means by which students may come to construct that knowledge for themselves. That is, when students engage with science as argument, they come to "know" not only the conclusions of science, but also the evidentiary base on which those conclusions rest, providing a more complex and integrated basis for scientific explanations (McNeill & Krajcik, 2008; Sandoval & Millwood, 2005).

But what is the nature of the relationship between argumentation and knowledge in science? Venville and Dawson (2010) suggest that the relationship between the two can be studied in two possible directions. The first, a classic hypothesis in the field of cognitive psychology, points to the effect of students' prior knowledge on the quality and complexity of the arguments they construct (Bell & Linn, 2010; Kuhn, 1991; Means & Voss, 1996; Sadler & Zeidler, 2004; Yerrick, 2000; von Aufschnaiter, Erduran, Osborne, & Simon, 2008), suggesting that it is difficult to argue effectively without adequate disciplinary knowledge (Norris & Phillips, 2003). In other words, the individual's prior content knowledge will impact the quality and complexity of scientific arguments she or he produces.

The second, perhaps less intuitive hypothesis is that argumentation may also affect the quality and complexity of knowledge (Venville & Dawson, 2010). There is a growing body of research that supports this hypothesis, exploring mechanisms by which argumentation might lead to learning (Anderson, et al., 2001; Duschl & Osborne, 2002; Erduran, Simon, & Osborne, 2004; Jimenez-Aleixandre, Bugallo-Rodriguez, & Duschl, 2000; Kelly & Chen, 1999; Kelly & Crawford, 1997; Osborne, Erduran, Simon, & Monk, 2001; Reznitskaya, et al., 2001). However, only a handful studies test the relationship empirically (Bell & Linn, 2000; Cross, Taasoobshirazi, Hendricks, & Hickey, 2008; xxx, 2009; Jiménez-Aleixandre & Pereiro-Muñoz, 2002; Nussbaum & Sinatra, 2003; Zohar & Nemet, 2002). For instance, Jimenez-Aleixandre and Pereiro-Muñoz (2002) showed that when students engage in argumentation they are better at applying knowledge to practical contexts, which results in a better integration of ideas.

Similarly, Zohar and Nemet (2002) found that when students are given explicit instruction in argumentation, coupled with the opportunity to practice with science content, they are more likely to cite specific scientific knowledge as evidence in their arguments and perform better on tests of content knowledge than peers in a control group. More concretely, Zohar and Nemet study (2002) focused on explicit teaching of reasoning patterns integrated into the teaching of scientific content in genetics. Their results showed that explicit instruction of reasoning patterns contributed to improving students' scores in the argumentation tests. Moreover, as the authors claim, students' scores improved not only in the genetic argumentation tests but also in the transfer tests, indicating that they were able to transfer reasoning abilities taught in the context of dilemmas in genetics to dilemmas taken from everyday life. In addition, Cross, et al. (2008) show how argumentation facilitates students' review of their prior knowledge, at times helping them to overcome misconceptions and to reach conceptual change. Nussbaum and Sinatra (2003) as well as Bell and Linn (2000) have also found positive effects of argumentation on students' conceptual change.

Understanding the Impact of Scientific Knowledge on Argumentation

However, fewer studies offer insight into to the mechanisms by which argumentation enhances scientific knowledge construction (von Aufschnaiter et al., 2008). In a case study analysis of argumentative discourse among junior high school science students, von Aufschnaiter, et al., (2008) found that at least among students who had prior knowledge of the content, argumentative discourse helped them improve their understanding of the content. In a microanalysis of students' discourse, these authors found that argumentation provided opportunities for students to refine their understanding of the content, prompting them to sort relevant from irrelevant information, make connections across contexts and increase the explanatory power of their scientific knowledge. But these findings did not hold for students who did not already possess the requisite knowledge, and mere interaction with knowledgeable peers, even with the gains that these peers made in explaining themselves, did not help them construct knowledge that they did not already possess. Moreover, data from the study suggest that the quality of argumentation itself was mediated by students' prior knowledge and familiarity with the content. Thus, high-level argument required high-level knowledge of the content. The authors propose two rather important conclusions from these findings: first, that students can only engage in argumentation at content and levels of abstraction that are familiar to them; and second, that when they possess the requisite knowledge, their understanding becomes more integrated and refined as a result of argumentative discourse.

However, these conclusions do not speak to the mechanisms by which argumentative discourse might promote or inhibit the exchange of conflicting claims and evidence or the tempering of conclusions in light of opposing viewpoints, two critical components of scientific reasoning. In the present paper, we attempt to examine this problem space by exploring the ways in which different goals in argumentative discourse may lead to different learning outcomes with respect to scientific reasoning, particularly alternatives-based reasoning.

According to Kuhn (1989), the defining feature of scientific thinking is the differentiation and coordination of theory and evidence. These skills underlying the instantiation of scientific thinking include the ability to consciously articulate a theory, to understand the type of evidence that could support or contradict it, and to justify the selection of one of competing theories that explain the same phenomenon. Thus, the ability to consider alternative hypotheses is essential in this process, as evidence may relate to competing hypotheses. Scientific thinking is ultimately defined as the metacognitive control of this coordination process (Kuhn, 1991, 1993). Kuhn further establishes that it is the desire for scientific understanding that drives the process of coordinating theory and evidence (2010). Thus, as Kuhn puts it, scientific thinking is, in essence, intentional knowledge seeking.

The underlying claim of this paper is that it is the scientific reasoning involved in argumentation that leads to learning. Along with Kuhn and other authors (Berland & Reiser, 2009; Duschl, et al., 2007; Erduran, et al., 2004; Garcia-Mila & Andersen, 2008; Iordanou, 2009; Lehrer, et al., 2008), we see argumentative discourse as a context in which scientific reasoning that aims at the coordination of claims and evidence where claims are debated in a framework of multiple alternatives. In order to argue, individuals elaborate their knowledge as they search for data, warrants, counterarguments and rebuttals to shore up their conclusions. Some of the reasons why argumentation interactive discourse is beneficial when we put dyads argue together are: (a) the students have to look at their own beliefs as contestable; (b) the dyadic interaction is a context where beliefs must be justified with claims and evidence; and (c) the students have the opportunity to weigh their claims and evidence against alternatives. Our claim is that under the right conditions, argumentative discourse provides students with an opportunity to engage in more complex scientific reasoning, exposing them to more complex and developed opposing viewpoints.

Quality of Argumentation

So far, we have outlined some research on the role of argumentation in scientific reasoning and the role of scientific knowledge on argumentation skills but how can we establish the quality of argumentation? In order to define quality of argumentation, we need first to define the analytic approach taken, and second, the criteria used for making judgments, since "the analysis of the argumentation is the point of departure for the evaluation" (van Eemeren, Grootendorst, and Snoeck Henkemans, 2002, p. xiii). Regarding analysis, there are two main approaches that are commonly used in the field of science education. The first is based on the work of Toulmin (1958, 2003) represented in the work of Jimenez-Aleixandre & Pereiro-Muñoz (2002) and Osborne et al., (2004), and Walton (1996; 1998), and the second is represented in the work of Duschl (2008) and Ozdem, Cakiroglu, Ertepinar & Erduran (in press). While Toulmin's model focuses on the components of an argument, Walton's schemes identify the types of arguments as well as the dialogical nature of argumentation (Erduran, 2008). We chose Toulmin's analytical framework because it allows us to explore the relationship between argumentation and reasoning outcomes at the individual level. Toulmin's well known model of analysis (1958, 2003; see Sampson & Clark, 2008; for a review) proposes a structure of argument according to 5 elements: claims (the conclusion, proposition, or assertion), data (the evidence that supports the claim), warrants (an explanation of the relationship between the claim and the data), backings (basic assumptions to support the warrants), qualifiers (words or phrases expressing the speaker's degree of certainty), and rebuttals (the restrictions to discard the claim). Toulmin has been mainly applied to discourse analysis where the unit is the individual (xxx, 2012) because it emphasizes the structure of individual arguments, rather than interactive discourse. Toulmin's model offers an additional advantage specific to our research question. Because Toulmin's model focuses on the structure of arguments, it allows us to examine the complexity of the arguments created in our two discourse conditions which we will discuss in more detail later in the paper. As with any methodological tool, there are limitations to using Toulmin's model pointed out by some researchers in the literature. For instance, Duschl, citing van Eemeren (Duschl, 2008, p.160) points to "the vagueness, ambiguity, and sometimes even inconsistency in his use of key terms", to illustrate that Toulmin Argument Pattern (TAP) uses very general and broad categories to characterize arguments. But despite these limitations, TAP is very useful for the analysis of short argument structures especially, as we will explain later, if we do not need to distinguish between some of the elements within Tolumin's model. As Erduran (2008) points out, the difficulty often associated with TAP is not necessarily an inherent feature of the model itself but rather the adaptation approaches utilised by the researchers trying to use it for their own and often very different purpose than what Toulmin intended with the model.

Given our choice to use Toulmin's model to code the students' discourse, we need to establish how we define quality of argumentation. We take the individual as the unit of analysis, with our focus on the strategies used by each student to fulfill the argumentative goals. Strategies refer to the presence of some specific discourse elements rather than others (e.g. rebuttals or qualifiers), or to the implementation of complex discourse structures, presupposing a high-level of metacognitive knowing, such as the consistent consideration of alternative viewpoints throughout one's argumentation, and the avoidance of "my-bias" perspectives (Baron, 2000).

Following Erduran et al. (2004), and other authors in science education (Berland & Reiser, 2010; Chin & Osborne, 2010; Erduran, et al., 2004; D. Kuhn, 1991; Lin & Mintzes, 2010; McNeill & Pimentel, 2009), we take the presence of rebuttals as an especially important indicator of argument quality in scientific reasoning. According to Kuhn's developmental work (1991), counterarguments and rebuttals are the most complex skills in argumentative discourse. Students must integrate alternative theories to their own, by arguing that their own theory is more correct. According this author a rebuttal is a claim that responds to an opponent's counterargument by countering this counterargument (Felton & Kuhn, 2004; Kuhn, Goh, Iordanou, & Shaenfield, 2008). Given that we take each individual's utterance for analysis, our definition of rebuttals is closer to Erduran et al.'s (2004). We think it pictures the students' wide approach in analyzing one's own claim in relation to the partner's claim. When students make a rebuttal, they not only need to justify their claim but also look for its limitations (advancing a partner's counterargument). For instance: *I propose the thermal station because, although it generates high amounts of CO2, we can prevent nuclear accidents. These could be very harmful for the species in the area, as was the accident in Chernobyl* (see Table 1 for more examples). We define it in terms of objections or exceptions of the Claim, as a statement related to its weak points. It is usually preceded by: "Although", "the only problem is".

The combination of Toulmin's elements (Claim, Data, Warrant, Backing and Rebuttal) resulted in eleven argumentative structures (see Table 1 in the Method

Section). Erduran et al. (2004) distinguish a hierarchy to code the quality of argumentation. According to this hierarchy, a minimum level of quality arguments must contain grounds (e.g., data, warrants, or backing) to substantiate a claim, while a higher level should include rebuttals.

Rationale for the Differences in Argumentation according to the Goals Task

Our prior work has shown that task instructions for argumentative discourse can lead to different outcomes in the quality of students written arguments (xxx, 2009; xxx, 2012). In a pre-posttest design, we asked 7th-grade students to argue in dyads according to two conditions: argue to convince and argue to reach consensus. A third control condition was added to look at change in the absence of argumentative dialogue. We tested whether these three conditions had a positive effect on reasoning about sources of energy in a written text prior and subsequent to the dyads' dialogues. We applied Kelly, Regev, and Prothero's (2008) rubrics to code the quality of reasoning in argumentative texts, and found that all three groups of students showed significant gains, but the students in the consensus condition had the highest rate of reasoning improvement, followed by the persuasion condition and the control, respectively. These results provide additional support to the hypothesis that argumentation promotes reasoning, but they also offer a window into the conditions under which these benefits accrue (see the Rubrics and some reasoning examples in Appendix A). The present study looks at the quality of arguments produced in the two dialogue conditions to explore the relationship between argumentative task goals and reasoning outcomes. We believe that the task goals during argumentative dialogue mediate reasoning outcomes but prompting students to construct and therefore exchange different kinds of arguments.

Literature on argumentation has classically distinguished two distinct kinds of argumentative discourse. People may argue in a disputative dialogue to defend a viewpoint and undermine alternatives, or they may argue in a deliberative dialogue to arrive at a viewpoint by comparing and evaluating alternatives. These two types of activities may be sometimes overlapping (Walton, 1992), but they are clearly distinguished by their goals (Kroll, 2005; Makau & Marty, 2001). Walton (1992) distinguishes the goals of persuasive dialogue from deliberative dialogue. In a persuasive dialogue, the goal of each speaker is to defend a viewpoint and undermine alternatives in order to convince an opponent to switch sides. Here the goal is to win. On the other hand, in deliberative dialogue, the goal of both speakers is to arrive at a shared viewpoint by evaluating alternatives. In other words, the goal is to seek consensus.

In addition, as Leitao (2000) explains, the way in which individuals process opposing viewpoints may be affected by these two goals. She clearly distinguishes these two types of processing by four basic responses involved in confronting opposing claims and evidence in argumentative dialogue: 1) to dismiss counter-arguments and maintain their position; (2) to agree with counterarguments locally, but deflect their impact by turning to other claims in support of their position; (3) to integrate counterarguments by rebutting, qualifying or adjusting their position; or, (4) to accept counterarguments and abandon their position. In the persuasive goal, individuals tend to dismiss counterarguments in order to convince others to adopt their conclusions, whereas in the consensus goal, individuals may combine a full range of these responses.

Various studies have analyzed the effect of task instructions on the quality of written arguments that individuals produce (Ferretti, MacArthur & Dowdy, 2000; Nussbaum & Kardash, 2005). These studies have contrasted the effects of broad goals “to persuade” with specific goals “to produce claims, counterarguments and rebuttals.” Ferretti, et al. (2002) have shown that if the objective is to stimulate adversarial discourse, then a persuasion goal is appropriate. If the objective is to stimulate exploratory discourse, then asking students to generate as many reasons as possible may be a useful pedagogical practice. More precisely, these previous studies found that persuasion goals undermined the quality of argument, particularly in the area of citing and rebutting counterarguments to one’s own position in the writing process. The goal to persuade leads individuals to suppress the use of alternative claims and evidence in their essays because they fear that it will undermine the persuasive strength of their essays (Nussbaum & Kardash, 2005). Similarly, when arguing in dialogues, students explore the problem space less deeply when the goal is to persuade (Nussbaum, 2005; Keefer, Zeitz and Resnick, 2000). Thus, the persuasion goal may prompt individuals to support their position with claims and data but may also prompt them to avoid other argumentative structures that acknowledge opposing viewpoints like rebuttals and qualifications. This hypothesis has not yet been tested.

In the present study, we set out to examine whether argumentative task goals elicited different levels of argument quality in discourse. Our hypothesis is that the students in the consensus group were more likely to produce complex arguments that acknowledged and responded to opposing side claims than students in the persuasion condition, even though both groups were asked to compare their competing views. We believe that these differences would help explain the between-group differences in argument quality at the posttest reported previously, and provide some insight into the mechanisms by which argumentative discourse can positively impact science learning.). Regarding the three reasons why argumentation interactive discourse is beneficial (look at one's own beliefs as contestable; justify one's own beliefs with claims and evidence and weigh claims and evidence against alternatives), we hypothesize that according to the my-side-bias, in the persuasive condition, the students may achieve the first two reasons but not the third one.

Method

Participants

The participants were 65 students drawn from five 7th grade classrooms at a public high school in a medium-sized urban setting near Barcelona, Spain. Students had matriculated from a wide range of public elementary schools in the area and represented diverse academic, ethnic, and socioeconomic backgrounds. Thirty-five were boys and 30 were girls and their mean age was 12.2 (*SD* = 0.4). Although we recognize that even very young children are able to use claims to support a conclusion, particularly in the context of discourse (Anderson, Chinn, Chang, Waggoner & Yi, 1997; Orsolini, 1993), we also recognize that strategies for addressing opposing viewpoints are inconsistent and context dependent well into adolescence (Felton, 2004; Kuhn & Udell, 2003). For this reason, we chose to work with adolescents in this study to ensure that participants were capable of engaging in alternative-based reasoning.

The participants were organized into dyads and randomly assigned to the two argumentative conditions defined by the independent variable (see Design and Procedure). In order to preserve the authenticity of dialogs in the two task conditions, we matched the students in each dyad according to their real opinions. We felt that it was essential for treatment validity that the students always held real, genuinely opposing views with respect to each of the three given dilemmas. Therefore, dyads were rearranged within group for each one of the three dilemmas. As a result, the unit of analysis when coding dialogues was the individual rather than the dyad. There were 34 students in the consensus condition and 31 in the persuasive condition.

Design and Procedure

The study included a between-groups design with one independent variable and one dependent variable. The independent variable consisted of the argumentative prompt that was provided to the dyad before each argumentation session on three successive dilemmas in three respective sessions. The consensus group was prompted to reach consensus, and the persuasion group was prompted to convince their partners (see tasks prompts below). The dependent variable was the quality of argumentation in each partner's discourse. As we have established in the Introduction, we defined the quality of argumentation in terms of the presence of rebuttals.

The study was situated within a teaching unit about energy sources and climate change in a science classroom. Both of these topics are quite common in science curricula around the world as evidenced by being referenced in key international curriculum and assessment documents (e.g. OECD, 2010). An experimenter (second author) worked closely with the teacher over eight 50-minute sessions on the topic of fuel sources and their role in climate change to ensure that participants across conditions had equal access to content knowledge. In the first two sessions, the students were presented with the content about climate change and energy sources, and they responded a pretest (see below). In sessions 3, 5 and 7, the students were presented with three different dilemmas regarding possible solution to their city energy problems (see Appendix B for the three dilemmas). Prior to each argumentative discussion, all participants were presented a dilemma and were asked to write about their position so they could be matched with a disagreeing partner for the study. In sessions 4, 6 and 8, the students were grouped into dyads and asked to argue on the topic of the dilemma for 15 minutes.

The two dialogue groups were asked to argue according to their experimental condition (persuasion goal versus consensus goal). The common instruction for both groups was as follows: '*Your task is to discuss the dilemma just presented to you with your partner for 15 minutes*.' The prompt for each condition continued:

1. In the *persuasive* condition: '*The goal of the task is to convince your partner of the choice you have made about the dilemma by means of a good justification.'*
2. In the *consensus* condition: '*The goal of the task is to reach a justified agreement with your partner and propose a consensus solution to the problem.*'

Finally, after session 8, the students took a posttest (identical to the pretest) to analyze their progress in learning and written argument.

Instruments

Dilemmas. All three dilemmas were about fuel sources and climate change. The first was about an Energy Project for the city designed to accommodate the city's increased population and new energy needs. The Project required a choice among different sources of energy (including nuclear, solar and biodiesel). The second dilemma centered on approving a project that involved developing windmill farms to generate energy. And the third dilemma was about research and development in biodiesels (see Appendix B)

Pretest and posttest. The pretest and posttest were identical. Students were asked to write an essay proposing an energy plan that argued in favor of using one or more energy sources. A full description of the pre-post test results comparison according to condition are presented elsewhere (See xxx). As we have mentioned in the introduction, the analysis of the quality of reasoning (Kelly, et al., 2008) yielded higher reasoning gains for the students in the consensus condition. The analysis of the dialogues will shed light to explain these gains. In particular, students in the consensus condition were more likely to retain information and craft arguments that acknowledged opposing viewpoints. They were also more likely to acknowledge the limitations of their own conclusions, suggesting that they were open to revising or refining their plans even after their dialogues. Finally, students in the consensus condition were also more likely to cite evidence for claims on their own side than their peers in the persuasive condition.

Coding Scheme. The argumentative structures were coded according to an adaptation of Erduran, et al.'s rubric (2004). The rubric has been used by a number of science education scholars across the world (e.g. Clark & Sampson, 2007; Skoumios, 2009) to investigate the nature and quality of argumentation in the context of science education. The rubric categorizes each argumentative utterance in terms of Toulmin's argumentative elements[1]: claim, data, warrant, backing and rebuttal. The combination of these elements resulted in eleven argumentative structures. Participants could produce an utterance that included a claim and only one data, or else, a claim with several data. In terms of coding, both cases were coded as the Claim-Data structure (see Table 1 for the coding rubrics). The 11 argumentative structures that resulted from the combination of Toulmin's elements were Claim (C), Claim-Data (CD), Claim-Backing (CB), Claim-Rebuttal (CR), Claim-Data-Warrant (CDW), Claim-Data-Backing (CDB), Claim-Backing-Rebuttal (CBR), Claim-Data-Warrant-Backing (CDWB), Claim-Data-Warrant-Rebuttal (CDWR), Claim-Data-

[1] Qualifiers were not included because we were not interested in the finer level of analysis of arguments but rather the overall structures of arguments that students produced in either condition. This ommission is consistent with Erduran, et al (2004)'s study.

Backing-Rebuttal (CDBR), Claim-Data-Warrant-Backing-Rebuttal (CDWBR). It is important to note that Claim-Data structures could comprise a claim supported by one data source or many. In either case, the structure was coded as an instance of the same unit. Inter-rater reliability was calculated by double coding forty-five per cent of the dialogues for the argumentative structures reaching 85.2% exact agreement. Disagreements were resolved through discussion. The statistics used to test significant differences between means was the student's *t* test (for normally distributed data) and the *U Mann Whitney* (for non normally distributed data).

Insert Table 1 about here

Results

The following results focus on the quality of argumentative discourse among the students. As we have mentioned in the Method Section (Instruments), we applied an adaptation of Erduran, et al's. (2004) scheme to individuals' utterances in the 111 dialogues (see Table 1).

Our analysis tests the hypothesis of the study by comparing the quality of argumentation according to the goals of the argumentative task. In order to rule out the possibility that between group differences were attributable to difference in utterance length, we compared the number of elements in the argumentative structure of each utterance, regardless of the type of element in it. The means (and *SD*) of the length of the structures according to condition are presented in Table 2. As seen in Table 2, none of the statistical tests yielded significant differences. The number of elements in the structures ranged from 1 to 7 and the highest frequency was for structures that contained 1, 2 and 3 elements whose mean values were, respectively, 18.3, 29.7, and 14.0.

Insert Table 2 about here

Once we ruled out the possibility that differences in the quality of the discourse might be due to differences in length, we went on to identify the structure of each utterance. We observed the highest frequency in two-element argumentative structures, which could be Claim-Data (CD), Claim-Backing (CB) or Claim-Rebuttal (CR). When the corresponding means are compared across the two conditions, we observe that the mean for CD in the persuasive condition [23.8 (10.5)] was significantly higher than the mean in the consensus condition [18.8 (9.1)] [$t\ (63) = 2.07,\ p = .04$); effect size $d = 0.51$]. The second two-element argumentative structure: CB did not yield significant differences. The means (*SD*) were much lower than for CD. They were for the persuasive condition 0.74 (1.2) and for the consensus, 0.29 (0.67) [*U Mann-Whitney* = 439, *ns)*. Finally, the third two-element argumentative structure: CR yielded a significant difference. The mean (*SD*) for the consensus condition was 1.48 (1.57) and for the persuasive condition was 0,45 (0.89), (*U Mann-Whitney* = 334 p=.005; effect size $r = 0.37$). Hence, we observed that the students in the persuasive condition tend to make more Claim-Data structures, while the students in the consensus condition tend to make more Claim-Rebuttal structures.

Also, beyond the 2-element structure, many of the students' argumentative structures showed several repeated elements. For instance, a structure CDDDD is radically different to a structure CDWBR. As mentioned in the Introduction, the presence of rebuttals is a good indicator of quality of the argumentation (Osborne, et al., 2004; Kuhn, 1991). In coding the argumentative structures, we collapsed all the structures according to the types of elements rather than to the number of elements in the same category. For instance, CDDD, CDD and/or CD were considered in the category CD. That is, the repeated elements in each structure were not taken into consideration. Out of the eleven argumentative structures, there were five that include the element rebuttal. Our hypothesis stated that there should have been more argumentative structures containing rebuttal elements in the consensus condition.

As expected, the means comparison of the two groups for the eleven argumentative structures indicated that the consensus condition was associated with a significant increase in four out of the five argumentative structures where rebuttal was present, with no other significant differences in the other structures in favor of the consensus condition. Table 3 shows the mean number of the structures of each type according to condition. The first structure that yielded significant results is Claim-Rebuttal (CR). The corresponding data are close to the data presented above, in the two-element argumentative structure, but data are slightly higher because in this structure we pooled the structures with claim and one or more rebuttals [mean (and *SD*) for the consensus condition = 1.6 (1.8) and the mean for the persuasion condition = 0.6 (0.9); ($U = 323.5$, $p = .004$; effect size $d = 0.70$). The second structure is Claim-Data-Rebuttal (CDR) where the mean for the consensus condition was 2.1 (1.3) and for the persuasive one, 1.3 (1.1), ($U = 378.5$, $p = .04$; effect size $r = 0.315$). Means for the third structure (Claim-Data-Warrant-Rebuttal) were 1.5 (1.5) for the consensus condition and 0.6 (0.9), ($U = 342.5$, $p = .01$; effect size $r = 0.34$) for the persuasive condition. The fourth structure containing rebuttals, Claim-Data-Backing-Rebuttal (CDBR), did not yield significant differences. The mean and *SD* were identical for both groups [0.03 (0.2)]. Finally, the last structure, Claim-Data-Warrant-Backing-Rebuttal (CDWBR) also yielded significant differences. The mean (*SD*) for the consensus condition was 0.15 (0.3) while for the persuasive condition it was 0. ($U = 449.5$, $p = .027$; effect size $r = 0.33$). As we can see in these data, out of the five argumentative structures that contained a rebuttal, only one did not yield significant results in the means comparison tests. It is also worth mentioning that none of the other comparisons for the structures that did not contain the rebuttal element yielded significant differences in favor of the consensus condition.

Insert Table 3 about here

However, we also want to highlight the significant difference that yielded the comparisons of the mean number of Claim-Data in favor of the persuasive condition. The mean number of Claim-Data structures in the consensus condition was 23.1 (*SD* = 9.5) and in the persuasive condition, the mean was 28.4 (10.8), ($t\ (63) = 2.1,$ p = .039; effect size $d = 0.53$)[2]. None of the other comparisons yielded significant differences. Table 3 shows the estimated marginal means for each condition, along with the results of the significance tests. It is worth mentioning that in a previous study reported elsewhere (xxx, 2012), we analyzed the rate of repetitions of Claim-Data across conditions and we observed that the students in the persuasive condition repeated more claim data structures with identical content than those in the consensus condition (xxx, in press). This means that although the students made more Claim-Data structures in the persuasion condition, a high proportion of those were repetitions of the same argumentative structures containing the same ideas.

The following dialogue excerpt from the persuasion condition debating dilemma 1 (see Appendix B) illustrates these trends. Here we observe how the partners in the dyad make claims and every once in a while add a warrant to elaborate the claim, but none of the utterances shows attention to weighing or examining alternatives (codes are added below each utterance):

[2] We must take into account that this measure of CD results from collapsing all structures that contain C and one or more D. This is why the numbers are different to the CD correspond to the two-long structure, which only container one C and one D.

Michael*: I chose B (Nuclear Energy) because I think it is less contaminating and it does not produce* CO_2*, and it does not aggravate climate change.*

CDW

Andrea*: I chose A (Fuel Energy) because I think that with nuclear energy, if there is a leak, we won't be able to go backwards, we won't have any chances to do anything.*

CD

Michael*: The thermal power stations work with cool energy, and we will run out of it in 75 years. Then with this power station we will be producing more* CO_2 *and cause climate change*

CD

Andrea*: but nuclear may cause many problems in a short time*

CD

Michael: *but the problem will not be as important as the temperature rise due to the* CO_2 *emissions.*

CDW

Andrea: *but we can suffer from many severe diseases due to radioactivity, our future generations may be born with malformations due to small leaks.*

CDW

Michael: *but thermal power stations produce acid rain, a type of rain very harmful for human beings.*

CD

Andrea*: Ok but if there is a leak? It may affect areas many kilometers around. It does not only contaminate the area where the nuclear station is located, but also many kilometers around it.*

CDW

In contrast with the previous dialogue, also from dilemma 1, Mark and John, in the consensus condition show a greater presence of two-sided reasoning measured by the presence of rebuttals (see rebuttals marked in bold face).

Mark*: Why did you choose option A?*

John: *Because it does not produce* CO_2 *and because it produces more energy than the thermal power station*

CD

Mark: *But the maintenance is very expensive*

CD

John: *Yes but it does not increase the greenhouse effect because it does not produce* CO_2 *in spite of the fact that they* ***their maintenance is more expensive****, they are better for the environment. They do not produce acid rain either and they are renewable*

CDDDDWWR

Mark: *central power stations can be installed anywhere*

CD

John: *nuclear power stations, too*

CD

Mark: *but they produce radiation*

CD

John: *they produce radioactivity but thermal stations produce* CO_2 *and it causes the greenhouse effect and climate change and it its effect reaches the whole world while* ***radioactivity only affect the area*** *where it is located.*

CDDWR

Mark: *but the thermal power stations generate radioactivity*

CD

John: ***although it produces radioactivity****, it only affects a specific location*

CDR

Mark: *and what happened in Chernobyl?*

CD

John: *Nuclear power stations are better because at least they do not contaminate the whole atmosphere like thermal stations with* CO_2

CD

Mark: *but there are still sick people in Chernobyl due to a radioactive leak produced 20 years ago*

CB

John: ***nuclear radiation may be the cause of illnesses****, but if thermal power keeps producing* CO_2*, our Planet will heat up and living beings will suffer from serious illnesses,* ***while nuclear radioactivity will only affect the specific areas nearby as in the case of Chernobyl***

CDWBR

Mark: *But radioactive waste remains alive for many years, even centuries*

CD

John: *... and* $C0_2$ *too! Radioactivity will disappear with time but* $C0_2$ *will not because we keep producing it more and more*

CDW

Mark: *but still today we are suffering the consequences of the nuclear power accident in Chernobyl that happened 20 years ago.*

CB

John: *You did not understand anything*. ***What happened 20 years ago in Chernobyl was a nuclear power accident but this does disappear*** *with time but CO_2 keeps being produced day after day.*

CDR

The dialogue continues, Mark and John go on to debating renewable energies, with their pros and cons, and end up reaching consensus for the hydraulic energy. The presence of rebuttals in the excerpt illustrates the higher occurrence of alternative-based reasoning in the consensus condition.

If we represent the previous dialogues using Erduran, et al.'s analytical framework (2004; see Table 4 for an adaptation of the five levels into four), we can observe in Table 5 and Figure 1 that any structure involving rebuttals is significantly more present in the consensus condition.

Insert Table 4 about here

As we observe in Table 5 and Figure 1, there were two levels that showed significant differences across conditions. The first one is level 2 that shows the means for Claim-Data (this is equivalent to the previous test in Table 2). The other level that yielded significant differences was level 4. The students' mean number of argumentative structures of level 4 in the consensus condition was higher than in the persuasive condition. The mean for the consensus condition was 3.7 (SD = 3.5) and the mean for the consensus condition was 7.2 (SD = 3.8); (*U Mann-Whitney =234.5,* p= .001, effect size r = 0.43) (see Figure 1).

Insert Table 5

Insert Figure 1 about here

Another interesting move observed in the dialogues of the consensus condition is the shift to a third alternative, neither nuclear, nor thermal. The students keep debating the advantages and disadvantages of each source, to end up reaching consensus on a different alternative. In the following excerpt, Sandra is pro thermal energy while Xavi is pro nuclear energy, but they reach consensus on three renewable energies (solar, hydroelectric and wind). The excerpt begins once Sandra and Xavi realize that they have discussed all reasons but did not reach consensus:

Sandra*: I vote A*

Xavi: *me, B*

Sandra: *A!*

Xavi: B! *I do not know what else to say*

Sandra: *Me neither*

Xavi: *Another choice would be propose renewable energies, such a solar or wind energy*

Sandra: *I agree with this idea, but the debate is about thermal and nuclear*

Xavi*: But since we do not agree, we can also propose different energies*

Sandra: *Why don't you get to agree with me?*

Xavi: *Do not interrupt me! This has nothing to do with it, because if we do not agree we can choose a renewable energy such as wind energy*

Sandra: *that's why I said I agree!*

Xavi: *Ok then, that's it!*

Sandra: *But we have not found a solution yet*

Xavi: *It's ok, we can think about it now. Which one do you think is better, wind, sun or hydroelectric?*

Sandra: *For me, the best is solar energy but if there is no sun, we will run out of energy. We can choose wind energy, because we will never run out of wind.*

Xavi: *We can choose all of them. You should think that the renewable sources of energy do not produce as much energy as thermal stations.*

Sandra: *but which ones do you propose? Wind, sun or hydroelectric?*

Xavi: *Yes, hydroelectric, we can put it near Ebro River, it is a very mighty river, Solar panels right here and windmills in the sea.*

Sandra: *So that's it!*

Xavi: *Yes, we could propose all renewable energies.*

Sandra: *Wind, sun and hydroelectric*

Xavi: *The hydraulic station would be installed in the Ebro River, windmills in the sea and solar panels here.*

Sandra: *But this would cost a lot of money, and I'm not sure we would generate enough energy to cover the needs.*

Xavi: *Of course we would*

Sandra: *But also, it will be very expensive to install only renewable energy*

Xavi: *But they do not contaminate, and they will be efficient, eventually*

Sandra: *But where will we get the money from?*

Xavi: *From taxes.*

Sandra: *So, then OK. We propose hydroelectric, solar and wind energy. Our proposal is renewable energies because they do not contaminate*

Xavi: *Yes, and we will cover the cost by increasing taxes.*

Discussion

The results of the present work show that argumentative task goals have an effect on the quality of argumentation, and help explain one way in which argumentation enhances learning outcomes in science (xxx, 2009). Our findings show that when students engage in argumentative dialogue to reach consensus with a peer rather than to persuade them, they produce a greater variety of complex argument structures, particularly those which involve two-sided reasoning. Consistent with our hypothesis, we found that the students in the consensus condition showed a significantly higher number of rebuttals in their discourse. Given that rebuttals represent an acknowledgement of the limitations to one's own claim, we see that the higher number of rebuttals show that the students are more likely to pay more attention to both sides of an issue. Qualitatively we can say that they also are more likely to acknowledge the limitations of their own conclusions, suggesting that they were open to revising their claims in the dialogical process. This may suggest that the students' discourse in the consensus condition was not as polarized and showed a wider array of arguments and evidence on either side of an issue and hence, a less biased discussion of the dilemmas. Our findings extend prior research into the impact of persuasion goals on reasoning (Nussbaum, 2005; Nussbaum & Kardash, 2005; Keefer, et al., 2000) by contrasting the use of two-sided reasoning in two argumentative discourse settings. Students in the persuasive condition did not show their "cards" by pointing at the limitations of their own position, and thus showed higher my-side bias (Baron, 2000) and narrower discourse.

Our interpretation of the data is further supported by a second set of significant results related to Claim-Data structures. We found that the students in the persuasive condition made more Claim-Data structures than the students in the consensus condition. We might interpret this finding to mean that in the interest of being persuasive, students tend to make sure to support their claims with clear-cut evidence, to dismiss counterarguments and maintain their position (Leitao, 2000). Taken together, our findings lend further support to the claim that, when asked to persuade, adolescents favor supporting their own claims with data at the expense of considering the limitations of their claims in light of opposing side data. Also, as shown in xxx (in press) the students in this group tended to repeat the arguments over and over using the fallacy of *argmentum ad nauseam.* Hence this higher number of Claim-Data structures contains a high number of repetitions and thus, fewer different ideas and a semantically poorer discourse.

Our results support Leitao's (2000) proposal of differential processing when individuals have to confront opposing claims and evidence depending on the argumentative goal. Individuals in the consensus condition tend to respond to opposing views by in a variety of ways: agreeing with counterarguments locally, but deflecting their impact by turning to other claims in support of their position; integrating counterarguments by rebutting, qualifying or adjusting their position; or, accepting counterarguments and abandoning their position. Individuals in the persuasive condition, on the other hand, tend to dismiss counter-arguments to maintain their position.

Also, along with Kuhn, et al.'s results (2008) we observed dialogues that sometimes led to the proposal of a third alternative (neither yours nor mine, no winner).

As illustrated in the excerpt in the Results Section, some of the students' dialogues, especially in the consensus condition shifted to identifying and elaborating a kind of neutral position clearly away from making counterargument against the partner's position. This corresponds to what Gilbert (1997) describes as ''coalescent argumentation.'' According to Gilbert (1997), this type of discourse pursues an increase of the understanding by a richer use of each other's ideas to construct and negotiate a shared understanding of a particular phenomenon in light of new information (Andriessen, Baker, & Suthers, 2003; Boulter & Gilbert, 1995; Nussbaum, 2005).

Our claim is that when students know they have to reach consensus, they tend to explore one another's claims more fully and look for ways to integrate knowledge rather than disregarding opposing claims and evidence out of hand. We observe a deeper analysis of the mutual arguments in order to co-construct a solution to the dilemma. The higher presence of rebuttals implies higher questioning and challenging the ideas being discussed. In contrast, the students in the persuasive condition tend to "rock" themselves in their position defending it strongly so they do not fail by letting the partner convince him/her. In Berland and Reiser (p.44): students' focus in the persuasive condition was to stand by their original claims without working to improve them. It is not so much a matter of attacking their partner but a matter of defending his or her own position. Hence, they do not spend energy in evaluation their partner's arguments with negative consequences for the students' learning (Jimenez-Aleixandre, 2008).

Finally, in order to establish the relationship between quality of argumentation and learning, we interpret the present results in terms of Mercer's (2000) types of classroom talk. We align with Mercer's main point in that the three types of classroom talk: disputative, cumulative and exploratory mediate learning differently. In the cumulative talk, a non-critical, non-competitive and constructive relation is established where the differences between the partners are minimized. In contrast, in the disputative talk, our conversational partners are treated as a threat to our interests. Finally, Mercer defines exploratory talk as dialogue that explicitly deals with differences as a common topic to be explored, accompanied by a reasoned assessment to facilitate resolution. In exploratory talk the goal is to enhance understanding of an issue, not to win a debate hence leading to the co-construction of knowledge. Mercer's (2000) distinction between the exploratory talk on the one hand, and cumulative and disputative on the other fits into our two types of discourse. Our students in the persuasive condition showed a discourse similar to that described by Mercer in the cumulative or the disputative talks, whereas the description he makes of the exploratory talk clearly matches with the discourse of the students in the consensus condition. That fact that we observed a higher presence of rebuttals in the consensus condition is an indicator of two-sided reasoning, in what we could hypothesize as an attempt to integrate different knowledge perspectives, and consequently reach better learning.

Students' typical uncooperative and disputational attitude (Maloney & Simon, 2006) combined with their lack of substantive engagement with one another's ideas (Brown & Campione, 1996; Hatano & Inagaki, 1991) lead to their lack of success in working collaboratively, and in learning. Hence, students need to be taught about the benefits of talking effectively (Drummond & Mercer, 2003), and one possible way to start is by making the goals of argumentation more explicit. We need to emphasize activities that promote coalescent argumentation (Anderson, et al., 2001; Kuhn, 2008; Nussbaum, 2005). In order to make classroom activities effective for learning, we need to design situations that engage students in explicitly analyzing one another's ideas. The consensus condition created a need to value one another's ideas and respond to one another's competing claims and evidence. We have seen that it is particularly important to provide opportunities for individuals to not only link claims and evidence through classroom argumentation tasks (Venville & Dawson, 2010), but especially to consider both in light of alternatives. The two-sided reasoning in which the students in the consensus condition engage came out to be essential for knowledge construction.

Limitations and Implications for Further Research

While the results of the present study offer some key insights into the benefits of argumentative discourse for scientific reasoning, some questions require further attention. In particular, our analysis of argument structure offers only one lens for argument quality. We focused our attention on opposing views, particularly in the form of rebuttals, as an important indicator of two-sided reasoning. However, the relevance of the opposing views cited, and the strength of the speakers' responses were not analyzed in the data set. As von Aufschnaiter, et al., (2008) point out, high-level content facilitates high-level argument, and nuances to the quality and complexity of arguments in this study deserve further attention. However, we believe that our current findings complement the extant literature by identifying two-sided reasoning as a mechanism by which argumentative discourse promotes knowledge construction.

Another limitation of the present study lies in the unit of analysis. While an analysis of the argument structures that individuals created in dialogues provides insight into their thinking, it does not provide insight into the role that collaborative reasoning played in their thinking and learning. This question warrants further study. In particular, it would be interesting to investigate the relationship between discourse goals and the particular questions, challenges and responses that students produce during dialogues. It is reasonable to expect that argument structures are not independent of partners' arguments, but are responses to these arguments, and we believe that an analysis of these interactions will provide a more complete understanding of the mechanisms by which argumentative discourse impacts independent reasoning. We are currently in the process of analyzing these data taking as the dyad as the unit of analysis to explore this question.

Despite these limitations, the results of our study articulate the nuances of effective argumentation at the level of the science classroom and confirm that under the right conditions, argumentative discourse can be a powerful tool for promoting two-sided reasoning in science classrooms. When students argue with their peers, they are exposed to alternative claims and evidence that can enhance their understanding of a topic. But the results also offer an important note of caution. Argumentative discourse is mediated by students' understanding of task goals and it is imperative for teachers to help their students appreciate the benefit, rather than the threat, of opposing viewpoints for learning. Curriculum interventions that facilitate argumentative discourse among young adolescents must be situated in contexts where students value other perspectives as a means of refining and elaborating their understanding in science.

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Table 1.

Rubrics for Coding the Argumentative Structures (see xxx, in press)

Type	Definition	*Example*
Claim C	The thesis.	*I want a nuclear power station. I do not want a thermal station.*
Claim Data CD	The thesis is followed by data that supports it.	*I want the nuclear power station because it does not produce CO2, and it can also produce more electrical energy.*
Claim Backing CB	The thesis is followed by one or more theoretical or historical statements that support it.	*I want the thermal power station because there are still people who are sick due to the Chernobyl accident.*
Claim Rebuttal CR	The thesis is followed by a comment that admits limitations or by one or more features that support the opponent's thesis.	*I prefer the nuclear power station. Although if there were a leak, the effects would last for many years.*
Claim Data Warrant CDW	The thesis is followed by one or more statements of data and by further elaborations to help justify the data.	*I support the nuclear power station because it does not produce CO2; thus, it will neither increase the greenhouse effect nor produce acid rain.*
Claim Data Backing CDB	The thesis is followed by one or more statements of data and is followed by a theoretical or historical statement that justifies them.	*I support the nuclear power station because it will not increase the greenhouse effect and it will not violate the Kyoto Agreement to reduce CO2 contamination.*
Claim Data Rebuttal CDR	The thesis is followed by data and by limitations and/or features that support the opponent's claim.	*I like the thermal energy project because there is no risk of radioactive*

		leaks, although I admit that nuclear energy does not produce CO2.
Claim Data Warrant Backing CDWB	The thesis is followed by data containing statements that support it and by theoretical or historical statements that support it.	*I support the thermal energy project because nuclear power stations can cause radioactive leaks, and this can cause cancer problems, as in Chernobyl.*
Claim Data Warrant Rebuttal CDWR	The thesis is followed by data that support it, followed by statements that support the data, and by limitations of the claim that refer to positive aspects of the partner's claim.	*I propose the nuclear power station because it does not generate the greenhouse effect, which would be very harmful for the adaptation of certain species, although it is true that it could cause nuclear accidents.*
Claim Data Backing Rebuttal CDBR	The thesis is followed by data, by theoretical or historical statements that support it, and by limitations of the claim that refer to positive aspects of the partner's claim.	*I propose the thermal station because it does not generate radioactive waste and because there could be nuclear accidents such as the one in Chernobyl. Although I admit that the nuclear station would decrease climate change.*
Claim Data Warrant Backing Rebuttal CDWBR	The thesis is followed by data, by statements that support it, by theoretical or historical statements that also support it, and by limitations of the claim that refer to positive aspects of the partner's claim.	*I propose the thermal station because, although it generates high amounts of CO2, we can prevent nuclear accidents. These could be very harmful for the species in the area, as was the accident in Chernobyl.*

Table 2. Means (*SD)* for the Number of Utterances for each Length of Argumentative Structure according to Condition

Number of Elements	Persuasive n=31	Consensus n=34	Statistical test
1	18.3 (11.2)	18.5 (10.3)	*t (63)* =-.05, *ns*
2	29.7 (11.5)	24.9 (9.9)	*t (63)* = 1.78, *ns*
3	14.0 (6.6)	13.3 (5.01)	*t (63)* = 0.44, *ns*
4	6.0 (4.1)	6.5 (2.8)	*t (52.5)* = 1.7, *ns*
5	1.2 (1.2)	1.9 (1.8)	*U Mann Whitney = 405.0 ns*
6	0.3 (0.6)	0.5 (0.9)	*U Mann Whitney = 452.5, ns*
7	0.03 (0.2)	0.1 (0.4)	*U Mann Whitney = 497.0, ns*

Table 3

Means (*SD*) for the Number of Utterances according to Type of Argumentative Structures and according to Condition

Structure	Condition		Statistical test
	Persuasion	Consensus	
C	18.3 (11.2)	18.5 (10.3)	*t* (63)= -.0.5; *p* = .9[a]
CD	28.4 (10.8)	23.1 (9.5)	*t* (63)= 2.1; *p* = .039* *d* = 0.53
CB	0.7 (1.3)	0.3 (0.7)	*U*= 439.0, *p* = .14
CR	0.6 (0.9)	1.6 (1.8)	*U*= 323.5, *p* = .004* *r* = 0.37
CDW	8.7 (5.1)	8.0 (4.3)	*t* (63)= 0.5, *p* = .6
CDB	0.6 (0.8)	0.4 (0.8)	*U*= 446.0, *p* = .2
CDR	1.3 (1.1)	2.1 (1.3)	*U*= 378.5, *p* = .04* *r* = 0.315
CDWB	0.4 (0.7)	0.35 (0.6)	*U*= 498.0, *p* = .6
CDWR	0.6 (0.9)	1.5 (1.5)	*U*= 342.5, *p*= .01* *r* = 0.34
CDBR	0.03 (0.2)	0.03 (0.2)	*U*=525.5, *p* = .95
CDWBR:	0 (0)	0.15 (0.3)	*U*= 449.5, *p* = .027* *r* = 0.33
Mean Total	69.50 (23.1)	% Coded: 84.60	

[a]This value for Level 1 corresponds to the value for a one-long structure in Table 2, and for C in Table 3. The value for Level 2 (CD) corresponds to the CD in Table 3 but not to the two-long structure given that the former may have more than one D (e.g., CD, CDD, CDDD, etc.). ________________________________

C: Claim, CD: Claim Data, CB: Claim Backing, CR: Claim Rebuttal, CDW: Claim Data Warrant, CDB: Claim Data Backing, CDR: Claim Data Rebuttal, CDWB: Claim Data Warrant Backing, CDWR: Claim Data Warrant Rebuttal, CDBR: Claim Data Backing Rebuttal, CDWBR: Claim Data Warrant Backing Rebuttal

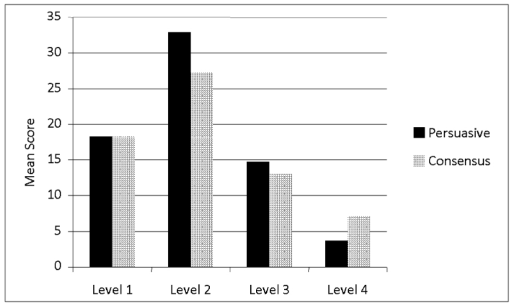
Table 4. Analytical Framework for Assessing the Quality of Argumentation (adapted from Erduran, et al., 2004)

Level 1: Arguments that contain a simple claim[a]
Level 2[3]: Arguments consisting of claim and data[a]
Level 3: Arguments consisting of claims with either data, warrants, or backings, but do not contain any rebuttals
Level 4: The above plus one or more rebuttals.

[a]Level 1 and Level 2 correspond to the data in Table 3.

Table 5. Means *(SD)* for the Number of Utterances according to Argumentative Level and according to Condition

	Argumentative Condition		
Level	Persuasive n=31	Consensus n=34	Statistics
Level 1	18.3 (11.2)	18.5 (10.3)	*t (63)* = -.05, *p* = .9
Level 2	28.4 (10.8)	23.1 (9.5)	*t* (63)= 2.1; *p* = .039
Level 3	14.7 (8.6)	13.0 (6.4)	*t (63)* = 0.91, *p* = .3
Level 4	3.7 (3.5)	7.2 (3.8)	*U Mann-Whitney* = 234.5, *p* = .001, *r* = 0.43



Argument Quality
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Appendix A. Rubrics for Coding the Argumentative Essay in the Pre/Post and Examples (adapted from Kelly, et al., 2008, see XXX, 2009).

Criteria	Examples
The proposal is justified by explaining the advantages of the choice	*i.e. I propose the windmill farms because they do not contaminate and wind energy is renewable energy*
There is clear proposal of the forms of getting energy, and also the student is aware of the limitations of the proposal	*Nuclear power stations are very energetic, and do not contaminate with CO2, but they are dangerous. They have the risk of leaks*
The discarded forms of getting energy are justified by explaining their limitations	*I discard the biodiesel because it would make the poor countries even poorer*
Although there is clear proposal of the forms of getting energy rejected, the student is aware of its advantages	*I'd never suggest the nuclear energy, because although it does not contaminate with CO2, it could have leaks and this would kill the population*
The thesis about the forms of getting energy proposed and discarded are kept until the end of the text in a coherent manner	*I think the best is sun energy because it does not contaminate and you can sell the extra energy produced. It does not destroy the environment (…). As I mentioned before, the best is the sun energy because in addition to al the advantages, it is unlimited*

Appendix B. Dilemmas

Dilemma 1. *The energy dilemma in the province of Tarragona*

The province of Tarragona has seen its population increased a 40% in the last ten years. This has caused a very significant increase in energy consumption in the province. Several studies have found that if this increase in population continues and with it, the increase of energy consumption, Tarragona could have problems to supply the necessary energy to its various locations, including Torredembarra. Currently, the province gets power generated by two existing nuclear power stations: Vandellòs and Ascó. It also gets energy from two fossil (coal and oil) power plants. Tarragona also consumes energy generated by two windmill farms as well as from other renewable energy sources that have been promoted in some small towns, although these types of clean energy means a very low and insufficient energy supply for the high energy demand expected in the future due to the strong population growth. Given this expected energy deficit in the near future, the Environmental Office of the Local Government met with mayors of the towns involved to inform about two projects submitted by two different companies to solve the energy problem.

Project 1 is led by the company *Power Stations of Fossil Energy* (PSFE). The project is based on the installation of a big Power Thermal Station based on coal burning. Project 2 is headed by the company "Nuclear Energy in Spain" (NES) and is based on the installation of a large Nuclear Station. The PSFE' directors explained the benefits of project 1 vs. project 2. The managers reported to the mayors that the installation of a thermal station based on coal combustion could be end with the energy deficit. They also explained that it would be cheaper, besides the fact that it could be installed anywhere in the province and it would create new jobs. In addition, the PSFE's management claims that the installation of a thermal station that works with coal combustion doesn't generate radioactive waste and avoids any risk of radioactive leaks. In fact, the PSFE company reminded the mayors of the nuclear disasters occurred in the past. Also, they explained that nuclear plants are being replaced by other forms of energy such as thermal energy obtained from fossil combustion.

On the other hand, the directors of NES Company (Nuclear energy in Spain) defends project 2. They claim that the best choice is to install a big Nuclear Power Station. First claim that the installation of a Nuclear Power Station would solve the problem of energy deficit suffered by the region. They argue that leading countries in Europe such as Sweden, France and Belgium are going back to Nuclear energy and they believe that Spain also should do it in order to decrease the effects of climate change. The managers claim that Nuclear Power Stations produce more energy than a Thermal Power Station by fossil combustion. They particularly emphasize that nuclear power doesn't generate carbon dioxide emissions or harmful gases that cause the Greenhouse effect. The managers have reminded the mayors of the province that currently thermal power stations by fossil burning produce 30% of the emissions that cause climate change. The carbon dioxide can also cause acid rain and health problems to the people living nearby. They have also pointed out that nuclear energy is inexhaustible while thermal stations use exhaustible energy.

The mayos of the province, after hearing arguments of the various directors of two companies that support each project, vote to choose one of two projects: Project 1 advocated for the installation of a Thermal Power station proposed by the company PSEF while Project 2 supported by the NES company proposed the installation of a Nuclear power station. Imagine that you're the mayor of your town and you'll be the last person to make your vote to choose one or another project. When your turn comes, there is a tie between the two projects, so your vote is vitally important because it will decide what project will be carried on. Before choosing one or the other, assess carefully which of the two projects is the best and think of arguments that support it.

Choice A: Project 1- proposed by the company PSFE- claims the settlement a thermal power station for fossil fuel combustion (coal).

Choice B: Project 2- proposed by the company NES- claims the settlement of a Nuclear Power Station.

Dilemma 2. *The dilemma of the windmill farm in the area of Tarragona*

The villages of Baix Gaià and Tarragona have initiated a joint project to promote renewable energy (clean energy), with the aim of reducing greenhouse gases emissions such as CO_2. One of the measures agreed upon by the Council members of the different towns in the area is to limit the local consumption of electricity to renewable and clean energy sources, excluding nuclear power plants and thermal power stations which operate on fossil fuel. This agreement would decrease the emissions of CO_2 a 75%, and it would certainly be a very important step to fight against the greenhouse effect and the effects of climate change. After having run several studies to decide the best location for the settlement of the windmill farm, engineers of the Local Government have agreed that the best area is the one located between Torredembarra and Pobla de Montornès. This proposal has divided the opinions among residents of Baix Gaià. They have got organized into two environmental organizations according whether they want to have the windmill farm r not. Those in favour are called the "Baix Gaià Renewable", while the residents who refuse tit are called "Green Planet".

The "Renewable Baix Gaià" group defend the settlement of the windmill farm of the wind park for different reasons. Firstly, they claim that the place is an ideal area because the wind blows with high intensity, which would guarantee sufficient energy for the whole region. They also argue that although it is a wooded area, the settlement of the farm would not be a problem because it is a very neglected area.

The group "Renewable Baix Gaià" thinks that with the windmill farm, the CO_2 emissions would be reduced because the villages in the area would consume only the energy provided by the windmill farm. Thus according to this group, this project would not involve environmental aggressions such as emissions of toxic substances, waste production, acid rain or emissions of greenhouse gases. In contrast, the environmental group "Green Planet" is totally opposed to the settlement of a windmill farm in the wooded area between Pobla de Montornès and Torredembarra. They believe that this is only a place for animals and vegetation in the area, as well as an area for migratory birds. It is a Mediterranean area in danger, with unique plant and animal species. The Local Government insists that this is the best area to locate the windmill farm but the group "Green planet" insists that the installation of the windmill farm of Pobla de Montornès will cause the destruction of the ecosystem of the area, while the Renewable Baix Gaià environmental group insists that with the settlement of the windmill the emission of many greenhouse gases like CO_2 will be avoided, which would ultimately reduce the effects of climate change.

The mayos of towns in Baix Gaià proposed a referendum in which people over 12 have to vote whether they are in favour or against the settlement of a windmill in the area located between Torredembarra and Pobla of Montornès. The results of the polls will determine if the project will be developed. You have to decide the choice that you think is appropriate, after weighing the two options and carefully thinking the pro and cons arguments.

Choice A: I will vote for the windmill farm. The most important thing is to reduce the greenhouse effect with its climate change consequences

Choice B: I will vote against the windmill farm. This is an area of woodland and although there is a neglected place there is an ecosystem. The park would affect the ecosystem of this area with the destruction of some species, in addition to the visual impact on the landscape.

Dilemma 3. *The Dilemma of the Biodiesel: Biodiesel yes-Biodiesel no*

Everything points out that one of the basic solutions to reduce the greenhouse effect-the main cause of Climate Change-may be the use of biodiesel. These are proposed as clear substitutes for fossil energy, which as we know, emit large amounts of CO_2 (carbon dioxide) into the atmosphere, the major problem of global warming. The Biodiesel is the alternative energy of the future in industrialized countries. In addition to solving problems of running out of fossil fuels, biodiesel can be a solution to reduce environmental problems related to climate change. Currently the U.S. defends the use of ethanol and the EU (European Union) the use of biodiesel. According to this, they have already invested large amounts of money and resources to promote these types of bioenergy. In order for biodiesel to become the energy of the future, Latin America and Africa must play an important role because they are expected to produce the 85% of the biomass from crops such as: sugar cane, beet, palm, soya, etc.

This implies the deforestation of millions and millions of square feet of land, leading to the loss of animal and plant ecosystems of the main areas of forests and jungles of the areas involved. That would mean the loss of world's greatest green areas (Amazon, Andes, El Chaco), that currently help to maintain the balance of the planet air (CO_2 and 0_2). On the one hand we have one of the measures to reduce climate change, through a future based on the use of biodiesel, which could reduce CO_2 emissions into the atmosphere and help combat the problem of the Greenhouse Effect, a major cause of climate change. The use of biodiesel can be very important for industrialized countries with higher rates of CO_2 emissions. We must not forget that for industrialized countries, biodiesel is presented as saving the planet from running out of fossil fuels.

A multinational firm wants to install a plant to produce biodiesel from biomass harvested in Africa and South America. This has generated a great controversy among people. Some people who are in favour of the installation and others are against it. The two environmental groups in the region are also confronted and defend different positions: on the one hand the group "Save the planet", thinks that biodiesel should be the energy source of the future, replacing fossil and reducing the emissions of CO_2 into the atmosphere. According to environmental group, this would reduce the greenhouse effect and thus substantially reduce the effects of climate change. The other environmentalist group in the area: "Nature and Life" has a completely opposite opinion. This group argues that biodiesel should not be the energy of the future because their production could have harmful effects. This group thinks that the production of biodiesel requires a lot of land for harvesting to produce the biomass. The exploitation of these lands would be in South America and Africa, involving deforestation of many wooded areas that are currently of great natural valuable as the lungs of the planet. For this reason the environmentalist group "Life and Nature" refuses the settlement of the biodiesel plant in the village. The mayor, tired of so much controversy and demonstrations in favour and against the factory, decided that the citizens over 12 voted one of two positions in relation to installing the factory in the town or not: "Saving the planet" if people are in favour of the settlement of the biodiesel plant or "Life and Nature" if people are against. What environmental group will you vote? Before choosing you have to balance the two choices and think carefully the arguments for which you have chosen one or the other.

Choice A: "Save the planet" (in favour settling the plant in the town).

Choice B: "Life and Nature" (against settling the plant in the town).