Lafuente Martínez, M. & Álvarez Valdivia, I. M. (2016). Promoting Student Metacognition through the Analysis of Their Own Debates. Is it Better with Text or with Graphics? *Educational Technology & Society, 19* (4), 167–177.

Promoting Student Metacognition through the Analysis of Their Own Debates. Is it Better with Text or with Graphics?

Marc Lafuente Martínez[1*] and Ibis M. Álvarez Valdivia[2]
[1]Fundació Jaume Bofill, Barcelona, Spain // [2]Educational and Developmental Psychology Department, Universitat Autònoma de Barcelona, Spain // marc.lafuentem@gmail.com // ibismarlene.alvarez@uab.es
[*]Corresponding author

(Submitted July 1, 2015; Revised November 4, 2015; Accepted January 29, 2016)

ABSTRACT

This paper presents a higher education experience aimed at explicitly promoting metacognitive processes in a social and collaborative context. Students carried out a debate on an e-forum, and were later asked to collaboratively analyse their own debates. The control group conducted this analysis using text-based tools; the experimental group analysed it with a graphical tool ("DebateGraph"). We examine the consequences of such experiences in promoting students' metacognitive processes for argumentative competence, as well as its impact on content knowledge learning. The analysis yields different results depending on the perspective adopted: students' self-assessment or instructor's assessment.

Keywords

Metacognition, Argumentation, Graphic representation, Information and communication technologies, Collaborative learning, Higher education

Introduction

The ability to argue is an important competence in many current education systems (Rapanta, Garcia-Milà, & Gilabert, 2013). Argumentation, defined as the valid combination of claims and premises (Plantin, 1996), is promoted under the assumption that it leads to the construction of more meaningful knowledge by means of metacognitive processes. Argumentation, developed either in monological or dialogical forms, is often related to the building of more functional and meaningful knowledge (Venville & Dawson, 2010). It is also associated with fostering the development of metacognitive abilities that lead to the control and appraisal of thinking processes, such as the critical revision of perspectives and the refinement of reasoning (Cross, Taasoobshirazi, Hendricks, & Hickey, 2008).

With the emergence of the socio-cultural approach (Nussbaum, 2008; Vygotsky, 1978), social and dialogical forms of argumentation have gained importance. Argumentative dialogue, often examined in collaborative learning settings, is viewed as a tool to promote the mutual regulation of thought processes among learners themselves. This mutual regulation of thought through language is viewed as a means of reaching further levels of thought that the student would not be able to achieve alone.

Debates are a common activity in secondary and tertiary education, and they are often aimed at promoting dialogical argumentation. While debates can be developed with the goal of pursuing the learning benefits described above, some authors (Tumposky, 2004) claim that debates have serious drawbacks, namely, oversimplifying knowledge, presenting false dichotomies or fostering win/lose scenarios in the classroom.

Although debates are commonly developed using oral and written language, with the advent of Information and Communication Technologies (ICT) new forms of representing arguments are available. In effect, ICT enables the representation of arguments in non-textual formats, supporting graphical representations in the form of schemes, tables or visualisations (Noroozi, Weinberger, Biemans, Mulder, & Chizari, 2012). When students are asked to use graphical features to present or analyse their arguments, they can employ technological programs as cognitive tools to modify the representational context of the task (Ertl, Kropp, & Mandl, 2008). As tools are a key element in human activities (Engeström, 1987), the selection of one over another is likely to influence the outcome. Indeed, the use of graphical tools for supporting argumentation has shown diverse benefits, such as the clarification of arguments, keeping arguments on track, giving a general overview of the argumentation's structure, or helping find new patterns of evidence (Noroozi et al., 2012).

In this paper, we present a study developed for higher education aimed at explicitly promoting metacognitive processes in a collaborative context. Teams of students collaboratively analysed their own previously held debates. They did these analyses using two different strategies: the control group had to perform the analysis using textual tools; the experimental group had to analyse it with a graphical tool ("DebateGraph," see http://debategraph.org). We examine the consequences of using different knowledge representational tools in promoting students' key metacognitive processes for argumentative competence. For this end, we take into account both the students' perspective (considering their opinions and subjective experiences) and the instructor's perspective (considering her assessment of students' products). We also examine the cognitive consequences of such an experience in terms of declarative content learning, considering the students' exam outcomes.

Background

Argumentation and metacognition

Argumentation, conceived as a dialogic form of discussion, can be seen as a social activity that has two goals: first, to support one's own position by providing evidence and favouring arguments; second, to undermine the opponent's position by identifying and challenging weaknesses in their argument (Walton, 1998). Achieving these goals requires awareness of one's own ideas and the other's position, seeking strengths in your own position and weaknesses in an opponent's arguments. These processes, which lead to thinking about thoughts themselves (Leitão, 2007), rely upon human metacognition. Metacognition can be defined as the cognition of cognition; it includes at least two main processes: knowledge of cognition and control over cognition (Flavell, 1979). Argumentation depends on and, further, develops the students' prior metacognitive skills, with argumentation competence requiring three different "metaknowing" components (Rapanta et al., 2013):

- Metacognitive knowing: being aware of the appropriate knowledge to support and construct arguments (know-what); metacognitive knowing mainly refers to declarative knowledge (e.g., what concepts can I use to support my stance? What evidence is appropriate to support my argument?).

- Metastrategic knowing: knowing suitable strategies, in accordance with the task requirements, to construct arguments (know-how); metastrategic knowing refers to procedural knowledge, and involves understanding and awareness of the task requirements in order to select appropriate strategies (e.g., what procedures can I use to better fulfil the argument task? On what basis can I decide whether an idea is right or wrong?).

- Epistemic knowing: being aware of the consequences derived from the cognitive performance in an argumentative task (know-be); this involves knowing about knowledge, both in general and in relation to individuals (e.g., has the argument provoked any knowledge advance in participants? Is argumentation a good setting for solving mathematical problems in teams?).

Argumentation in educational settings relies heavily upon prior metacognitive skills development in students, and instructors. However, argumentation can also be regarded as providing the ideal context to promote such skills in students.

Given that instructors have to be aware of the metacognitive processes involved in argumentation in order to promote them in their students, argumentative tasks have been considered as an excellent method for teacher-training. Argumentative activities are likely to promote Student teachers' metacognitive abilities. Moreover, with the emergence of ICT, asynchronous forums have proved to be a cost-efficient and generally effective activity for this purpose (Topcu, 2010; Topcu & Ubuz, 2008). Although synchronous discussions have also been used by Student teachers (Chen, Chen, & Tsai, 2009), asynchronous argumentation seems to clearly promote higher metacognitive-knowledge strategies through messages, such as, exemplification, clarification or elaboration (Topcu & Ubuz, 2008).

Metacognition has mostly been examined as an individual process, rather than a social or distributed phenomenon among members of a group (Goos, Galbraith, & Renshaw, 2002). In a study that involves pre-service science teachers in a problem-based learning scenario, Siegel (2012) broke group metacognition down into three components, with the group using these components to reduce the distance between their member's positions:

- Metasocial awareness: the group identifies "who" has "what" expertise and resources;
- Monitoring understanding: the group manages to identify what they know on a public level; rendering "holes" in the group's understanding visible is especially important;
- Monitoring process: the group manages to set goals and revise them according to the process they have followed.

Group metacognition may have distinctive properties compared with individual metacognition. Group metacognition is under-researched and its effects on teaching and learning are highly underappreciated (Anderson, Nashon, & Thomas, 2009). Therefore, we must take into account the need to develop and study such processes at a group level.

Argumentation and knowledge representation

Over the last 15 years, researchers and practitioners have implemented the use of ICT for supporting argumentation in collaborative activities (Noorozi et al., 2012). Some of these studies used technology to represent arguments in different communicational formats (e.g., graphics or text), and their impact on the collaboration-process and students' learning outcomes was studied. During these activities, students commonly used technology to scaffold their argumentation, engaging with ICT to represent arguments in a graphical format, such as schemes (Schwarz & De Groot, 2007), tables (Suthers & Hundhausen, 2003), or visualisations (Munneke, Van Amelsvoort, & Andriessen, 2003). Most of these studies compared two conditions (i.e., using graphical representation of arguments versus textual representation), and generally yielded positive outcomes for the graphical condition.

For instance, Dwyer, Hogan and Stewart (2012) claimed that students using argument mapping in an e-learning course gained a significantly larger improvement in critical thinking skills than students in the control group, who used textual tools. Argument mapping improved learning by minimising the cognitive load involved in interpreting arguments. Dwyer et al. (2012) affirmed that argument mapping may enhance metacognitive thinking by making the structure of the argument open to appraisal and discussion, and by revealing strengths and weaknesses in the structure. Similarly, Nguyen (2009) asserted that undergraduate psychology students benefited from using visual features (e.g., discourse maps) in their online discussions. Critical thinking and knowledge construction are enhanced when students are allowed to visualise their entire discussion along with the relationship between messages through clear pictures.

Along similar lines, other studies have supported the use of visual technological features. Munneke, Andriessen, Kanselaar and Kirschner (2007) confirmed that students argue more thoroughly, both broadening the debate space and examining in greater depth, when they use a tool to represent arguments in a diagrammatic fashion. However, students seem not to take full advantage of tools proposed to foster argumentation. Students may lack experience using such tools, or interpret them differently to how the researcher or instructor intended (Erkens, Jaspers, Prangsma, & Kanselaar, 2005). Therefore, diagrammatic representations may improve collaborative argumentation, but only when they are used in a co-constructive way (Van Amelsvoort, Andriessen, & Kanselaar, 2007). Janssen, Erkens, Kirschner and Kanselaar (2010) concluded that diagrammatic representations may have a positive impact on outcomes and subsequent elaborated student outputs, such as written essays, but not less so in relation to the online collaboration process itself. Indeed, students reported more negative evaluations of the social process and more neutral technical remarks. This was interpreted by the researchers as an indication that using a graphical tool rendered the argumentation process more complex to students. As a result, students do not perceive the graphical tools as more useful than a textual tool. Janssen et al. (2010) argued that students' perceptions of a tool's usefulness may not correspond to its objective efficacy or efficiency.

Some studies yielded unfavourable results for visual representations. For instance, Van Drie, Van Boxtel, Jaspers and Kanselaar (2005) attempted to promote argumentation in the subject of History by using representational guidance, such as diagrams and matrices. Contrary to expectation, they found that students actually engaged in increased historical reasoning during subsequent discussions, if they had not used representational guidance. Namdar and Shen (2013) presented a study where students could use multiple representations in a virtual environment (textual and visual representations through concept maps, wikis and events entries), in order to engage in collaborative argumentation in physics. Although students used all the available representational modes to make sound arguments, text entries were most frequently employed by the student-teams. According to Namdar and Shen (2013), although students are perfectly able to represent their knowledge in the form of concept maps or pictorial representations, they may still feel the need to convey understanding to their peers through verbal explanations. Although personal preferences in the processing of information might be involved (i.e., visual versus linguistic), some studies also suggest gender differences: given the same conditions, female students prefer to build and use textual digital artefacts rather than visual ones (Ding & Harskamp, 2006).

Methods

Design

This research used a case study approach. The case study is an appropriate method for researchers who want to attain a perceptive understanding of an instructional context, by seeking answers to descriptive and explicative questions (Yin, 2003). Specifically, this study used a quasi-experimental design, with a multi-method approach to the data analysis. Qualitative and quantitative data may be combined, used independently, concurrently or sequentially, embedded into each other, or used as a foundation to develop the other (Creswell & Clark, 2007). It allows the researcher to view the study phenomenon from different perspectives, and therefore be able to use one or various methods in order to address specific questions.

Participants

The study took place on a Developmental Psychology course in a postgraduate programme (a Master's degree for Second Language Education Teachers) in a public university in Barcelona, Spain. There were 56 students (43 female, 13 male, M = 25.6 years, SD = 5.9; range = 21-43). A large proportion of the students (49, 88%) had a Philology Bachelor's degree (33 Catalan Philology, 16 Spanish Philology). The rest had a Bachelor's degree in Journalism or Audiovisual Communication. Most of the participants (72%) stated they did not have any experience in learning through technology.

Procedure, tasks, and instruments

In this study, we examined three different activities that occurred as part of the same unit: "Development of thinking in adolescence." The first two activities were developed in collaborative teams of five or six members (n = 10); these teams were organised by the students themselves at the beginning of the course. The third activity was an individual exam.

The first activity was a forum-based debate developed within each group. On the Moodle platform, the groups had their own work space within the debate area to carry out critical discussions. They received the same instructions from the teacher, and were assigned the same amount of time to develop the debate. The students were presented with a video-clip that showed possible ethnic conflicts in the context of relationships between adolescents and adults, which stemmed from adolescent thought characteristics. The students were asked to adopt the role of a secondary education teacher, and discuss the viewpoint that they should have as educators: "*Must the teacher promote any specific ideology in the adolescent? And a religious stance? To what extent are we entitled to promote an ideological or political change in the student?*"

With respect to the participation norms, each student had to submit at least two messages: one to present new ideas, and another one to react to peers' contributions. There was no limitation to the number of contributions allowed. The instructor recommended ideas and arguments were grounded in unit content (Development of thinking in adolescence). The debate was open for two full weeks.

In order to assess the virtual debate's quality, the instructor took into account the quality of the ideas elaborated by the students, the argumentation and support of the ideas, and the accomplishment of the debate instructions. In accordance with those criteria, every debate was evaluated and scored using a three-point scale, where A was excellent, B was good, and C was acceptable/passing. Students' debate quality was used in their assignment to the experimental or control condition, alongside their gender and experience in learning through ICT. All these variables were well-balanced.

The second activity took place two months after the end of the virtual debate, in a two hour face-to-face session. The aim of the second activity was to analyse the previous debate. Half of the groups (n = 5) were assigned to the experimental condition, where they used the tool DebateGraph. The experimental groups had the support of another instructor who, in the first 45 minutes of the session, trained the students in the use of the tool. The other half of the groups (n = 5) were assigned to the control condition, where they did not receive any specific instructions regarding tools. In order to present their analysis, all the control groups used the text editor Microsoft Word.

During this activity, students in both conditions used a printed record of their messages that was handed out by their instructor. The messages were ordered chronologically and organised by thread. The students received the instruction to identify and present the main ideas or standpoints that emerged in their forum. They then had to identify and present the main counter-ideas or counter-standpoints that emerged; and finally, to identify and present the main arguments that arose to support all the key ideas and counter-ideas.

The third activity was an individual exam, where the students were presented with an open question that assessed the conceptual knowledge discussed in the debate: "*Explain the main features of adolescent thinking*." The answers were graded by the instructor on a 0 to 10 scale point, according to the theoretical framework of the course, the epistemological theory of Jean Piaget. Below, in Table 1, we provide the criteria used to assess the answers.

Table 1. Criteria used to assess the students' exam answers

Grade	Description
0	No answer
1-4	Incorrect answer: no contents addressed or anecdotic / no theoretical or conceptual framework provided / vague or ambiguous answer / important conceptual mistakes in the answer
5-6	Acceptable answer: the answer presents most of the features but lacks the conceptual framework / the student gives opinions rather than documented topics / the content is not correctly explained
7-8	Good answer: the answer correctly presents most of the cognitive developmental features but lacks some of them
9-10	Remarkable answer: the answer covers all the cognitive developmental features and is developed within an appropriate theoretical framework

To explore the data, we firstly examined the students' appraisal of their own experience through a questionnaire. This questionnaire addressed different metacognitive processes involved in argumentative competence. Second, for a more detailed approach, we analysed their debate's analysis products, which also focused on different metacognitive processes. Third, we evaluated the repercussions of the whole experience in terms of specific content learning, by assessing their answers to the final exam question on the unit contents.

Table 2. Questionnaire to assess the students' perspectives on metacognition

	Items
Metacognitive knowing (know-what)	1. The analysis has helped me identify and present the main ideas and counter-ideas of our debate
	2. The analysis has helped me identify and present the main arguments of our debate
	3. The analysis has helped me organise and synthesise the content of our debate
Metastrategic knowing (know-how)	4. The analysis has helped me acknowledge the main strengths of our debate (e.g. interesting ideas, contrast of relevant ideas, solid arguments, etc.)
	5. The analysis has helped me acknowledge the main weaknesses of our debate (e.g. poor ideas, absence of counter-ideas, weak or non-existent arguments, etc.)
Epistemic knowing (know-be)	6. I think that through this activity I have been able to develop skills for debate analysis that perhaps I did not previously have
	7. On a scale from 0 to 10, mi general satisfaction with the debate analysis experience is…

Note. The alpha coefficients for internal consistency averaged .85.

With the purpose of assessing the experience from the students' perspective, a brief questionnaire was constructed. As we showed in Table 3, the survey covered the different metaknowing strands involved in the student's debate analysis, according to the conceptual framework presented in the literature review (Rapanta et al., 2013). The questionnaire consisted of 7 Likert-type items with a 4-point response scale; from strongly agree to strongly disagree. In addition, an open question allowed the students to express any comments they judged relevant. The questionnaire is completed online once they had finished their debate analysis. The questionnaire was voluntary and anonymous. 43 students complete the questionnaire (77% of participants), 23 from the experimental group and 20 from the control group. Table 2 shows the metacognitive strands assessed through the questionnaire.

To fulfil the second stage of analysis, we created a rubric, allowing us to evaluate the student's debate analysis products. The rubric was the product of an inductive-deductive design procedure (Moskal & Leydens, 2000). Firstly, we defined the operational criteria for every category, based on theoretical principles derived from the literature review. Then, the rubric was revised by the researchers in an iterative process that involved modifying categories. Discrepancies between the researchers were resolved via consensus. The final aspect of examining the analysis involved a cross-case analysis (Miles & Huberman, 1994). The rubric was used by the instructor to assess the debate's analysis of both the experimental and control groups. That rubric aligns with the theoretical framework adopted in this study, and was used to assess the quality of the students' analyses, based on the metacognitive, metastrategic and epistemic strands found in their products (see Table 3).

Finally, to complete the third step of the analysis, in the final exam, the instructor included a question relating to the contents of the previous debate. The question assessed the conceptual knowledge constructed by the students as a result of their participation in all prior activities of the unit. The results of the exam question were then compared with the results of the prior steps in analysis.

Table 3. Rubric to assess the students' analysis product

		D (1)	C (2)	B (3)	A (4)
Metacognitive knowing	*Clarity of ideas, counter-ideas and arguments*	Most of the ideas, counter-ideas and arguments presented in the analysis are unclear or difficult to understand.	Some ideas, counter-ideas and arguments presented in the analysis are unclear while others are perfectly understandable.	Most of the ideas, counter-ideas and arguments are expressed in the analysis in an understandable fashion.	All the ideas, counter-ideas and arguments are presented in the analysis in a very clear and understandable fashion.
	Relation between ideas , counter-ideas and arguments	Most of the ideas and counter-ideas are not clearly related or opposed to each other in the analysis.	Some ideas and counter-ideas are not clearly related or opposed to each other in the analysis.	Most of the ideas and counter-ideas are related or opposed to each other in the analysis.	All the ideas and counter-ideas are clearly related and opposed to each other in the analysis.
	Quality and appropriateness of ideas, counter-ideas and arguments	Ideas, counter-ideas and arguments presented in the analysis generally do not address or answer the debate questions.	Some ideas, counter-ideas and arguments presented in the analysis do not address the debate questions.	Most of the ideas, counter-ideas and arguments address the debate questions.	All the ideas, counter-ideas and arguments address the debate questions.
	Organisation and synthesis of contents	The product is badly organised and it does not appropriately synthesise the debate.	The product synthesises some parts of the debate, while others remain uncovered or excessively reported.	The product synthesises the overall debate, although some parts could be improved.	The product is well organised and synthesises the debate in a successful manner.
Meta-strategic knowing	*Understanding and meeting the analysis requirements*	The students clearly do not understand and meet the requirements of the analysis.	The students understand and meet some requirements of the analysis, while others are neglected.	The students generally understand and meet the requirements of the analysis.	The students clearly understand and meet all the requirements of the analysis.
Epsitemic knowing	*Understanding and deepening of contents*	The students clearly show incomprehension of the contents, and a superficial conception of the analysis topics.	The students show comprehension and adequate conception of only some contents, while others are clearly not understood.	The students generally show comprehension and a deep understanding of most of the contents.	The students show excellent comprehension and deep understanding of all contents.

Results

Our aim was to study the metacognitive consequences of using textual or graphic tools by students when analysing their own debates. We examined whether there were differences between the experimental and control groups, regarding the metacognitive strands involved in the students' analysis. Below we present the answer to this initial question, firstly from the students' perspective, taking into account their responses to the questionnaire, then from the instructor's viewpoint, considering her assessment of the students' analysis products. We then consider the cognitive consequences of such an experience, analysing whether there are differences between the experimental and control groups in terms of declarative knowledge content learning. To inform this, we consider the instructor's assessment of the students' exam answers.

We observe significant differences in the appraisal of the learning experience by the students. All the item scores show a statistically significant difference, with the exception of the item "awareness of development of new analytical skills". Table 4 summarises the *ANOVA* conducted to compare both groups.

Table 4. Summary of ANOVA for students' questionnaires

Criteria	Experimental group (n = 23) *M*	Experimental group (n = 23) *SD*	Control group (n = 20) *M*	Control group (n = 20) *SD*	F(1,41)	p
Metacognitive knowing						
Identification of ideas and counter-ideas	2.85	.67	3.34	.64	6.12	.018
Identification of supporting evidence and arguments	2.8	.62	3.34	.64	8.01	.007
Support to organising and synthesising contents	2.8	.83	3.47	.67	8.79	.005
Metastrategic knowing						
Identification of strengths	2.85	.67	3.57	.59	13.84	.001
Identification of weaknesses	2.5	.76	3.74	.45	43.64	.000
Epistemic knowing						
Awareness of development of new analytical skills	2.35	.93	2.7	.93	1.48	.231
Satisfaction with the activity	6.35	1.79	7.83	1.44	9.03	.005

Analysis of the debate's analysis products, as evaluated by the instructor, did not yield any significant differences. As we show in Table 5, when a *t-test* analysis is conducted, none of the rubric's criteria show a statistically significant difference. Hence, the tool used to perform debate analysis does not seem to have a significant impact on the students' product quality. Further, the analysis conducted does not show any difference in any of the metacognitive strands, regarding the analysis products of both groups.

Finally, ANOVA results do not show statistically significant difference between the groups in terms of their exam outcomes. Students' answers, as assessed by the instructor, in the experimental group (M = 6.33, SD = 3.26) and the control group (M = 7.69, SD = 2.22), are not statistically significant F(1,54) = 3.337, p = 0.73. Hence, the students' answers to the exam question do not show any difference in terms of acquired declarative knowledge related to the unit's.

Table 5. *t*-test: Instructor's assessment of the students' debate analysis

Variable	Experimental (n = 23) *M*	Experimental (n = 23) *SD*	Control (n = 20) *M*	Control (n = 20) *SD*	t	p	95% CI
Ideas identified	4.0	2.23	6.0	3.0	1.20	.266	[-1.86, 5.86]
Counter-ideas identified	2.2	1.3	2.4	.89	.28	.784	[-1.43, 1.83]
Arguments identified	6.8	2.49	7.6	2.1	.55	.596	[-2.54, 4.14]
Metacognitive knowing							
Clarity of ideas and counter-ideas	3.8	.45	3	1.0	-1.63	.141	[-1.93, .33]
Relation between ideas and counter-ideas	3.8	.45	3	1.09	-1.13	.290	[-1.82, .62]
Quality and appropriateness of ideas and	3.6	.55	3.2	.83	-.89	.397	[-1.43, .63]

counter-ideas							
Organisation and synthesis of contents	3.8	.44	3.6	.54	-.63	.545	[-.93, .53]
Metastrategic knowing							
Understanding and fulfilment of the analysis requirements	3.8	.45	3.6	.55	-.63	.545	[-.93, .53]
Epistemic knowing							
Understanding and deepening of the contents	2.6	.54	2.8	.84	.45	.667	[-.83, 1.23]

Note. CI = Confidence Interval.

Discussion

Our study yielded some interesting results on how graphical and text-based tools promote the metacognitive skills involved in argumentation. With regard to the accounts of students themselves, gauged by our questionnaire, the students using the graphical tool reported a significantly worse appraisal of metacognitive abilities fostered in their debate analysis.

Indeed, according to their subjective experience, the students using text-based tools reported higher scores in all three declarative metacognitive (know-what) components included in our questionnaire: identification of ideas and counter-ideas; identification of supporting evidence and arguments; and supporting the organisation and synthesis of the debate. Therefore, we may state that the students felt that their debate content is better appraised and acknowledged when using text-based tools to analyse it. Similarly, the students using text-based tools showed significantly higher scores related to metastrategic knowing (Rapanta et al., 2013). Know-how metacognition encompasses showing awareness of the debate task and assessing whether the procedures used for constructing arguments are valid or not. This process, if it is developed in a distributed fashion within the group, may also be related to an important element of group metacognition, namely, monitoring understanding (Siegel, 2012). Metastrategic knowing was appraised in our questionnaire by two different items: identification of strengths, and identification of weaknesses. Hence, we can affirm that students believed that using the graphical tool is not as useful as text-based tools, when it comes to analysing whether their argumentation is based on valid strategies. As for the epistemic (know-be) component, the students in both groups showed an equally moderate perception of having developed new skills for analysis after the activity. However, when they assessed their overall satisfaction with the analysis activity, the students using the text-based tools show significantly higher scores again.

In sum, although the students judged that representing their previous debates in a graphical form may fairly support their analysis (most of their average scores are above the mid-point), text-based tools are judged to be more effective for promoting the metacognitive processes involved in argumentative competence (Rapanta et al., 2013). In fact, if we consider the comments made by some students from the experimental group in their questionnaires, we recognise a rather negative attitude to the graphical tool. This negative approach tended to highlight the tool's constraints, and omit its affordances when considering its contribution to their analysis. This perspective can be illustrated through the following student comment:

> *"I think that the activity was interesting […]. However, the tool is not entirely appropriate. I would have liked to draw certain relationships that the program didn't allow, and that frustrated me. For that matter, the team members ended up thinking that it would have been better if we had used Prezi or PowerPoint. With these tools we would be freer to draw our own scheme without restrictions."*

However, when it comes to assessing the real outcome in terms of developing new analytical skills, the experimental and the control group converged in giving an equally moderate score. These results reflected the conclusions of previous research (Janssen et al., 2010), where students reported a rather negative appraisal of the collaboration process and the role played by a graphical digital tool. The fact that the students were not experts in such a program, and that they might have idiosyncratically interpreted the goal of using the tool, for example, not as a means to foster metacognitive processes but simply as a means to draw their arguments, could also explain these results (Erkens et al., 2005). The limited time invested in the classroom for mastering a new tool, or the students' effort put into abstracting and making the structure of their debate explicit (Dwyer et al., 2012), could have decisively tainted their experience. After all, students may have much more experience reading and writing text-based arguments, compared to graphic-based arguments. Prior research has identified that students feel generally more comfortable using text for representing and communicating their knowledge to peers (Namdar & Shen, 2013). In addition, female students may have a tendency to construct and use text digital artefacts rather than graphical ones (Ding & Harskamp, 2006). Given that our class group was composed of 42 female students and 13 male students, students' gender could also have played a role in their subjective appraisal of the learning experience. This explanation is supported by the fact that, although the instructor in the control group did not give any specific instructions regarding the written tool for their analysis, they all used Microsoft Word.

Regarding the quality of the students' analyses, as assessed by our rubric, we can assert that although the experimental group was slightly above the control group in most of the strands considered, the differences are not statistically significant. Hence, their products reflected the same overall level of achievement in all the metacognitive strands assessed (Rapanta et al., 2013). We may speculate that a bigger sample of groups could have led to statistically meaningful differences; however, in our sample those differences are not significant. Therefore, we can affirm that using a graphical tool instead of a text-based tool did not yield any significant differences regarding the clarity of their ideas, counter-ideas, and arguments expressed in their analysis. Likewise, the appropriateness and quality of those ideas, counter-ideas, and arguments were at the same level for both groups. Both groups also showed equal achievement in the relations expressed between debate elements (relations between ideas and counter-ideas, and between arguments and ideas). Finally, when assessing the contents' organisation and synthesis, both groups showed an equally excellent level.

Given that we find no significant differences between the experimental and the control group, we cannot corroborate the advantages identified by previous research in the use of graphical formats for supporting argumentation (Noroozi et al., 2012). The benefits found by others, such as enhancing metacognition by making the structure of the argument more open to appraisal, and by revealing its strengths and weaknesses (Dwyer et al., 2012), or broadening and deepening the debate scope (Munneke et al., 2007), cannot be supported by our study. However, we must consider that the approach adopted in this study is different to that of other studies: while previous studies usually propose using a graphic tool for supporting consequent (or simultaneous) argumentation, we used the graphical tool as a metacognitive tool to analyse previous argumentation. Using a tool as a means of fostering evaluation of one's previous argumentation might be more demanding than simply considering it as a support for argument planning or execution. After all, evaluation of one's cognition is clearly a different process than planning and monitoring (Meijer, Veenman, & Van Hout-Wolters, 2006), as it requires demanding operations to revise one's behaviours and thoughts, in relation to specific goals. Therefore, exploiting the tool to evaluate personal and group understanding (Siegel, 2012), and measuring those advantages, might be more difficult than using it for planning or execution purposes. We might speculate that the advantages of using external representations in graphic formats may be more easily fostered and measured when the tool is used to promote subsequent argumentation, but more difficult to determine when the tool is used to evaluate previous argumentation.

It is noteworthy that although the experimental group showed a more negative subjective appraisal of their experience, when we assessed their products, their results were at least as positive as the control group. In our view, this reinforces previous conclusions that students' perceptions of tool advantage may not correspond to objective effectiveness (Janssen et al., 2010). Students' perceptions may be driven by their struggle to master a new digital tool (72% of students did not have any experience in learning through technology); therefore, drawing their attention to the tool's limitations, rather than its affordances. Likewise, the positive experience reported by the control group may have more to do with working with a familiar and comfortable form of representation (i.e., text), than with its objective consequences (Namdar & Shen, 2013).

Finally, regarding the student's acquisition of declarative knowledge, it must be asserted that using either tool did not make any difference in learning ideas, concepts, and facts from the unit. Hence, using text or graphic tools did not have any impact, neither on the "higher" metacognitive processes developed while analysing their own debates, nor on the "lower" cognitive processes carried out while learning the ideas and concepts used in those debates.

Conclusions

In our study, students did not take advantage of using a graphical tool to enhance their learning while analysing their own previous debates. Students in the experimental group neither improved their metacognitive nor their cognitive processes in comparison with the text-based tool group. Students using text-based tools reported a more enriching learning experience, but, according to our results, this may be caused by tool familiarity and prior skills of students, rather than real learning outcomes. Our study shows that while graphic tools may enhance learning when used to prepare or execute students' argumentation, it is not clear that it is beneficial for analysing previous debates. Indeed, analysis of arguments is different from planning, and requires different skills.

The present study reminds us that while the tool (either digital or analogue) may be an important element of the educational activity, many other variables in the educational setting may interact with each other, and eventually play a role in learning processes. In our study, students' learning styles or preferences (e.g., visual or linguistic), or even their gender, may have played a role in the results. However, we must accept, as a clear limitation of the present research, that those variables were not controlled. Likewise, we must admit that small-scale studies, such as ours, do not provide a representative sample for generalising results. We urge further research to be conducted, where these limitations can be overcome.

Innovative educational experiences may be rewarding for all stakeholders, as long as they are adequately planned and implemented. A sufficient amount of time and resources must be allocated for instructors and students to learn new tools and scenarios. Likewise, innovative experiences have to be adequately assessed. Our study shows that both students' and instructors' perspectives must be taken into account to fully evaluate the soundness of innovation in education.

References

Anderson, D., Nashon, S. M., & Thomas, G. P. (2009). Evolution of research methods for probing and understanding metacognition. *Research in Science Education*, *39*(2), 181-195.

Chen, Y., Chen, N. S., & Tsai, C. C. (2009). The Use of online synchronous discussion for web-based professional development for teachers. *Computers & Education, 53*(4), 1155-1166.

Creswell, J. W., & Clark, V. L. P. (2007). *Designing and conducting mixed methods research*. Thousand Oaks, CA: Sage publications.

Cross, D., Taasoobshirazi, G., Hendricks, S., & Hickey, D. T. (2008). Argumentation: A Strategy for improving achievement and revealing scientific identities. *International Journal of Science Education*, *30*(6), 837-861.

Ding, N., & Harskamp, E. (2006). How partner gender influences female students' problem solving in physics education. *Journal of Science Education and Technology, 15*(5), 331-343.

Dwyer, C. P., Hogan, M. J., & Stewart, I. (2012). An Evaluation of argument mapping as a method of enhancing critical thinking performance in e-learning environments. *Metacognition and Learning*, *7*(3), 219-244.

Engeström, Y. (1987). *Learning by expanding: An Activity-theoretical approach to developmental research.* Helsinki, Finland: Orienta-Konsultit.

Erkens, G., Jaspers, J., Prangsma, M., & Kanselaar, G. (2005). Coordination processes in computer supported writing. *Computers in Human Behavior, 21*(3), 463-486.

Ertl, B., Kopp, B., & Mandl, H. (2008). Supporting learning using external representations. *Computers and Education, 51*(4), 1599-1608.

Flavell, J. H. (1979). Metacognitive monitoring: A New idea of cognitive development inquiry. *American Psychologist, 34*(10), 906-911.

Goos, M., Galbraith, P., & Renshaw, P. (2002). Socially mediated metacognition: Creating collaborative zones of proximal development in small group problem solving. *Educational studies in Mathematics*, *49*(2), 193-223.

Janssen, J., Erkens, G., Kirschner, P. A., & Kanselaar, G. (2010). Effects of representational guidance during computer-supported collaborative learning. *Instructional Science*, *38*(1), 59-88.

Leitão, S. (2007). Argumentação e desenvolvimento do pensamento reflexivo [Argumentation and development of reflective thinking]. *Psicologia: Reflexão e Crítica*, *20*(3), 454-462.

Meijer, J., Veenman, M. V., & Van Hout-Wolters, B. H. (2006). Metacognitive activities in text-studying and problem-solving: Development of a taxonomy. *Educational Research and Evaluation*, *12*(3), 209-237.

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An Expanded sourcebook* (2nd ed.). Beverly Hills, CA: Sage.

Moskal, B. M., & Leydens, J. A. (2000). Scoring rubric development: Validity and reliability. *Practical Assessment, Research & Evaluation, 7*(10), 71-81.

Munneke, L., Andriessen, J., Kanselaar, G., & Kirschner, P. (2007). Supporting interactive argumentation: Influence of representational tools on discussing a wicked problem. *Computers in Human Behavior*, *23*(3), 1072-1088.

Munneke, L., Van Amelsvoort, M., & Andriessen, J. (2003). The Role of diagrams in collaborative argumentation-based learning. *International Journal of Educational Research, 39*(1-2), 113-131.

Namdar, B., & Shen, J. (2013). Knowledge organization with multiple external representations in an argumentation based computer supported collaborative learning environment. In N. Rummel, M. Kapur, M. Nathan, & S. Puntambekar (Eds.), *To See the World and a Grain of Sand: Learning across Levels of Space, Time, and Scale: CSCL 2013 Conference Proceedings* (Vol. 1, pp. 344-351). Madison, WI: International Society of the Learning Sciences.

Nguyen, H. T. (2009). *Effects of discussion constraints, discourse maps, and interactive intercultural elaboration in online discussions on students' knowledge construction, critical thinking, and intercultural sensitivity* (Unpublished doctoral dissertation). The Pennsylvania State University, PA.

Noroozi, O., Weinberger, A., Biemans, H. J., Mulder, M., & Chizari, M. (2012). Argumentation-based computer supported collaborative learning (ABCSCL): A Synthesis of 15 years of research. *Educational Research Review, 7*(2), 79-106.

Nussbaum, E. M. (2008). Collaborative discourse, argumentation, and learning: Preface and literature review. *Contemporary Educational Psychology*, *33*(3), 345-359.

Plantin, C. (1996). *L'argumentation* [Argumentation]. Paris, France: Seuil.

Rapanta, C., Garcia-Milà, M., & Gilabert, S. (2013). What is meant by argumentative competence? An Integrative review of methods of analysis and assessment in education. *Review of Educational Research, 83*(4), 483-520.

Schwarz, B. B., & De Groot, R. (2007). Argumentation in a changing world. *International Journal of Computer-Supported Collaborative Learning, 2*(2), 297-313.

Siegel, M. A. (2012). Filling in the distance between us: Group metacognition during problem solving in a secondary education course. *Journal of Science Education and Technology*, *21*(3), 325-341.

Suthers, D., & Hundhausen, C. (2003). An Empirical study of the effects of representational guidance on collaborative learning. *Journal of the Learning Sciences, 12*(2), 183-219.

Topcu, A. (2010). Relationship of metacognitive monitoring with interaction in an asynchronous online discussion forum. *Behaviour & Information Technology*, *29*(4), 395-402.

Topcu, A., & Ubuz, B. (2008). The Effects of metacognitive knowledge on the pre-service teachers' participation in the asynchronous online forum. *Educational Technology & Society*, *11*(3), 1-12.

Tumposky, N. R. (2004). The Debate debate. *The Clearing House: A Journal of Educational Strategies, Issues and Ideas, 78*(2), 52-56.

Van Amelsvoort, M., Andriessen, J., & Kanselaar, G. (2007). Representational tools in computer-supported collaborative argumentation-based learning: How dyads work with constructed and inspected argumentative diagrams. *The Journal of the Learning Sciences*, *16*(4), 485-521.

Van Drie, J., Van Boxtel, C., Jaspers, J., & Kanselaar, G. (2005). Effects of representational guidance on domain specific reasoning in CSCL. *Computers in Human Behaviour, 21*(4), 575-602.

Venville, G. J., & Dawson, V. M. (2010). The Impact of a classroom intervention on grade 10 students' argumentation skills, informal reasoning, and conceptual understanding of science. *Journal of Research in Science Teaching*, *47*(8), 952-977.

Vygotsky, L. S. (1978). *Mind in society: The Development of higher psychological processes.* Cambridge, UK: Harvard University Press.

Walton, D. N. (1998). *The New dialectic: Conversational contexts of argument*. Toronto, Canada: University of Toronto Press.

Yin, R. (2003). *Case study research: Design and methods*. New York, NY: Sage Publications.