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Collaborative Learning Through Chat Discussions and Argument Diagrams in Secondary School

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Abstract

This study clarifies whether secondary school students develop their argumentation skills through reading and collaboration. The students first constructed an individual argument diagram on genetically modified organisms, read three articles, and improved their diagrams. Next, they engaged in a chat debate, reflected on their debate by constructing a collaborative argument diagram on it, and finally finished their individual diagrams. The analyses compared the diagrams students finished after the debate and reflection with the diagrams they constructed before the debate. Collaboration not only encouraged students to elaborate their previous arguments but also helped them to recall and create ideas and arguments. (Keywords: collaborative learning, argumentation visualisation, chat, dyadic debate, secondary education.)

INTRODUCTION

Bereiter (2002) emphasized that enculturation into a knowledge building society is important for all students if education is to make headway in the Knowledge Age. According to him, an idea crucial to advancing educational thought is the distinction between learning and knowledge building. *Learning* concerns the subjective or mental world, i.e. the acquisition of knowledge, whereas *knowledge building* is concerned with the world of ideas, i.e., wholly human creations like concepts, factual assertions, problem statements, theories, designs, and plans. This distinction does not mean that knowledge building could take the place of learning; rather learning as the acquisition of new knowledge serves knowledge building by being a prerequisite for it. Namely, knowledge building allows for many situations where students have to report what they have learned in order to use and share their knowledge and ideas, and to work together on improving those ideas (Bereiter & Scardamalia, 2003). Furthermore, a legitimate concern has to do with what individual students learn from taking part in knowledge building activities (Scardamalia, 2002).

In this study both individual learning activities and collaborative knowledge building are combined to enable students to construct and develop their ideas about a current societal topic with argument diagrams. At the beginning of the learning period students are stimulated to recall their earlier knowledge on the topic by asking them to construct an argument diagram individually. The idea of the active recall of earlier knowledge before encoding new knowledge is in harmony with the cognitive psychology of learning. After the construction of the first argument diagrams students are given articles pertaining to the topic which they can utilize in further developing their argument diagrams. In this case the argument diagram—in which the main thesis is linked to arguments and counterarguments which in turn can be linked to other arguments and counterarguments—functions as a visual advance organizer for knowledge acquisition. Here, Ausübel's classic idea of meaningful learning with advance organizers (Ausübel, Novak, & Hanesian, 1978) is applied in a computer-based environment in which an internet tool provides the students with possibilities to alter and modify their argument diagrams on a computer screen in an easy-to-do way. Variation in the form of the diagrams is built in so that students can create different numbers of arguments and counterarguments and construct argumentative chains with branches varying in size. Furthermore, a commentary box can be attached to each argument box as well as to each link between boxes. Thus, the idea of argument diagrams represents visual advance organizers that are presented "at a higher level of abstraction, generality, and inclusiveness than the new material to be learned" (p. 171).

Argument diagrams also fulfil the conditions under which advance organizers might be expected to facilitate learning. According to Mayer (1979), effective advance organizers should have the following characteristics: have a short set of verbal or visual information; be presented prior to learning of a larger body of to-be-learned information; contain no specific content from the to-be-learned information; provide a means of generating the logical relationships among the elements in the to-be-learned information; and influence the learner's encoding process. When in the present study students are asked to construct argument diagrams, they commence to work on an empty screen, having been instructed only about the rules governing how argument and comment boxes can be created and linked to each other. Thus, students have only the mere visual idea of argument diagrams in their mind when they are asked first to recall their earlier knowledge. There are various ways in which the content of the boxes can be filled in; hence students are forced to decide what to write inside them. When they start reading, the idea of argument diagram directs their encoding, i.e., it organises their knowledge acquisition in such a way that they are more likely to pay attention to the argumentative structure of the texts.

In addition to advance organizers, argument diagrams are also conceptual artefacts. As defined by Bereiter (2002), conceptual artefacts are immaterial human constructions that serve purposes such as explaining and predicting, i.e., they are discussible ideas; things we can become knowledgeable about. Owing to their artificial nature, we can use them as knowledge objects and can therefore criticise them and suggest improvements—in short, make them part of a collective human enterprise. In this study, argument diagrams served as the students' conceptual argumentative constructions on the topic discussed. The students reflected on their diagrams and improved them in different phases of their studies. After their first diagrams have been created, students can use them as knowledge objects, which means that they can be further developed and shared with other students. When creating and improving their argument diagrams together, students can build new knowledge. While participating in the knowledge building process students can incorporate material into their diagrams, they can suggest and create new boxes and links as well as modify the texts inside the boxes.

The individual learning and collective knowledge building situations in this study are arranged so that after a considerable amount of individual knowledge work with argument diagrams, students start to collaborate in pairs. They engage in a reflective debate on the topic. They also construct a joint argument diagram after their debates. In this way students can profit from each other's ideas as they explore the topic more profoundly. Finally, in the last phase students make further improvements to their individual argument diagrams.

By alternating collaborative knowledge building and individual work phases in this study, we were able to investigate the connections between the changes students make in their individual diagrams and the ideas they present during their dyadic debate and during their joint construction of argument diagrams. More precisely: do the new arguments and counterarguments as well as other modifications in the students' individual diagrams come directly from the thoughts of their partners, from their own ideas as they present these during the debate, or does collaborative knowledge work stimulate students to recall ideas from the texts they have read earlier? Comparable methodology has been used by Suthers (2006) who uses the term "information uptake" to refer to an event a person modifies previously expressed information, or relates it to new information.

Before we take a closer look at the teaching arrangements and research problems concerning the construction and modification of successive argument diagrams some recent studies on collaborative learning in dyads and collaborative argumentation are briefly described.

COLLABORATIVE LEARNING IN DYADS AND SMALL GROUPS

Research has repeatedly shown that collaborative working between students is an appropriate method of learning. The meta-analysis of 122 studies by Johnson, Maruyama, Johnson, Nelson, and Skon (1981) indicated that cooperation with other students was a considerably more effective teaching method than interpersonal competition and individualistic studying. In a more recent review of 486 independent findings from 122 studies, Lou, Abrami, and d'Apollonia (2001) compared small group learning and individual learning with computer technology. They found that, in general, groups performed significantly better than individuals during the study. However, students learning individually on average interacted more with computer programs, requested more help from the teacher, and accomplished tasks faster than students working in groups.

A lot of recent research on student–student collaboration has focussed on learning situations in which two individuals work together, in dyads. Ploezner, Dillenbourg, Preier, and Traum (1999) pointed out that when two individuals collaborate they have to justify to each other what they are doing and why they are doing it. Justifications, according to them, may lead individuals to explicate their thinking and assumptions that would otherwise remain tacit. They emphasise that when an individual explains his/her decisions and arguments to another individual there is the possibility for both parties to learn. van Boxtel, van der Linden, and Kanselaar (2000) also stress that collaborative learning may be a consequence of social interaction, which stimulates the elaboration of conceptual knowledge; hence in a collaborative learning situation students verbalise their understanding. The effect of dyadic working in promoting elaborative thinking is supported by van der Meijden and Veenman (2005). They studied primary school students who worked collaboratively on a mathematics task and found that about 70% of the utterances produced by face-to-face dyads and about 53% of the utterances produced by computer-mediated dyads were cognitive statements, i.e., a combination of high- and low-level elaborations.

Webb, Troper, and Fall (1995) emphasise that in small groups students learn from each other by giving and receiving help, by recognizing contradictions between their own and other students' perspectives, seeking new knowledge to resolve those contradictions, and constructing new understandings from them. Reciprocal help and assistance also often characterises students' study in dyads. Fuchs et al. (2000) pointed out that dyads provide each individual with more time to participate compared to small groups. They compared third- and fourth-grade students in pairs with students in groups of four working collaboratively face-to-face on complex tasks. They found that students working in pairs performed better than students in groups of four. In addition, students with low achievement status, in particular, benefited from dyadic teaching arrangements which provided them with greater opportunities to participate and collaborate.

In a study by Uribe, Klein, and Sullivan (2003) university students worked either individually or in dyads on a problem-solving task in a Web-based learning environment. Students who worked in dyads used synchronous computer-mediated communication for collaboration. The results indicated that the computer-mediated collaborative dyads performed significantly better than the students who worked alone. The results suggest that a computer-mediated collaborative environment is well-suited to problem-solving activities and higher-order learning.

Collaborative work in dyads has been found to be particularly effective when students are given representational support during their work. In a study by Suthers and Hundhausen (2003) college science students worked in pairs with one of three computer-based representations (graph, matrix, text) while investigating complex science and public health problems. Their study suggested that visually structured and constrained representations can provide guidance for collaborative learning that is not afforded by plain text. In the present study, the argument diagram is one variant of visually structured and constrained representations that are applied in a computer-based environment. The content and structure of argument diagrams can be easily altered both individually and in dyads.

COLLABORATIVE ARGUMENTATIVE DEBATE AS A MEANS FOR LEARNING

The term *collaborative argumentation* refers to discussion, the aim of which is to get to the core of the issue in question through critical but constructive debate (Marttunen, Laurinen, Litosseliti, & Lund, 2005). During collaborative argumentative debate the primary purpose is not to win "a competition for the best argument" through proving other people's arguments as wrong and one's own arguments as right, but to learn together by examining different points of view and arguments for and against each others' positions. In the same vein, Stein and Albro (2001) state that winning disputes by presenting more complex and logically cohesive arguments does not necessarily lead to an accurate and deeper understanding of the other person's position. Hence, they emphasise the importance of the kinds of negotiation skills that lead to both personal and interpersonal success rather than only to personal success at other's expense.

Argumentative debate can be regarded as an appropriate method for learning in many respects. Andriessen, Baker, and Suthers (2003) differentiate between two situations: *learning from the debate* and *learning about the debate.* The former refers to a situation where students, through engaging in argumentative discussion, deepen their understanding of the topic, and concepts associated with it. The latter means that through engaging in debate students become better acquainted with the diversity in viewpoints held about a topic and the types of arguments commonly advanced to support those viewpoints. In a study by Simonneaux (2001) students in their 2nd year of upper secondary education engaged in a classroom debate on an issue involving animal transgenesis. Although in number the students' arguments did not greatly increase as a result of the debate, the debate helped the students to enhance the persuasiveness of their discourse: the same arguments were better supported and more strongly expressed after the debate.

Simonneaux (2001) emphasized that through debate students learn to express, defend, and criticize other students' viewpoints and to distinguish discourse describing facts from discourse evaluating facts. In a study by Walker and Warhurst (2000) university students engaged in a class debate in three groups from four to six members. The task of one group was to argue in support of a statement drawing on the previous lecture and supplementary readings, a second group was to oppose the statement, and the third group (adjudicating group) was to decide which argument was the most convincing. Walker and Walhurst found that the class debate enabled students to develop a critical view of the topics under discussion, and to acquire a number of other transferable skills such as those relating to team work.

Although the research results presented above show in favour of collaborative argumentation and collaborative learning in dyads or small groups, many unresolved questions remain. In particular, the various learning processes that are made visible through collaborative debates and their connections with learning products deserve more attention. How, for example, are the contents of dyadic debates reflected in learning products? Furthermore, there is a lack of research results concerning the usefulness of representational conceptual artefacts, like graphs, matrixes, and diagrams, as the objects of knowledge work in computer-supported collaborative learning environments. The usefulness of representational artefacts is, however, largely dependent on the learning arrangements surrounding their use. Students need time to construct, elaborate, and further develop their ideas instead of merely messing around with computer tools. This means that we have to plan meaningful individual learning and knowledge acquisition periods combined with collaborative knowledge building, using easily modifiable representational artefacts as advance organizers.

In this study secondary school students studied the topic of genetically modified organisms (henceforth GMO) during two double lessons by engaging in successive periods of reading, debate, and construction of argument diagrams. The study aims at clarifying whether reading of topic-related texts followed by collaborative working (dyadic debate + construction of a joint diagram) on a current societal topic affects students' learning on that topic. The research questions are: 1) How did the students modify their individual diagrams after collaboration with their interlocutor? 2) To what extent are the students' modifications associated with the collaborative process and with the topic-related texts they read earlier?

METHOD

Subjects

The subjects of the study were 17 Finnish secondary school students (7 males and 10 females) aged from 16 to 17 years. The school in question was a university's teacher training school in which research activities are commonly promoted, and thus it was an appropriate site for the study. During the fall term 2003, the students participated in a six-week course, *The power of language,* included in the mother tongue curriculum. Four 90-minute sessions from this course were planned for studies on argumentation. During the course the students exercised their argumentation skills with CABLE (**C**ollaborative **A**rgumentation-**B**ased **Le**arning) Internet tools. These tools form a network learning environment in which students can construct argument diagrams individually or collaboratively, engage in chat with each other, and write text together (more information on the tools can be found at: http://scale.emse.fr/).

Teaching Arrangements for Studies on Argumentation

The first lesson was spent on teaching students the basics of argumentation to prepare them for subsequent exercises using CABLE tools. The students and the teacher discussed the essential characteristics of argumentation, the purposes and aims of argumentation, and the difference between argumentation and merely presenting opinions. In addition, the students were taught the main concepts of argumentation: thesis, secondary thesis, argument, counterargument, chain of arguments, and the elaboration of arguments.

The second lesson was devoted to practising how to use the CABLE tools. The students were given a self-study pack on how to use the chat area, how to make argument boxes (claims, arguments and counterarguments) and argumentative links between boxes, how to fill in the boxes with meaningful content, and how to add comments and elaborations to arguments by means of commentary boxes. The students also studied the basic rules for constructing argument diagrams by analysing the argumentative structure of a short passage of dialogue and constructing a diagram on the basis of their analysis.

In the third lesson the students constructed an individual argument diagram (*1st individual diagram*) on GMO. They were given 25 minutes to do the diagram in which they were asked to think about the advantages and disadvantages of GMO, and to indicate their personal stance on the question: *Should the production of GMO be allowed?* After the students had completed their individual diagrams they read three articles on the topic: an anti-GMO article (by Greenpeace), an article representing a permissive approach to the topic (on a food biotechnology company, Monsanto), and a neutral article with respect to GMO (a report on the French ministry of research). The students were asked to scan the articles for 30 minutes, and to make notes and underline text if they so wished. After the students had read the articles they were given 35 minutes to improve their individual diagrams (*2nd individual diagram*) on the basis of the articles and their notes. They were allowed to read and screen the articles while improving their diagrams.

At the beginning of the fourth lesson, for the first 10 minutes, the students were given paper copies of the diagrams they had prepared in the previous lesson. They used the time to recall their earlier thoughts on GMO. The diagrams were then collected. Next, the students engaged in dyadic debates on GMO for 30 minutes. The teacher formed seven dyads and one trio from the students, and tried to form as many mixed gender pairs as possible. She also tried to form pairs with students she knew could work collaboratively. The teacher did not otherwise participate in the research. The students were given the following instruction:

> Your task is to argue with your partner on the following question: Should the production of genetically modified organisms be allowed?

After the debate, the students were given 15 minutes to reflect on their debate by constructing a new argument diagram jointly with their partner. The task was as follows:

> Construct an argument diagram together with your partner on the basis of your previous debate. Try to present in the diagram the most essential claims, arguments and counterarguments included in your debate. If you wish, you may also add new arguments and counterarguments into the diagram.

After finishing the joint diagram the students recapitulated their discussion for five minutes. They talked through computer chat about what they had learned from the debate and from the co-construction of the diagram, and assessed how well the joint diagram presented the pros and cons of GMO. During the next 25 minutes of the lesson the students completed their individual diagrams (*3rd individual diagram*) on GMO. The task was set as follows:

> Your task is to modify and complete the diagram presenting your answer to the question: *Should the production of GMO be allowed?* In completing your diagram you may utilise the viewpoints and arguments you discussed with your partner. In improving your diagram you may make use of the following suggestions: (1) Improve your diagram with

new arguments which either support or criticize the ones that already exist in your diagram; (2) Read through each of your arguments once more and improve and specify their content if needed; (3) Check the argumentative links between different arguments. Check also the points at which you have elaborated your arguments (commentary boxes).

DATA

The study data consisted of the 2nd individual diagrams (n = 15) the students constructed before the debate, transcriptions of the students' debates (7 debates), the new joint diagrams (n = 6) the students constructed after the debate, and the 3rd individual diagrams (n = 15) they finished up after their collaborative work (debate + the joint diagram). Not all the 17 students were present in all lessons.

Data Analyses

The analyses focus on the textual modifications included in the students' third individual diagrams after the debate and the jointly constructed diagrams. To identify modifications, the students' third individual diagrams were compared with the second diagrams constructed before the debate.

A textual modification refers here to a) revision of text in an existing argument box or commentary box, b) new text added to an existing argument box or a commentary box, and c) a new argument box or commentary box containing new text. The modifications were classified into the following five categories:

1) Revisions and replacements. This category includes modifications in which a student has revised his/her previous argument or replaced it with a new one that (s)he felt better expressed his/her position. A student could revise an argument by removing extra words from the argument or irrelevant comments from the commentary boxes. A student could also re-specify the wording of an existing argument or commentary box. For example, after the debate one student replaced the question "Should the production of genetically modified products be allowed?" he had written before the debate with the claim "The production of genetically modified products should be allowed."

2) Counterarguments. Counterarguments with which a student questioned or rebutted an existing argument were classified into this category. A student could put forward criticism by writing his/her counterargument in a new argument box and link it to an existing argument or by adding a commentary box and writing the counterargument there.

3) Extensions. Modifications by which students had extended or elaborated their previous arguments were classified into this category. In order to extend their previous thoughts students could present new ideas or clarifying comments or add examples that made their thinking more explicit and understandable. One student extended his previously presented statement "It (GMO) can bring about such means which help us to better treat familial diseases" by adding an example "For example, insulin is down to gene modification."

4) New arguments or counterarguments directly linked to the main thesis. This category includes new arguments, counterarguments and possible comments on them that were directly linked to the main thesis in the diagram. By means of these modifications the students enlarged the range of their argumentation for or against the main thesis.

5) Minor modifications. These modifications did not change the meaning of the original arguments. The students, for example, corrected spelling mistakes, condensed the wording of their previous arguments or replaced words with corresponding abbreviations. One student, for example, replaced the words "Genetically modified organisms" with the abbreviation GMO. Extra words or statements that added no argumentative value to the diagram were also classified into this category.

In order to track the sources for the students' modifications we investigated the associations of the modifications with a) the content of the students' debate, b) the jointly constructed diagram (i.e., reflection on the debate), and c) the content of the texts the students had read previously. Figures 1 and 2 (pages 118-119) illustrate the modifications one student (Eero, a pseudonym) made to his 3rd individual argument diagram after the debate and the joint construction of a new argument diagram with his interlocutor. The same modifications, related argument boxes, categories of the modifications and their associations with the debate, jointly constructed argument diagrams, and previously read texts are described in Table 1 (page 120-121).

RESULTS

How Did the Students Modify Their Diagrams?

The students made a total of 98 (mean 6.5) textual modifications to their individual diagrams after the debate. The range of modifications was 1–13; one student made only one modification and another made as many as 13, while the remainder made from 3 to 9 modifications.

A majority (71/98, 72.4%) of the students' modifications changed the content of the diagram (categories 1–4, henceforth called as content modifications), and 27 modifications were only minor. When the students' 71 content modifications were analysed in more detail it was found that most (50) of them concerned existing arguments: in 24 modifications a student had extended his/her previous arguments with new ideas or comments, 17 modifications were counterarguments against existing arguments, and 9 modifications were revisions or replacements of existing arguments or comments (Figure 3, p. 122). The remaining 21 modifications were new arguments or counterarguments added to the diagram.

Sources of the Students' Modifications

Most (30 out of 71) of the content modifications were associated with both the students' collaborative work (i.e. debate and joint diagram) and the topic-related texts (Figure 4, page 122). Some (15) of the modifications were associated only with the collaborative work and slightly fewer (12) only with the texts. The remaining 14 modifications were not associated either with the student collaboration or with the texts.

So far we have focused on the effects of both dyadic debates and the collaborative construction of joint argument diagrams without making any distinction

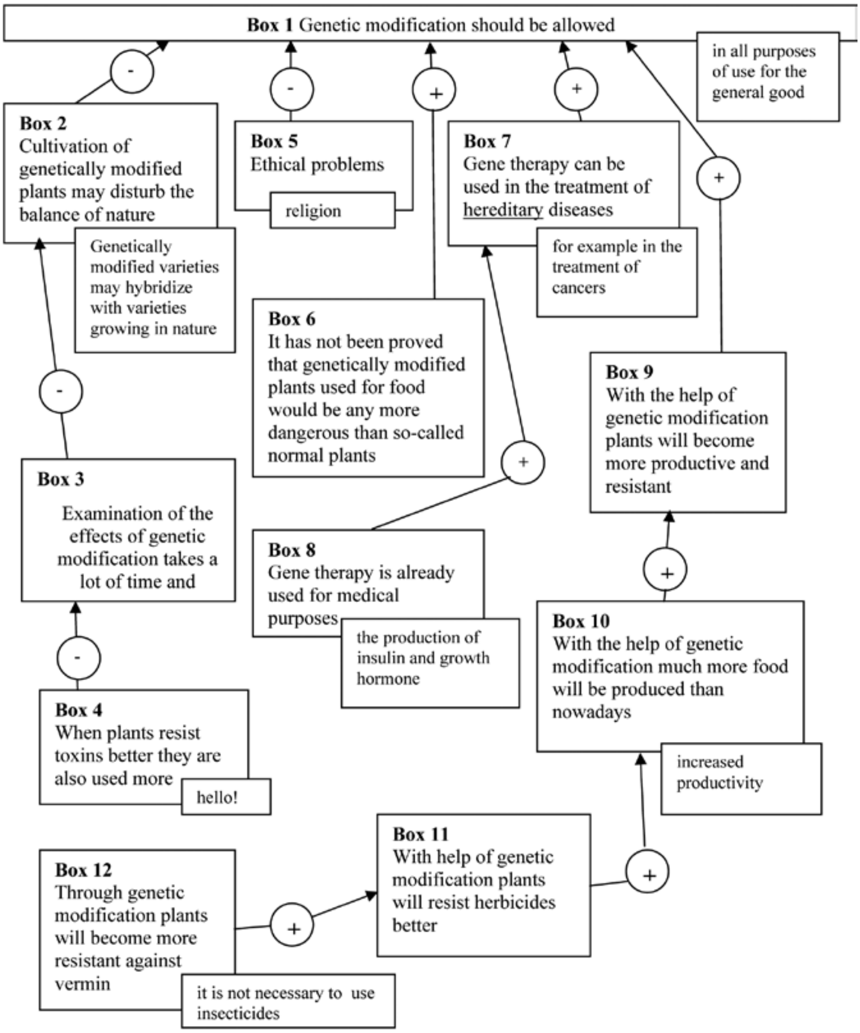

Figure 1: An argument diagram constructed before the debate (2nd diagram, Eero).

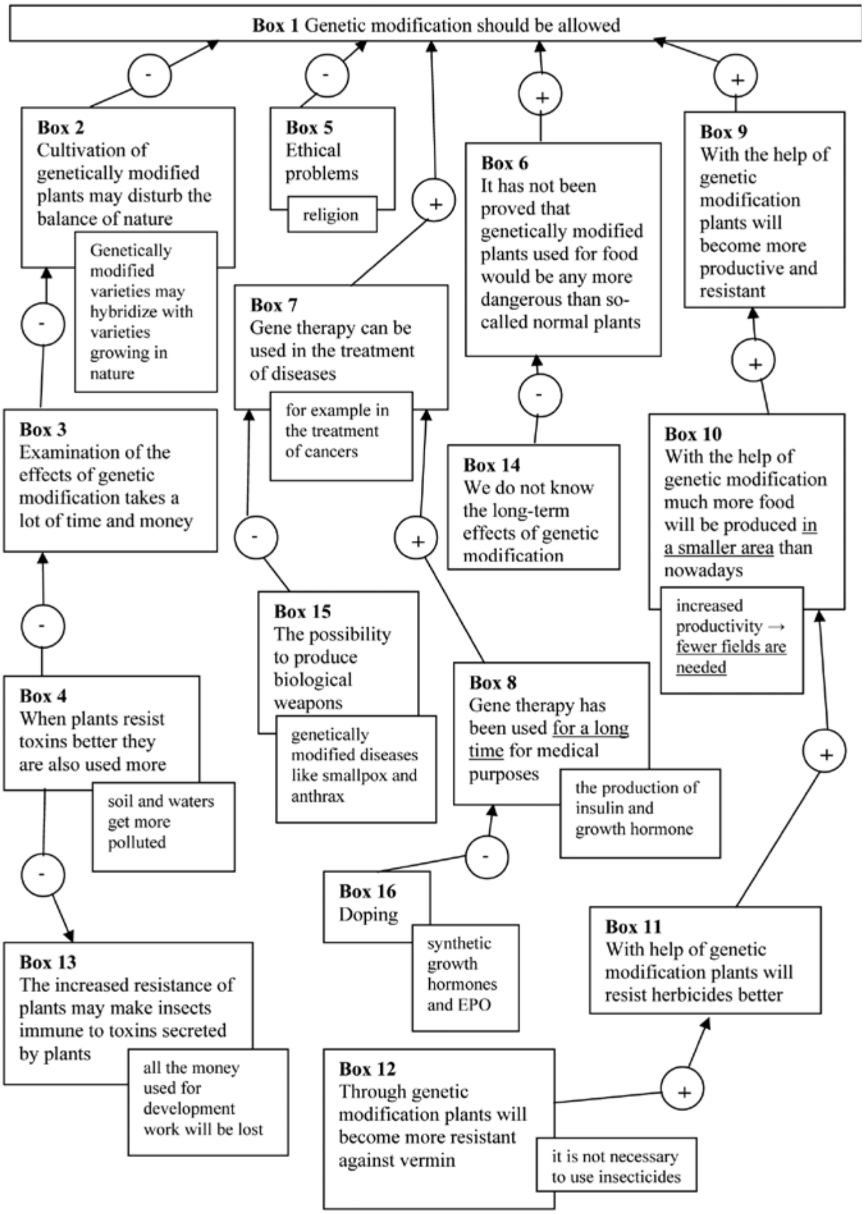

Figure 2: An argument diagram constructed after the debate (3rd diagram, Eero).

Table 1: Association of Modifications (Eero) With the Debate, Jointly Constructed Diagrams and Previously Read Texts

Modification (No. of related box and category)	**Location of conceptual equivalent of the modification**		
	Idea presented during the *debate* (either by the person him/herself or by his/her interlocutor)	Idea presented in the *jointly constructed diagram*	Idea presented in the previously read *text*
1. The student has removed the commentary box "in all purposes of use for the general good" (Box 1, Revisions and replacements)	no equivalent	no equivalent	no equivalent
2. The student has replaced a non-relevant comment with a relevant one "soil and waters get more polluted" (Box 4, Revisions and replacements)	no equivalent	no equivalent	Since genetically modified soybean (produced by an agricultural company) is resistant to Roundup weedkiller, it is possible to increase the dose of the weedkiller (marketed by the same company) which at the same time increases pollution of soil and groundwater (Greenpeace, p. 4)
3. The student has removed the word "hereditary" (Box 7, Revisions and replacements)	no equivalent	no equivalent	Gene therapy gives hope in the more efficient treatment of some inheritable diseases, like cancer (Greenpeace, p. 1)
4. The student has added words "for a longer time" (Box 8, Revisions and replacements)	no equivalent	no equivalent	no equivalent
5. The student has added the words "in a smaller area" (Box 10, Revisions and replacements)	Person himself: By growing more productive plants the area needed for cultivation would diminish	The increased production of plants reduces the area of cultivation needed	Gene technology may lead to increased agricultural efficiency and improved productivity, particularly in difficult circumstances (Ministry of research, p. 17)
6. The student has added the words "fewer fields are needed" in the commentary box (Box 10, Extensions)	Person himself: By growing more productive plants the area needed for cultivation would diminish	The increased production of plants reduces the area of cultivation needed	Gene technology may lead to increased agricultural efficiency and improved productivity, particularly in difficult circumstances (Ministry of research, p. 17)

Modification (No. of related box and category)	**Location of conceptual equivalent of the modification**		
	Idea presented during the *debate* (either by the person him/herself or by his/her interlocutor)	Idea presented in the *jointly constructed diagram*	Idea presented in the previously read *text*
7. The student has added the counterargument "The increased resistance of plants may make insects immune to toxins secreted by plants" and the comment "all the money used for development work will be lost" (Box 13)	Interlocutor: When plants resistant to pests are created they secrete so many toxins that finally insects may become resistant to those toxins, and it will cost a lot when there is no means to stop this	When the production of pesticides by plants is increased insects may become resistant to toxins, causing extra costs	The maize gene has been modified so that it is active at once when secreted in the plant, and so before long it will cause the butterfly and other insects to become resistant (Greenpeace, p. 8)
8. The student has added the counterargument "We do not know the long-term effects of genetic modification" (Box 14, Counterarguments)	Interlocutor: We do not know the far-reaching effects of genetic modification	Its (GMO) far reaching plans are not known	The consequences of genetic modification both in the medium and long-term are totally unknown (Greenpeace, p. 2) The real risks of genetic modification are poorly known. So it is better to avoid all risks relating to its uncontrolled spread (Ministry of research, p. 18)
9. The student has added the counterargument "A possibility to produce biological weapons" and a comment "genetically modified diseases like smallpox and anthrax" (Box 15, Counterarguments)	no equivalent	no equivalent	Gene therapy, in which a functional gene is brought into the cells, including weak genes, gives hope of more efficient treatment of some inheritable diseases, like cancer (Greenpeace, p. 1)
10. The student has added the counterargument "Doping" and the comment "synthetic growth hormones and EPO" (Box 16, Counterarguments)	no equivalent	Nowadays insulin and growth hormone are produced by the help of genetically modified bacteria	no equivalent

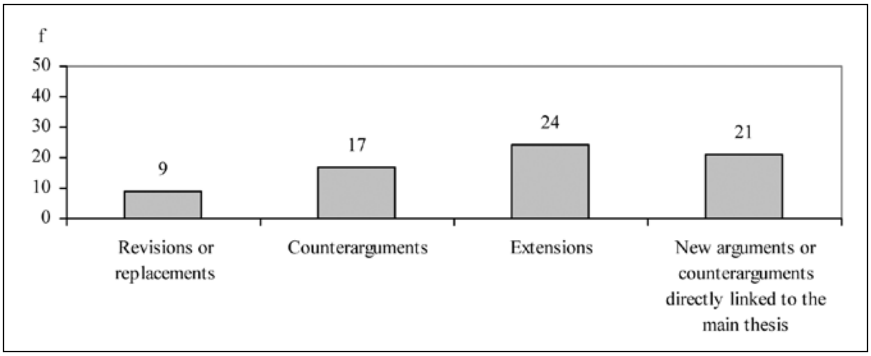

Figure 3: Distribution of the students' content modifications (n = 71).

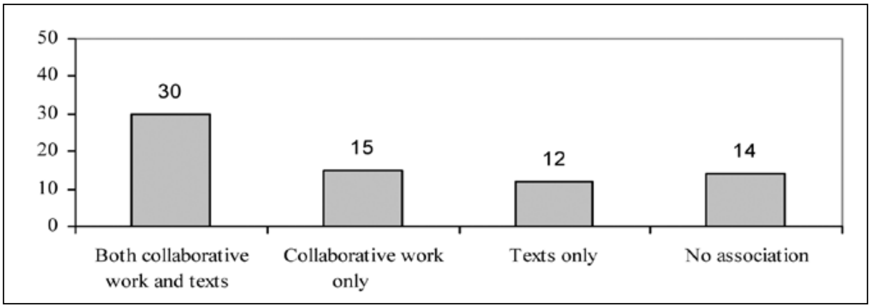

Figure 4: The associations of the content modifications (n = 71) with the students' preceding collaborative work (debate and joint diagram) and individual reading of texts.

between them. The reason for this is that it is not easy to observe who is presenting an idea when students are both speaking and writing simultaneously as they construct their joint argument diagrams. In order to answer the question of whether the students' modifications came from the thoughts of their interlocutors or from their own ideas during the debate, we looked more closely at the content modifications which had their origins in the content of the debate.

From the 45 (30 + 15) modifications that were associated with the students' previous collaborative work (see the two first bars in Figure 4), 20 were associated with both the debate and the joint diagram, 18 with only the debate, and seven with only the diagram. The further analysis of the 38 (20 + 18) modifications associated with the debate (Figure 5) showed that 55.3 % (21 in total) of the modifications were related to ideas presented by the person himself/herself while the remaining 44.7 % (17 in total) of the modifications had semantic equivalents in the interlocutors' speech.

DISCUSSION

The result that the students made several modifications to their final individual diagrams indicates that collaborative work (dyadic debate and joint argument diagrams) helped students in their knowledge construction. Although most of

Figure 5: The source of the modifications during the debate.

the students' content modifications concerned previously created arguments, the students also enlarged the range of their argumentation by adding new arguments for or counterarguments against the main thesis (Figure 3). This means that the students both *deepened* and *broadened* their argumentation. These results are parallel with the study by van Amelsvoort (2006) who found that students presented broader and deeper arguments as a result of collaborative discussion and writing.

The results in this study stand also for the usefulness of argument diagrams as they provided the students with a tool for reflecting on their previous debate and earlier knowledge. The use of several conceptual tools together with versatile working methods to support students' learning probably also increase students' motivation and promote their active involvement in studies. The pedagogical benefits of argument diagrams have also been found in previous studies. Argument diagrams have been shown, for example, to improve students' critical thinking (Twardy, 2004), and to clarify argumentative relations (Suthers, 2003).

As dyadic debate and collaborative knowledge building by the aid of joint construction of argument diagrams was the focus of the present study, we were only concerned with the modifications that the students made between their second and third individual diagrams. Earlier, when we studied the changes between three successive individual diagrams, using the same data, we found that the clearest improvement in the quality of the diagrams occurred after the students had read the texts on the topic, i.e., from the first diagram to the second diagram (Marttunen & Laurinen, 2006). Thus, when an argument diagram was used as an advance organizer in the individual knowledge acquisition phase, it proved its strength. Nevertheless, this result does not allow us to conclude that an argument diagram works at its best as an advance organizer during individual reading and less well as a collaborative tool. Anyhow, when modifying their third diagrams the students continued to deepen and broaden their argumentative knowledge on the topic. Thus, during the collaborative knowledge building phase the students both consolidated their earlier knowledge gained from the texts, and developed it further.

The sources of the students' modifications (Figure 4) indicate that the majority (42.3%, 30 in total) of the content modifications came from both the collaborative work and the texts. This means that collaborative knowledge work stimulated students to recall their earlier knowledge acquired from the texts. The stimulated recall effect continued when the students worked alone with their third individual diagrams as the proportion of only text-based content modifications was 16.9% (12).

In addition, during their collaborate work the students also reflected on the general knowledge of the world they had acquired outside the classroom, or at least outside the course in question. The students utilized their knowledge of the world both when they were collaborating and when they were modifying their third diagrams individually. The modifications made by the students to their individual diagrams showed that the overall proportion of knowledge of the world was 40.8% (29 = 14 + 15 in Figure 4), approximately a half of which was presented during the collaborative phase. The application of knowledge of the world in connection with the knowledge given in the texts is in harmony with the general goal of education, i.e., with the idea that students should not learn for school but for their future lives. Scardamalia (2002) calls this phenomenon *pervasive knowledge building.* According to her, pervasive knowledge building is not confined to particular occasions or subjects but pervades in mental life—in and out of school.

The result that the modifications were almost equally often (44.7% vs. 55.3%) associated with the ideas presented by the person him/herself as with the ideas presented by the interlocutor means that the students really did listen to each other. When this notion is combined with the result that the students improved their argumentative diagrams in this study, we can say that the students benefited from their dyadic debates. The benefits of dyadic collaborative discussions have also been demonstrated in other studies (Saab, van Joolingen, & van Hout-Wolters, 2007; Simonneaux, 2001).

In the study by Kuhn, Shaw, and Felton (1997) the subjects participated in five dyadic discussions on capital punishment, each with a different classmate. According to the results, the new elements presented in the arguments of the post-tests were first voiced by the other party during the discussions in 71% of cases among adolescents and 52 % of cases among adults. When the results of the study by Kuhn et al. (1997) are seen in conjunction with the results of the present study, it can be concluded that dyadic debates foster the development of arguments, but the process cannot be characterized as the simple incorporation of another's ideas through the mechanism of social *transmission*. If anything, the opinions, arguments, and questions presented by the other party invite a person to *transform* his or her own knowledge. The knowledge transforming process becomes partly visible when the person replays his/her interlocutor's ideas during the debate. Scardamalia (2002) puts this phenomenon into a wider context when she considers the socio-cognitive dynamics of knowledge building discourse. According to her "the discourse of knowledge building communities results in more than sharing of knowledge; the knowledge itself is refined and transformed through the discursive practices of the community—practices that have the advancement of knowledge as their explicit goal."

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