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Arguing to learn

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Many people think that arguing interferes with learning. They link argumentation to a certain type of oppositional argument that is increasingly prevalent in our media culture. Tannen (1998) analyzed the aggressive types of argument that are frequently seen on talk shows and in the political sphere, where representatives of two opposed viewpoints spout talking points at each other. In these forms of argumentation, the goal is not to work together toward a common position, but simply to score points. All teachers and parents have seen children engaged in this type of argumentation, and most would probably agree that it has little to contribute to education.

The learning sciences are studying a different kind of argumentation, which I call *collaborative* argumentation. For example, collaborative argumentation plays a central role in science; science advances not by the accumulation of facts, but by debate and argumentation (Kuhn, 1970; Bell, 2004). Even when two scientists disagree, they still share the common values of science and both of them are interested in achieving the same goals. Argumentation in science is not oppositional and aggressive; it is a form of collaborative discussion in which both parties are working together to resolve an issue, and in which both scientists expect to find agreement by the end of the argument. Exposure to collaborative argumentation can help students learn to think critically and independently about important issues and contested values.

When students collaborate in argumentation in the classroom, they are *arguing to learn.* When viewed as a collaborative practice, argumentation can help learners to accomplish a wide variety of important learning goals. First, argumentation involves elaboration, reasoning, and reflection. These activities have been shown to contribute to deeper conceptual learning (Bransford, Brown, & Cocking, 1999). Second, participating in argumentation helps students learn about argumentative structures (Kuhn, 2001). Third, because productive argumentation is a form of collaboration, it can help develop social awareness and collaborative ability more generally (Vygotsky, 1978; Wertsch, 1985). Fourth, groups of people, at work, at home, in social contexts, often share a common tradition of argumentation, and effective participation in these groups requires knowing how to argue competently within them (Billig, 1987; Koschmann, 2003). This is particularly true of the knowledge-based communities that are so central to the knowledge society—groups of highly trained professionals such as scientists, doctors, lawyers, and executives.

Argumentation has been studied from many perspectives—philosophy, literature, public speaking—but there have been very few educational studies of argumentation. However, a few learning scientists have been studying the educational use of argumentation, and this chapter summarizes this research. Studies of arguing to learn have the potential to help learners, teachers and researchers design learning environments that facilitate collaborative argumentation. First, I will discuss Argumentation Theory, for its vocabulary and different viewpoints on argumentation. Then, I discuss the relation between argumentation and learning. Finally, I summarize learning in learning environments where argumentation is mediated by computer networks, such as chat rooms and Internet newsgroups.

Argumentation theory

Argumentation theory (van Eemeren, Grootendorst & Snoeck Henkemans, 2002) studies the production, analysis and evaluation of argumentation. The goal is to develop criteria for judging the soundness of an argument. Describing and evaluating arguments are some of the oldest topics of scholarship; Aristotle distinguished several kinds of argumentation: including didactic, dialectical, examination and eristic. For most of the last century, the study of argumentation has been dominated by scholars who focused on the sequential structure of an argument. In this tradition, a good argument was thought to have a certain type of structure, and scholars attempted to specify the “grammar” of argument, by analogy with the syntax of a well-formed sentence. For example, Toulmin (1958) identified the following stages of sound argumentation:

A *claim* states the standpoint or conclusion: “The Kyoto protocol to reduce global warming is necessary.”

The *data* are the facts or opinions that the claim is based on: “Over the last century, the earth’s temperature has been rising as a result of greenhouse gas emissions.”

The *warrant* provides the justification for using the data as support for the claim: “Scientists agree that there is no other explanation for this rise in temperature.”

Optionally, the *backing* provides specific information supporting the warrant. “Scientists have identified the atmospheric mechanisms whereby greenhouse gases cause a warming of the earth’s surface.”

A *qualifier* adds a degree of certainty to the conclusion, indicating the degree of force, which the arguers attribute to a claim: “However, the earth’s temperature has been found to fluctuate over geological time, in some cases without any obvious cause.”

Exceptions to the claim are expressed by a *rebuttal*: “The Kyoto protocol would not be necessary if the world’s countries voluntarily reduced their output of greenhouse gases.”

This type of approach has been very influential, especially in the analysis of written argumentation. It is a concise description of what appears a sound line of reasoning, or even a productive line of inquiry. However, in recent years, the study of argumentation has become a more empirical and scientific study, and the grammatical approach does not correspond very well to the ways that arguments unfold in collaborative discourse. Van Eemeren & Grootendorst (1999) note that the model fails to consider both sides involved in (real-world) argumentation; it covers only the proponent, not the opponent. A related problem is that it fails to consider argumentation as a discourse phenomenon, which is always embedded in a specific contextual and social environment. For the learning sciences, another serious problem is that the grammatical view ignores development (Leitão, 2001), as well as the higher level problem-solving nature of argumentative discourse (Voss, Tyler, and Yengo, 1983).

Instead of this grammatical concept of argument, the learning sciences draw on scholars who analyze argumentation as a type of dialogue. For example, *formal dialectics* (Barth & Krabbe, 1982) describes argumentation as a dialogue between a proponent and an opponent around a certain thesis. *Pragma-dialectics* (van Eemeren & Grootendorst, 1992; 1999) explains the interaction between proponent and opponent in terms of the necessary conditions for critical discussion rather than on rules of logic for generating a debate. Van Eemeren & Grootendorst (1999) show how pragma-dialectics can be applied to the analysis of argumentative discourse. In *dialogue theory* (Walton, 2000), an argument is seen as a move made in a dialogue in which two parties attempt to reason together. Six types of dialogue are described —persuasion, inquiry, negotiation, information-seeking, deliberation, and eristic (personal conflict)— to be used as a normative model to provide the standards for how a given argument should be used collaboratively. A dialogue begins with an opening move, and then each pair of moves represents a so-called adjacency pair. Sequences of moves, formal dialectical structures, are meant to model argumentation, but also other speech acts. Figure 1 provides an example of such a sequence, the first line illustrating the moves "why-question" (asks for justification) and "putting forward an argument" (supports a proposition by quoting another one).

Proponent	Respondent
1. Why should I accept *A*?	Because *B*, and if *B* then *A*.
2. Why should I accept *B*?	Because you accepted it before.
3. All right, I accept *B*.	Do you accept 'If *B* then *A*'?
4. Yes.	Do you accept *A*?
5. No.	You are inconsistent!

Figure 1: Moves in a sample dialogue (from: Walton, 2000)

Argumentation and learning

Dialogue theory suggests that in arguing to learn, students are not primarily attempting to convince each other; instead, they are engaged in *cooperative explorations of a dialogical space* of solutions (c.f. Walton, 1989; Nonnon, 1996). An argument for learning should be evaluated on the basis of its collaborative value as a contribution to the conversation (Grice, 1975).

Baker (2004) identified four learning mechanisms that are potentially associated with effective arguing to learn. These mechanisms are based on general learning sciences findings that seem to apply broadly to a wide range of content knowledge (Sawyer introduction, this volume):

Making knowledge explicit: Learners that provide explanations, or make explicit the reasoning underlying their problem solving behavior, show the most learning benefits (Chi & van Lehn, 1991). Argumentation provides many opportunities for explanation, and preparing a justification or argumentative defense fosters reflection that often leads to deeper learning.

Conceptual change: Debating a question may raise doubt about initial misconceptions. Conceptual transformation is supported by argumentation.

Co-elaboration of new knowledge: In argumentation, learners work together to develop new knowledge. The interactive interpersonal nature of verbal interaction helps to scaffold individual learning.

Increasing articulation: Argumentation obliges learners to precisely formulate question and statements, and articulation transforms and deepens during the argument .

The development of argumentative skill

The ability to understand argumentation emerges early in development. It develops out of a desire to ensure that personally meaningful goals are attained. By the age of 3 children generate and understand the principal components of an argument (Stein & Albro, 2001; Stein & Miller, 1993). The ability to construct detailed, coherent rationalities in defense of a favored position improves with age. This development, however, does not guarantee a deeper understanding of one's opponents, because argumentative knowledge is necessarily asymmetrical (Stein & Bernas, 1999). Individuals have more knowledge about the positive benefits of their own position than of those of their opponent's position. Also, they know more about the weaknesses of their enemies than of their own weaknesses. We can train people to understand the opposing position in a more accurate and complex fashion; but only when they begin to change their stance do learners start generating reasons that favor the opponent's position.

The mental structures used to understand arguments are related to those used to understand social conflict and goal-directed action. A conflict may exist between displaying good argument skills and participating in morally and socially responsible negotiations. It may be the case that good arguers have less knowledge about and poorer relationships with their opponents. The question then is how to teach skill in negotiation that leads to personal and interpersonal success rather than personal success at the expense of the other (Stein & Albro, 2001). This is of direct relevance to argumentation in learning contexts, because arguing contributes more effectively to learning when it is not competitive. If we want to use argumentation for learning, students need to balance an assertiveness in advancing their claims with a sensitivity to the social effects of their argument on their opponents.

Arguing to learn contributes to reasoning skills

During reasoning, individuals make inferences from given knowledge to reach a conclusion that was not given (Voss & Means, 1991). The inferences that support reasoning have a similar structure to an argument, and the same criteria are applied to evaluate the legitimacy of an inference as are applied to evaluate an informal argument. This is why Means & Voss (1996) concluded that informal reasoning skills develop through the learning of discourse structures like argumentation; argumentation facilitates storage of and access to knowledge in memory, and the development of elaborate mental models, which helps inference generation, problem solving and learning.

Kuhn (1991) studied argumentation and informal reasoning about issues of genuine importance: What causes prisoners to return to crime after they are released? What causes children to fail in school? Participants were 160 individuals in 4 age groups (Teens, 20s, 40s, and

60s) who were asked to prepare arguments and counterarguments. Kuhn interviewed the participants to determine their causal theories, the evidence they used to support their theories, their ability to generate an alternative theory on their own, and their ability to generate counterarguments to their theory and to rebut the counterarguments.

Most participants tended to provide ineffective arguments. Instead, they provided theories along with a list of unrelated causes. Only 16% of the participants could generate genuine evidence for their theories. Most evidence generated was of a type that Kuhn called *pseudoevidence*; there was a lack of separation between theory and evidence. Somewhat better scores were obtained for the ability to conceive of an alternative theory (33%). Equally crucial is the ability to produce counterarguments, and subjects showed similar scores: Thirty-four percent were consistently able to generate a counterargument to either their own or an alternative theory that they had generated. Finally, the percentage of subjects that generated valid rebuttals to their own theories was between 21% to 32% across topics.

Kuhn related these findings about people's argumentative skills to their epistemological theories, that is, the view they held about the nature of knowledge and knowing. It appeared there are two very different kinds of knowing. At one pole knowing prevails in complete ignorance of alternative possibilities (the absolutist epistemology). At the other pole, knowing is an ongoing, effortful process of evaluating possibilities, one that is never completed (the evaluative epistemology). Only a minority of the subjects (from 9 to 22% of the subjects across topics) held to the evaluative epistemology. This means that most people do not hold to the appropriate epistemology to reason through argumentation. For such learners to progress to the more advanced understanding of argumentation, they have to be capable of reflection on their own thought.

Learning to argue in small groups

The learning sciences have shown that collaborative classroom interaction can often contribute to individual learning (Greeno, this volume; Sawyer, this volume; Billig, 1987; Kuhn

& Udell, 2003). This is particularly true of argumentative discourse. For example, Kuhn, Shaw and Felton (1999) asked participants (students and adults) to write an essay about capital punishment, and then engaged these students in argumentation over this topic for a period of several weeks, following which an essay justifying their positions was elicited again. The argumentation was in pairs with multiple partners, with each argument lasting 10-15 minutes. The results showed that sustained engagement involving multiple dialogues with different partners over a period of weeks significantly enhanced the number of two-sided (as opposed to one-sided) and functional (as opposed to non-functional) arguments in the subjects' reasoning.

The approach of Reznitskaya, Anderson, McNurlen, Nguyen-Jahiel, Archodidou & Kim (2001) was based on a method called *collaborative reasoning*, an approach to discussion that aims to provide elementary school children with the opportunity to become skilled in argumentation. Collaborative reasoning helps students develop *argument schema*, abstract knowledge structures that represent extended stretches of argumentative discourse. Such a schema enable the organization and retrieval of argument-relevant information, facilitate argument construction and repair, and provide the basis for anticipating objections and for finding flaws in one's arguments and the arguments of others (Anderson & Pearson, 1984; Reznitskaya et al, 2001).

Fifth graders in the experimental group participated twice a week, during a period of 5 weeks, in small groups, in discussions about controversial issues. Students were asked to take positions on an issue (on the basis of story information) and provide supporting reasons and evidence for their opinions. With coaching from their teacher, students challenged each other's viewpoints, offered counterarguments and rebuttals, and asked for clarifications. In addition, these students were exposed to the formal argument devices in teacher-led activities. At the end of the 5-week period, twice per week students engaged in 15-minute discussions with other participating classrooms via the Internet.

Learning was assessed by analyzing an argumentative essay that was based on a realistic story dilemma. The essay was scored on relevant arguments, counterarguments, and rebuttals. Students who participated in the collaborative reasoning discussions wrote essays that contained a significantly greater number of arguments, counterarguments, rebuttals, and references to text information than the essays of students who did not experience collaborative reasoning (Reznitskaya et al. 2001).

Learning through collaborative argumentation

Argumentation is one of the features of collaborative learning that make student groups so effective at promoting individual learning. Keefer, Zeitz & Resnick (2000) studied argumentation during oral classroom peer discourse. Their point of departure is the idea that statements, assertions and arguments can be understood as (tacitly agreed) *commitments* that a participant in the dialogue is obliged to defend if challenged (Grice, 1975; Walton & Krabbe, 1995). An important contribution of this study is that it empirically attempts to identify different types of discussion (Walton & Krabbe, 1995). Each dialogue has an initial starting point, an assigned goal, the participants' goals, and the characteristic means of reaching the goal. Participants' goals may shift during discussion, possibly changing dialogue type.

The most suitable type of dialogue for a peer-led discussion focusing on understanding literary content was called a *critical discussion*. The characteristics of critical discussion are: (1) starting with a difference of opinion; (2) having a goal of accommodation and understanding of different viewpoints; (3) a balance-of-considerations style, in which the most persuasive arguments prevail; (4) the participant goal of persuading others and sharing understanding.

A second type of dialogue is called *explanatory inquiry*, characterized by (1) a lack of knowledge as a starting point; (2) the goal is correct knowledge; (3) achieved by cumulative steps; (4) the participants goal being convergence to a solution or conclusion.

The assessment involved 4 minutes of conversational reasoning of 12 peer discussions (six groups at the beginning and at the end of the year) by fourth grade students. The researchers identified a number of features of argumentation that resulted in the most learning. The biggest influence was holding a sustained commitment to the pursuit of an issue. For issue-driven critical dialogues to be sustained, concessions (that is: one agrees to being convinced) in the course of argumentation were necessary to accommodate the differences in opinion that existed at the start of the dialogue. Sometimes this involved altering some commitment, by either attacking arguments that supported conclusions previously presented, or by building on arguments that attacked those previously presented conclusions. Dialogues with too many challenges (critical questions or attacks) were not necessarily productive, because the challenges were not always followed by serious consideration of their impact on some viewpoint. Dialogues where participants conceded their positions too easily were also unproductive; they built on the first claim presented, without seriously considering alternatives.

Summary: Argumentation and learning

Many people have trouble arguing productively. They are not good at distinguishing evidence from theory, and do not tend to consider alternative positions. And because the social cost of threatening a good relationship is rather high, people are not inclined to argue in situations in which they do not feel at ease. There may be important cultural differences here; but in the Western European context, students must be explicitly socialized into productive argumentation in school contexts.

Individual reasoning can benefit from arguing to learn, but argumentation must be scaffolded by the environment to support a gradual appropriation of collaborative argumentation. In collaborative learning, argumentative activities are grounded in other (shared) activities, they are not goals in themselves, or perhaps only during brief moments of reflection. Arguing to learn needs embedding into collaborative activity driven by a desire for understanding and sharing that with others.

Collaborative argumentation in electronic environments

The learning sciences are discovering that much knowledge is learned more effectively in collaboration. But in the above section, I reviewed research showing that most people have difficulty arguing collaboratively. Technology, especially computer-supported collaborative learning (CSCL), has the potential to support productive argumentation, with the potential to lead to deeper understanding (see Koschman et al., this volume). In this section, I describe several software systems in which students type their arguments on the computer. These systems aim to *scaffold* student argumentation in some way— by providing structure to the roles of each student and the relationships between them in a dialogue, and by offering new and multiple ways of *representation* (argument maps) and manipulating the structure and content of argumentation. These systems aim to somehow guide and structure the way students argue, in order to raise awareness of argumentation, and ultimately, argumentative learning. Because we are dealing with new forms of mediation of argumentative knowledge, learners may require considerable experience to appropriate these tools to their advantage.

The topics that I address in this section are: (1) scaffolding argumentation with dialogue games; (2) scaffolding argumentation by assigning roles; (3) scaffolding negotiation in computer supported collaborative writing; (4) scaffolding arguments with argument maps; and (5) scaffolding scientific argumentation.

1. Scaffolding argumentation as a dialogue game

Inspired by dialogue theory (Walton, 2000, see above), dialogue game theory (Levin & Moore, 1980) attempts to structure participants behavior on terms of roles and constraints, made explicit by a list of ordered moves and parameters for the types of behavior the participants are supposed to be engaged in at each point in the argument. For example, Mackenzie (1979) developed an argumentation computer game called DC that allowed the user to select a move and type in its content. The moves that were provided included Question, Statement, Challenge, Resolution, and Withdraw. The system then evaluates the contribution according to a preset list of rules. There are rules defining what happens as a result of a move, and there are rules defining when a move may be made. The rules prevent each player from evading a question, arguing in a circle, or failing to support a claim.

Also based on dialogue game theory, McAlister, Ravenscroft & Scanlon (2004) developed a tool called AcademicTalk that supports synchronous debate between peers. The system requires a learner to choose a sentence opener for each new message (see Figure 2), and then to complete the message (note similarities with the scaffolds in Knowledge Forum: Scardamalia & Bereiter, this volume). The openers were designed to support argumentation, and at each point in the argument certain openers are highlighted as suggestions to be considered. Students prepare for a debate by reading source materials, then engage in the debate, and finally there is a consolidation phase and a summary of key arguments posted to the group.

The tool was compared with a tool which allowed on-line discussion but with no scaffolding. Preliminary results from a group of 22 students indicate that students using AcademicTalk engaged more directly with each other's positions and ideas (claims, challenges and rebuttals), and produced more extended argumentation. In contrast, students in normal chat did not engage in as much argumentation and instead simply exchanged information.

Inform	Question	Challenge
I think…	Why do you think that…?	I disagree because…
Let me explain…	Why is it…?	I'm not so sure…
Let me elaborate…	Can you elaborate…?	How is that relevant…?
Because…	Can you give an example…?	A counter-argument is…
An example…	Is it the case that…?	An alternative view is…
My evidence…	Don't we need more evidence…?	Is there evidence…?
		How reliable is that evidence…?
Reason	**Support**	**Maintain**
Therefore…	I agree because…	Yes
What I think you are saying…	I see your point of view…	No
That is valid if…	Also…	Ok
Is your assumption that…?	That's right	Thank you
Both are right in that…	Good point	Sorry…
To summarise…		Is this ok…?
Let's consult…		Would you please…
		Ok. Let's move on.
		Can we…?
		Goodbye…

Figure 2. Sentence openers in AcademicTalk (McAlister et al, 2004)

2. Scaffolding argumentation through role play

In a postgraduate university course on computer-mediated communication, Pilkington & Walker (2003) asked their students to adopt one of three *argumentation roles*, based on research showing that when students are forced to adopt these roles, it leads to improved argumentative reasoning (Mercer, Wegerif & Dawes, 1999). Role 1 students challenge others to provide evidence and pointing out alternatives or contradictions (e.g. "No because…', or 'Yes, but…'); Role 2 students ask for explanations and clarifications; and Role 3 students provide information, either spontaneously or in answer to an inquiry. Students had regular electronic discussions throughout the course. At the beginning of the course, a teacher was heavily involved in the discussions; the teacher was responsible for a substantial number of argumentative contributions (between 27% and 42% of the challenges). Part way through the semester, the students participated in a role-playing exercise in which they were asked to assume one of the three roles; after this one role-playing session, there was no mention of roles anymore. Even so, after the role-playing session, the tutor’s responsibility for scaffolding the students’ argumentation declined to between 21% and 25%; students increasingly took over the responsibility for sustaining the debate. The level of content building (role 3) fell down as the adoption of other roles increased. No one was explicitly assigned that role, and the authors took its drop as a positive sign because it led to fewer but deeper parallel discussion threads. The exercise showed that there is gain to be obtained by making students aware of roles in discussions and by providing them with role-play experiences in CMC.

3. Scaffolding argumentation in collaborative writing

Andriessen, Erkens, van de Laak, Peters & Coirier (2003) studied the role of argumentation in collaborative writing by university students. Students worked in pairs to write a letter to the local government about employment contracts, arguing for either steady contracts with infinite duration, or for flexible temporary job contracts, both from the point of view of the workers and that of the employers. They used both electronic communication and a shared text editor. Before the discussion, each participant received a (different) list of three arguments, as an incentive for a debate. These arguments will be called *given arguments* in what follows. The researchers examined in detail the relationship between the specific concepts that were discussed in the online dialogues and the concepts included in the collaborative text. For each concept, researchers examined when it was discussed (the protocol was divided into 3 phases), to what extent it was discussed and if and when it was included in the text. This conceptual analysis revealed that the three phases of collaborative text production could be characterized as 1) content generation (many new concepts proposed in the chat), 2) text generation (many concepts from earlier chat put in the text), and 3) text completion (less discussion, more text).

Negotiations were distinguished by their function (informative or argumentative) and their degree of elaboration (minimal, moderate and elaborate). Minimal negotiation merely involved the proposition on one argument to include in the text, moderate negotiation implied that there was some elaboration, as a short explanation or additional support by one of the participants. Only in elaborate negotiation there was two-sided argumentation, by each participant proposing and/or elaborating an argument.

Most negotiation (77.3%) did not involve explicit agreement. Given arguments were only part of minimal negotiation, even though each participant received different concepts. Most negotiation of any type involved defending the preferred position. Elaborate negotiation was only 10.2% of the dialogue patterns, but when the arguments that were given beforehand are not included in the count, proportions of elaborated negotiation were found between 37% and 52%, depending on the argumentative orientation (in favor or against the main claim) of the dialogue pattern. Finally, negotiations were different in each of the three phases, indicating that argumentation during complex learning tasks serves different functions, and may require different scaffolds.

4. Scaffolding argumentation with argument maps

Many systems use the graphical power of today's personal computers to graphically display the relations between moves in an argument. Systems that use visual argument maps to scaffold argumentation include CHENE (Chaines ENErgetiques: Tiberghien & de Vries, 1997), which was designed to be used by two students who were collaborating to build an electronic circuit; C-CHENE (Baker & Lund, 1997), which provided dialogue buttons for each of about 10 different dialogue moves, as well as dialogue buttons for agreeing, disagreeing, and managing the ongoing argument; and CONNECT (Baker, 2004), which displayed every statement made by each of the two students, and provided buttons for each student to agree or disagree with each statement.

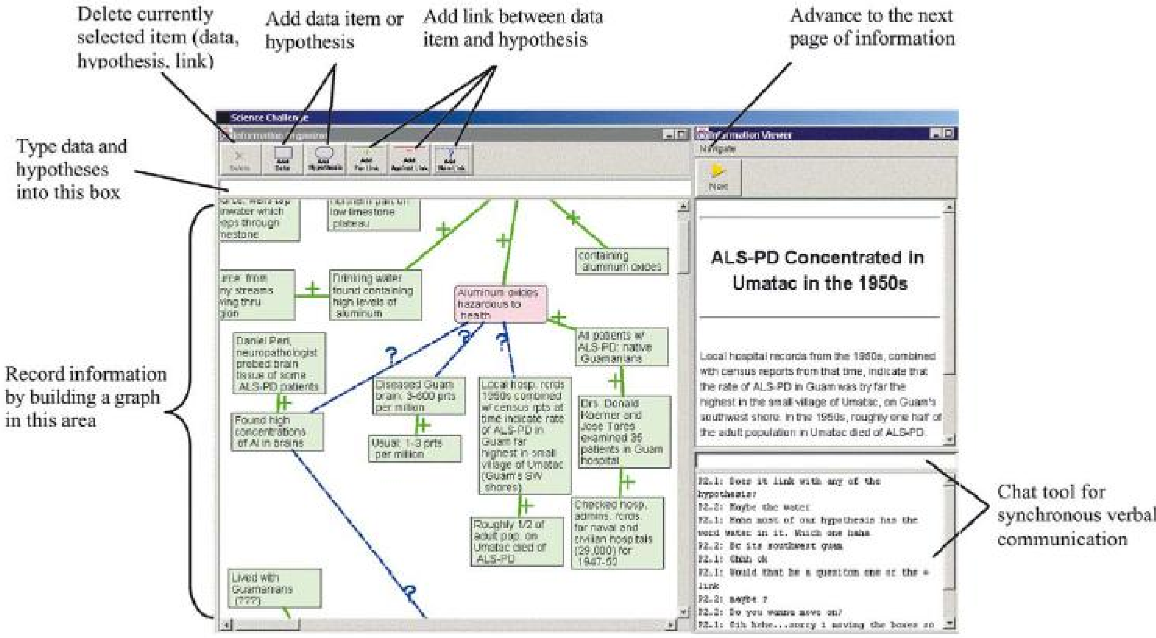

Figure 3. Belvedere 3.0. graph interface in the online condition of Suthers et al (2003)

Figure 3 shows a screen display of the argument map system Belvedere 3.0. Belvedere is intended to support secondary school children's learning of critical inquiry skills in the context of science (Suthers, 2003). The diagrams were designed to engage students in complex scientific argumentation. The boxes represent hypotheses and data, and the lines show relations of support and disagreement. An earlier version had many more visual primitives than Figure 2, allowing propositions to be categorized as *Principal, Theory, Hypothesis, Claim,* or *Report*. Research with this early version showed that most interesting argumentation was not within the diagrams, but was the oral discussion between students who were working together at a single computer (Suthers, 2003). As a result, the diagrams were later simplified to focus on evidential relations between data and hypotheses, and this is the version in Figure 3.

In a study of their VCRI tool (Virtual Collaborative Research Institute: Jaspers & Erkens, 2002), Munneke, van Amelsvoort & Andriessen (2003) analyzed argumentative interactions and the possible roles of argumentative diagrams in supporting them. The variable of interest was broadening and deepening the space of debate. Broadening referred to students using different epistemological and societal views with the associated arguments, and deepening referred to students using many related concepts and modes of reasoning while exploring. Graphical representations support these activities in many ways: by forcing students to make their ideas explicit and complete (van Bruggen, Boshuizen & Kirschner, 2003; Suthers & Hundhausen, 2003), by helping them to share focus (Veerman, 2000), as an aid for organizing and maintaining coherence during problem solving (Suthers, 2001), and by serving as resources for conversation and reasoning (Baker, 2003; Suthers, 2003).

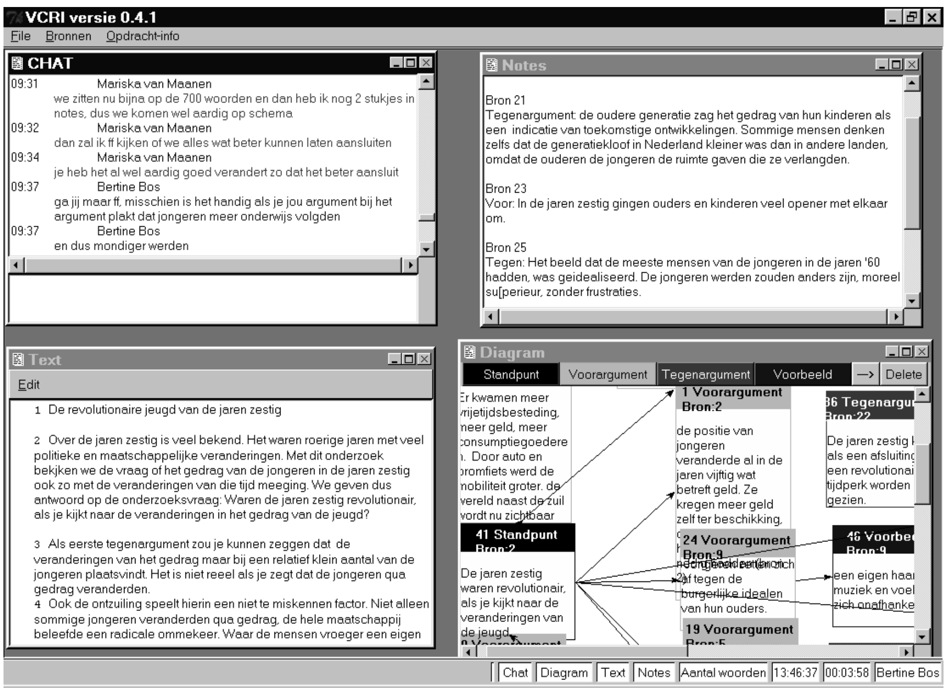

Figure 4: The VCRI-tool, showing 4 windows, to be arranged by the students, serving (1) synchronous chat; (2) individual notes (not in the experiment described here); (3) a collaborative text editor; (4) a collaborative diagram

In their study, Munneke et al. compared the effect of constructing diagrams (individually) *before* or (together) *during* an electronic discussion, on argumentative interactions in the dialogues. The assignment was the construction of a collaborative text on genetically modified organisms, using the VCRI tool (see Figure 4). In the first condition, diagrams were individually constructed as a preparation for debate. Subjects were instructed to represent their own opinion, supported by arguments and by refutation of counterarguments, in a diagram . After that, subjects were paired, and individual diagrams were available to be consulted during the collaboration phase, where participants discussed and produced a collaborative text on the topic. In the collaborative diagram condition, students discussed the topic, also after a reading phase, while collaboratively constructing a diagram which had to reflect their discussion.

All content-related episodes were scored using an ordinal score system of increasing depth: (1) stating an argument; (2) giving and example or explanation; (4) presenting support, or rebuttal; (8) explanation of a relation between several arguments. A total score of depth could be calculated for every pair and for every individual, as well as for every subtask. In addition, individual utterances were coded for dialogue function: social relation, interaction management, task management, or content elaboration. Some findings were:

1. Most chat activities were task management, and most of this in the collaborative diagram condition (67.5% vs. 76.9%).

2, Conversely, in the individual diagram condition there was somewhat more argumentation in the chat (8.6% vs. 13.8%).

3. The diagrams constructed individually differed widely in the number of boxes, and, as always, there were more arguments in favor than against the claim (56 vs. 137).

4. It seemed that the individual preparation diagrams were used as information sources during the debate most of the time, to find (and copy) arguments for the discussion or the text to write.

5. In the collaborative diagram condition there were instances of diagrams being used as notebook to summarize the discussion.

6. Discussions in the individual condition were somewhat broader (more different topics).

7. Diagrams and discussions were similar in depth in both conditions.

8. The texts produced were deeper than the diagrams in both experiments, showing more rebuttals, supports and relations between arguments.

Overall, students did not really discuss each other's arguments, they simply took proposed arguments for granted. Short fragments of argumentation were followed by rapid reconciliation. Hence, it seems that the role of diagrams in directly forcing students to make their ideas explicit was very limited. The second role of the diagram, maintaining focus, was confirmed by the task and content focus of most of the utterances, but it seemed that the goal of writing a collaborative text (simultaneously) distracted the students from discussing the content in depth.

5. Scaffolding argumentation in scientific inquiry

In everyday issues we are often skillful in challenging, counterchallenging, justifying or agreeing during conversation, but the arguments we hold are generally mediocre according to analytical criteria (Pontecorvo, 1993). In contrast, in scientific domains we simply accept expert arguments; but we generally do not use them in further activities to convince, challenge or justify our viewpoints (Schwarz & Glassner, 2003).

Good argument depends on knowing the facts of a field, but knowing the facts does not predict good argumentation (Goldman, Duschl, Ellenbogen, Williams & Tzou, 2003). Goldman et al.'s intervention program, using Knowledge Forum (see Scardamalia & Bereiter, this volume), takes the private knowledge claims of individual students and small groups of students and makes them public. This form of argument is then taken as a starting point to develop more complex argumentation skills. Students are provided with tools that address the construction, coordination and evaluation of scientific knowledge claims, which include claims about theory (what knowledge is important), method (strategies for obtaining and analyzing data), and goals (outcomes and how to determine they are attained). The role of the teacher in whole-class and small-group discussions is to actively process the reasoning of the students, and intervene with questions, comments and prompts for additional student input always oriented towards evidence-based consensus building. This is no easy task, and it is still uncertain how and if this kind of teacher role gives the desired results.

Argumentation and debate are the motors of progress in the natural sciences (Bell, 2003). Argumentation serves the exploration of theoretical controversy, involving the explicit coordination of evidence with theoretical ideas. Linn and her team designed the Web-based Integrated Science Environment (WISE; formerly known as the Knowledge Integration Environment or KIE; see Linn, this volume) to scaffold students in these activities. Knowledge integration is a dynamic process through which students connect their conceptual ideas, link ideas to explain phenomena, add more experiences from the world to their mix of ideas and, restructure ideas with a more coherent view (Linn, this volume; Bell & Linn, 2000).

Research on WISE focuses on how argument construction and collaborative debate could be promoted in the science classroom for the dual purpose of having students learn science content while also learning about scientific practice. In an integrated approach (Linn, Bell & Hsi, 1998; Bell & Linn, 2001) middle school students are engaged in forms of scientific inquiry as they simultaneously develop scientific knowledge that is grounded and relevant to scientific and personal life situations.

After a 5-week curriculum sequence, a debate started on the topic “How far does light go?,” during which students explore multimedia evidence items, construct explanations and arguments about how the evidence relates to the debate topic, and then engage in a whole-class debate about the issues, claims, and evidence.

It was a design- based research project, during which the research design was adapted as a function of the observed learning activities (Confrey & Lehrer, this volume). The cycle involved iterative refinement of the collaborative activity, spanning several years of teaching. We describe a total of five iterative phases of this research project.

For the first phase the teacher selected two competing theories to frame the debate: students indicated their initial positions and then explored 12 multimedia evidence items.

Analysis of the second phase revealed that students were overly focused on particular evidence items, instead of considering the entire corpus of evidence. Perhaps unsurprisingly, they focused on one or two pieces of evidence they believed would strongly support their perspective, and ignored counterevidence. In addition, the arguments they produced were not very elaborated. This led Linn’s colleague Philip Bell to develop a tool called SenseMaker (Bell, 1998), which supported the coordination of claims (the boxes in Figure 5) and evidence (the lists in each box) to create argument maps. SenseMaker is an *argument editor* and it supports development of an argument that makes sense of the collected evidence (Bell, 1998).

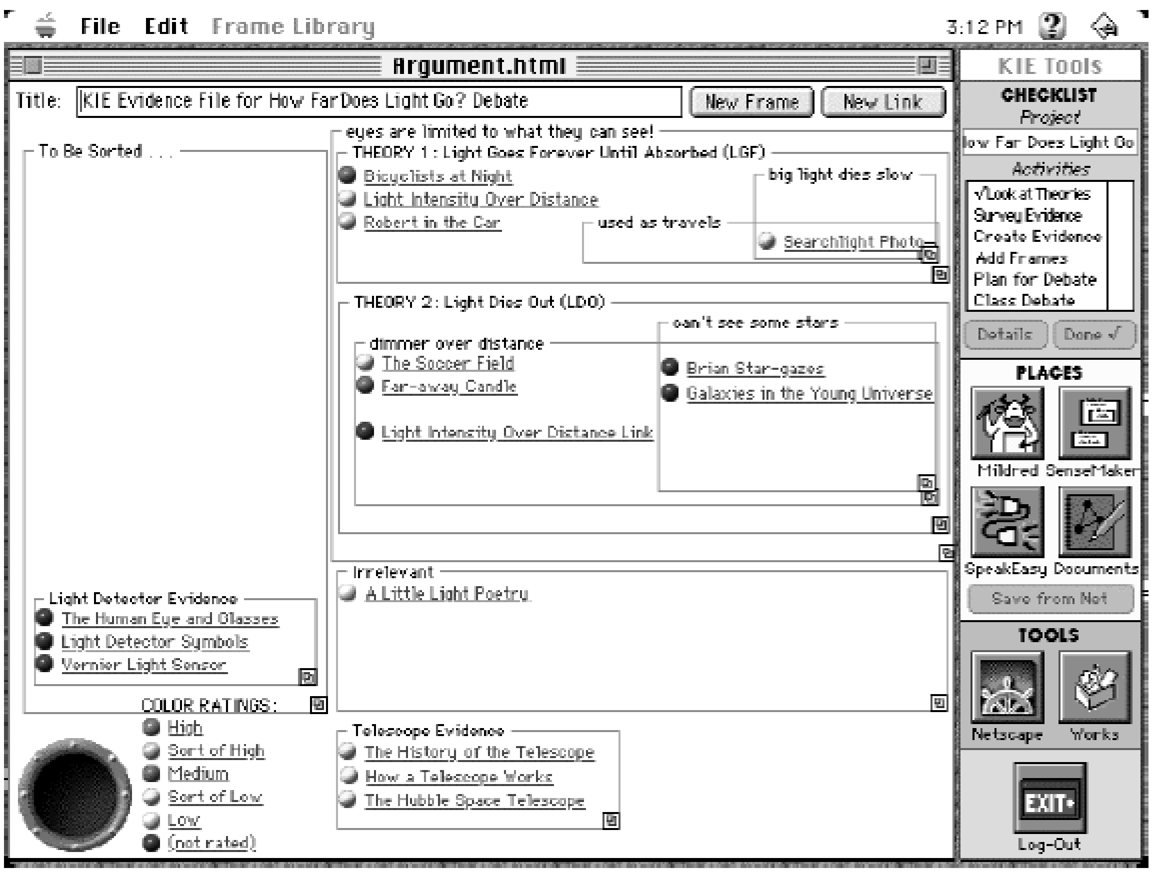

Figure 5. SenseMaker, with a display of two claim boxes (Theory 1 and Theory 2) and lists of supporting evidence in each.

In the third phase, students were told to organize evidence with claims after having explored all of the evidence. There was evidence showing that this time, students did consider the entire corpus of evidence. However, they needed still more experience with the use of argument maps, because students did not categorize the claims in a manner originally intended by the researchers.

The fourth phase started with a 2-day curriculum project to better introduce the concept of argumentative map representations and to more systematically support students in using the argumentation tool. The students created more elaborated arguments within an activity structure where the knowledge representation tool was integrated into their interpretation and theorizing about evidence. Evidence and claims were central and visible features of the user interface, so as to scaffold their inquiry processes. On the other hand, students were still generally confused about the argument map representation and the manner of working with it to produce a synthesis rather than an ongoing product.

In the fifth phase, a historical debate between actual scientists was represented in an argument map prepared in advance by the researchers. This allowed students to understand aspects of scientific argumentation and the creativity involved in theorizing and coordinating with evidence, as well as how individual ideas can shape one’s interpretation of evidence and constructed arguments.

When students debated in class without the argument maps, they presented their strongest pieces of evidence to make their points. When the argument maps were incorporated into the debates, the discourse patterns shifted. Students still highlighted the strongest forms of evidence, but now questions from students in the audience focused on evidence not presented. The argument maps became collectively shared scaffolds that allowed students to compare interpretations of evidence. Audience members used the maps to hold presenters more accountable to the total corpus of evidence involved with the project. The maps provided a social mechanism for articulating and externalizing student thinking.

Final evaluations showed that students developed greater understanding of the evidentiary basis of scientific argumentation, the general connection between argumentation and learning, and the social refinement of their own integrated understanding during the debate activity (Bell & Linn, 2000).

Conclusion

Some researchers believe that all teaching is in some sense an argumentative activity, because the task facing the teacher is to persuade learners to assume a novel point of view (Laurillard, 1991). Petraglia (1998) proposed the rhetorical tradition as a framework for education, emphasizing the essentially dialogic nature of learning. When learning is conceived of as a process of active construction, of collaborative knowledge building, then it can be thought of as an outcome of argumentative processes.

Based on the research summarized in this chapter, I draw six conclusions.

(1). Students cannot simply be told to learn by arguing; arguing to learn requires significant scaffolding. In order to show why and how argumentation is good for learning we first have to create appropriate learning contexts (Andriessen, 2005) in a kind of design experiment (Confrey & Lehrer, this volume). I suggest constructing complex task sequences, incorporating many argumentative activities over an extended period.

(2). Students should be scaffolding in supporting each other's argumentation. This approach is at odds with the traditional view of argumentation as oppositional, and of knowledge and expertise as absolute.. Arguing to learn is a collaborative process of collective knowledge building.

(3). The type of medium has a major impact on arguing to learn. We have seen some examples of tool use which, one the one hand, lead to results similar to argumentation in oral communication contexts, but also, we find possibilities for scaffolding that extend the oral situation. Researchers are working on finding the appropriate conditions of instructions and tool design for adequate support.

(4). Students are more efficient at managing their ongoing collaboration through face to face conversation than when mediated by the computer. The educational quality of argumentation decreases if students have to spend a lot of time working with the software tool. The challenge for developers is to make the user interface as learner-centered as possible (Quintana et al., this volume).

(5). How a tool is used depends in part on what other tools and activities are in focus at the same time. The role and nature of argumentation differs between phases of a complex task sequence such as collaborative writing or a project-based science class. However, sometimes it seems that transfer between such phases is very limited; students tend to approach each phase as a separate activity. When a complex task sequence is designed, we need to know more about what transfers from one phase of the sequence to the next and what conditions facilitate the most transfer.

(6). Most studies report great individual differences in using tools. Understanding why participants use these tools differently may allow us to discover how tool appropriation may develop; I think we must be careful not to fall into trap of deciding too early what use is correct and which one is not. An argumentation tool is not like a hammer, for which we know how it should be used, rather it is like a toolkit, with many possible solutions and uses, including new ones.

Currently, many learners feel argumentation is a waste of time; they simply want their teachers to give them the answers. Piaget argued that learners should be allowed to discover as much as possible on their own, and that each decision that the teacher makes for them deprives them of a potentially more powerful learning experience. The question seems who should bridge that gap: the teacher or the learner. If argumentation in learning situations can be detached in some way from competition, losing face, and hollow rhetoric, and adequate support for argumentation is designed, so that focusing on understanding, explanation and reasoning, and interpersonal success, is the rule rather than the exception, the virtual promises of arguing to learn and of computer support for learning may become reality. In that case, students do not want answers any more; they want to argue for them: because then they will experience autonomy, and powerful learning.

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