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19

Arguing to Learn

Jerry Andriessen and Michael Baker

Many people think that arguing interferes with learning, and that's true for 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 argument, 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 is studying a different kind of argumentation, which we call *collaborative* argumentation (see Schwarz & Baker, 2017, ch. 7). For example, collaborative argumentation plays a central role in science; science advances not by the accumulation of facts, but by debate and argumentation (Osborne, 2010). Even when two scientists disagree, they still share the common values of science and both of them are interested in achieving the same goals (determining what claim should be upheld). Argumentation in science should not be primarily 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 aim to reach agreement. Engagement in collaborative argumentation can help students learn to think critically and independently about important issues and contested values. Before students can successfully engage in collaborative argumentation, they must overcome the traditional and deep-seated opposition between reason and emotion (Baker, Andriessen, & Järvelä, 2013; Picard et al., 2004), stop being aggressively opposed to others, and instead orient their positive motivations and emotions toward the question being discussed and others' views on it.

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. There are many ways that argumentation can contribute to learning. First, argumentation involves knowledge 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 (Wertsch, 1985). Fourth, groups of people, at work, at home, in social contexts, often share a common tradition of argumentation (Billig, 1987), and effective participation in these groups can enable learning how to argue competently within them (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. Fifth, there is something special about the *dynamic* of collaborative argumentation that makes it a learning experience, once you are into it. This relates to the notion of interactive tension (Baker, 1999; Andriessen, Baker, & van der Puil, 2011), or the pressure to react to a previous utterance during interaction, like giving an answer after a question. A speaker uttering an argument during interaction is a powerful invitation to the other speaker to link (and add) to that utterance. This interactive tension, or pressure to react, is personal as well as epistemic and, in argumentation, may not be resolved by a single utterance, but instead require several exchanges, and thereby elaboration of meaning.

Argumentation has been studied for millennia, from many perspectives, notably in philosophy, logic, literature, and public speaking. In recent years, 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, we discuss argumentation theory for its vocabulary and different viewpoints on argumentation. Then, we discuss the relation between argumentation and learning. Finally, we have a short discussion about argumentation in learning environments, such as chat rooms and Internet newsgroups, where argumentation is mediated by computer networks.

Argumentation Theory

Argumentation theory (Van Eemeren, Grootendorst, & Snoeck Henkemans, 1996) is designed to explain 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, rhetorical, examination, and eristic. For most of the 20th century, the study of argumentation has been dominated by scholars who focused on the logical, sequential structure of argument. In this tradition, a good argument was thought to have a certain type of structure, and scholars attempted to specify the underlying “grammar” of argument by analogy with the syntax of a well-formed sentence. In the first half of the 20th century, the “logicism” of Frege, Russell and the early Wittgenstein emphasized argument as logical demonstration operating on formal representations of language. Toulmin (1958) produced a more elaborate model of argument in so-called everyday language and professional practices such as law, that distinguished the elements of argumentation, going beyond purely logical propositions and inferences:

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 past 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*, such as “probably,” indicates the degree of certainty that the arguers attribute to a claim.

Exceptions to the claim are expressed by a *rebuttal*: “Unless it can be shown that the earth’s rise in temperature is entirely due to fluctuations in temperature that have occurred over geological time, independently of human activity.”

This type of approach has been very influential, especially in the analysis of spoken and written argumentation (e.g., Voss, 2005). However, in recent years, the study of argumentation has become a more empirical and scientific study, and empirical analysis has shown that Toulmin’s grammatical approach does not correspond very well to the ways that arguments unfold in collaborative discourse. Van Eemeren and 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 doesn’t provide any insight into how argument structures might change during development (Leitão, 2001).

In contrast to this grammatical and monological concept of argument, more recent argumentation theory views 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, 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 and Grootendorst (1999) show how pragma-dialectics can be applied to the analysis of argumentative discourse. In Walton’s work (Walton, 1989, 2000), different “dialogue types” are distinguished – persuasion, inquiry, negotiation, information seeking, deliberation, and eristic (personal conflict) – on the basis of their main goals (e.g. hitting out, establishing proof, imparting knowledge) and the methods by which they are to be achieved (e.g. personal attack, questioning, bargaining). Walton’s types of dialogue have been used as methods for analyzing educational dialogues in order to identify its productive forms, in relation to the teacher’s pedagogical repertoire (Rapanta & Christodoulou, 2019).

These newer theories are more useful for learning scientists, because they provide guidance for how to analyze and evaluate students’ collaborative argumentation – for example, in terms of whether acceptable moves have been made, and whether the dialogue converges toward a constructive outcome. In educational research, similar proposals have been made for analyzing students’ dialogues as “types of talk” (e.g., “disputational,” “exploratory”), each of which has associated “ground rules.” It has been shown that explicitly teaching such ground rules to students improves their collaboration and learning (Mercer, Wegerif, & Dawes, 1999). Several computer-based learning environments have been designed to foster argumentation dialogue games (see further on in this chapter).

Argumentation and Learning

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 to problems and fundamental concepts underlying them (cf. Nonnon, 1996). Baker (2009) identified five learning processes that are potentially associated with effective arguing to learn. These processes are based on general learning sciences findings that seem to apply broadly to a wide range of content knowledge (Nathan & Sawyer, Chapter 2, this volume):

Change in view: As a result of argumentation, learners may be led to transform their basic beliefs about the problem domain or their overall viewpoints (Harman, 1986). As well as simply changing their minds about beliefs, more subtle changes may occur as students elaborate more reasoned and nuanced views that take alternative views into account.

Making knowledge explicit: Learners who 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 one’s initial conceptions of the problem. Conceptual transformation is supported by argumentation when students make new distinctions between concepts or elaborate new definitions of them (also see diSessa, this volume).

Co-elaboration of new knowledge: Learners work together to elaborate new meanings. The interactive interpersonal nature of verbal interaction helps to scaffold individual learning.

Increasing articulation: Argumentation obliges learners to precisely formulate question and statements.

There are close relations between change in views, beliefs, opinions and processes of meaning-making and conceptual change in argumentation in that a change of meaning of a proposal obviously changes whether it is acceptable or not. Meaning-making in argumentation is a two-edged sword, in that it can be used for ill — to prevaricate and avoid well-founded critique — or for good, in the sense of moving towards more subtle meanings and institutionally approved knowledge. The way that these processes function depends very much on the knowledge domain in which they operate. Thus, in socio-scientific domains involving deeply-entrenched values (for example, discussing human cloning), beliefs are generally resistant to change (e.g. Simmoneaux, 2007), although students may deepen their understanding of the concepts involved. In more ‘neutral’, scientific domains (such as physics), beliefs in the acceptability of solutions proposed to problems may be much more fluid (Baker, 2009).

The Development of Argumentative Skill

The ability to participate in and comprehend argumentation emerges early in development. By the age of three, children generate and understand the principal components of an argument (Stein & Albro, 2001). The ability to construct detailed, coherent rationales in defense of a favored position improves with age. This

development, however, does not guarantee a deeper understanding of one's opponents; in fact, argumentative knowledge develops asymmetrically (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 opponents 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 are forced to change their stance do learners start generating reasons that favor the opponent's position.

Understanding arguments is related to one's developing knowledge of social conflict and goal-directed action. For example, a conflict may exist between displaying good argument skills and participating in morally and socially responsible negotiations. Sometimes, good arguers have less knowledge about and poorer relationships with their opponents than do poor arguers. Teachers should be aware that although argumentation can be way to achieve interpersonal success, it can also lead to personal success at the expense of the other (Stein & Albro, 2001).

Dewey argues that education should be built on how people naturally think rather than on the imposition of abstract formalisms. An argumentative schema can be seen as such an artificial formalism, based on logic. According to Dewey, a more natural way for children to learn is inquiry (Dewey, 1933/1986a). In a study by Anderson, Chinn, Chang, Waggoner & Yi (1997), transcripts of 20 discussions by 4th graders were analyzed. The arguments by these children often had vague referring expressions, sometimes missed conclusions, and often lacked warrants that authorised the conclusions. However, the authors found that the missing or obliquely identified information was given in the text or preceding discussion, or as a commonplace from everyday life and therefore readily inferable by cooperative participants in the discussion.

Arguing to Learn Contributes to Reasoning Skills

During reasoning, individuals make inferences from given knowledge to reach a conclusion. Learning scientists studying reasoning at the end of the 20th century contended that the inferences that support sound reasoning can be understood as an effective argument. Informal reasoning skills develop through argumentation, because argumentation facilitates a student's ability to organize subject matter, and the ability to 'play' with information, which helps inference generation (Voss & Means, 1991).

Kuhn (1991) studied argumentation skills by asking people to prepare arguments and counterarguments about issues of societal importance such as: What causes prisoners to return to crime after they are released? What causes children to fail in school? Kuhn interviewed 160 individuals in four age groups (teens, 20s, 40s, and 60s) 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 of these people provided poorly structured arguments (in the sense of missing elements from a Toulmin structure) and provided theories along with a list of unrelated causes. Only 16 percent of the participants could generate genuine evidence for their theories. Most of the evidence they presented was of a type that Kuhn called *pseudoevidence* (for example, when asked the question "what causes prisoners to return

to crime after being released?” subjects might give a pseudo-reason such as “some of them can have a normal life, you know”). More of the participants (33%), although still a minority, were able to conceive of an alternative theory. An important argumentation skill is the ability to produce counterarguments, and only 34 percent were consistently able to generate a counterargument to their theory. Finally, the percentage of subjects that generated valid rebuttals to their own theories was between 21 percent to 32 percent across topics.

Kuhn argued that argumentative skills are based on a person’s epistemological theories, that is, the view they hold about the nature of knowledge and knowing. She proposed that a person’s epistemological theory falls on a spectrum between two very different extremes: an *absolutist epistemology* and an *evaluative epistemology*. In the absolutist epistemology, knowing prevails in complete ignorance of alternative possibilities. In the evaluative epistemology, knowing is an ongoing, effortful process of evaluating possibilities, one that is never completed. The evaluative epistemology is associated with argumentative skill and understanding. A minority of the people she studied (between 9 and 22%, depending on the topic) held to the evaluative epistemology. For such learners to progress to a more advanced understanding of argumentation, they first would have to change their epistemology.

Learning to Argue in Small Groups

The learning sciences has shown that collaborative classroom interaction can often contribute to individual learning (Engeström & Greeno, this volume; Enyedy & Stevens, this volume). This is particularly true of collaborative argumentation. For example, Kuhn, Shaw, and Felton (1997) 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. Arguments took place in pairs, with multiple successive partners, with each argument lasting 10–15 minutes. After participating in these activities, students and adults provided significantly more two-sided (as opposed to one-sided) and functional (as opposed to nonfunctional) arguments.

Reznitskaya and colleagues (2001) used a method called *collaborative reasoning*, an approach to discussion that aims to provide elementary schoolchildren 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. Argument schema enable the organization and retrieval of argument-relevant information, facilitate argument construction and repair, and provide a basis for anticipating objections and for finding flaws in one’s arguments and the arguments of others (Reznitskaya et al., 2001). Fifth graders in the experimental group participated in small groups twice a week, during a period of five weeks, 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, the teacher led students in activities that exposed them to formal argument schema. At the end of the five-week period, learning was assessed by analyzing a student’s

argumentative essay on a realistic story dilemma. The essay was scored on relevant arguments, counterarguments, and rebuttals. Students who participated in collaborative reasoning 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, and Resnick (2000) studied argumentation during oral classroom peer discourse in a fourth grade class. Their point of departure was 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 (Walton & Krabbe, 1995). An important contribution of this study is that it attempts to identify empirically different types of dialogue (Walton & Krabbe, 1995). Each type of dialogue has an initial starting point, an assigned goal, the participants' goals, and a characteristic means of reaching the goal. Participants' goals may shift during discussion, possibly changing dialogue type.

The type of dialogue that was most effective in fostering learning of literary content was *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 that was effective for learning 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 is convergence on a solution or conclusion.

At the beginning of the school year, and again at the end, students were assessed by asking them to participate in four minutes of conversational reasoning in different peer discussions (six at the beginning and six at the end of the year). The researchers identified a number of features of argumentation, documented in class during the year, that were associated with the largest increase in conversational reasoning. The strongest increase was the degree to which the student held a sustained commitment to the pursuit of an issue. A sustained commitment in a dialogue involved a student to grant concessions (to agree potentially to being convinced) accommodating the differences in opinion that existed at the start of the dialogue. Sometimes this involved altering a 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) did not lead to improved outcomes at the end of the year, perhaps because no single challenge was followed by a sustained consideration of its impact on some viewpoint. Dialogues where participants conceded their positions too easily also did not lead to improved outcomes, perhaps because this led to an avoidance of any argumentation at all.

Arguing to Learn in Context

There is some evidence that argumentation proceeds differently in different cultural and social contexts (see the review in Muller Mirza, Perret-Clermont, Tartas, & Iannaccone, 2009). For example, the sort of argumentation that is considered appropriate in school may be a culturally specific school-based form of discourse (Wertsch, 1991). These school-based forms of argumentation are those most likely to align with the idealized forms proposed by argumentation theory. Outside of school, different cultures possess differing norms that influence argumentation; for example, there are cultural differences in the extent to which social conflict is avoided and consensus is preferred. According to Peng and Nisbett (1999), people from Asian countries (notably China and Japan) have a tendency to avoid contradiction and to search for a consensual “middle way.” Cultures, such as in Israel, have developed a specific form of discourse – called “dugri speech” (“straight talk”) – that is explicitly based on confrontation of views, but with a view to harmonious acknowledgment of differences (Matusov, 2009). In some nations, such as France, certain arguments (for example, those propounding racism) cannot legally be made in public spheres, which include schools (Golder, 1996).

Even within a single culture, one typically finds that a broad range of pedagogical approaches is used in schools. Andriessen and Sandberg (1999) described three basic educational scenarios – “transmission,” “studio,” and “negotiation” – that differ in terms of how knowledge is supposed to be acquired (from the teacher, by exploratory activities, by discussion). Collaborative argumentation aligns with the negotiation scenario. But even if individual teachers try to introduce negotiation scenarios, encouraging students to discuss and argue, this may be at odds with students’ previous school experience, which is more likely to be in “instructionist” classrooms (Sawyer, Chapter 1, this volume) that implicitly encourage the idea that authoritative texts are simply to be summarized (Andriessen, 2009).

Researchers have identified important differences in argumentation among children in different classes, even within the same school. This has been explained in terms of how the teacher frames the activity, as either a collaborative opportunity to learn about one another’s ideas, or as a kind of competition (Berland & Reiser, 2011). Teachers have a complex task to perform in framing activities, involving providing relevant information at the right time, resolving issues, and scaffolding the debate toward a clear and understandable outcome (Simonneaux, 2007).

The most effective form of collaborative argumentation is likely to vary depending on the school subject. In math and science, students may occasionally engage in heated argument when their proposed solutions are criticized, but this will not challenge their identity and self-esteem nearly as much as when the topic under discussion involves deeply entrenched value systems and personal or group identities, as in history, psychology, sociology, or anthropology (Goldberg, Schwarz, & Porat, 2011).

There are obvious reasons why argument can become “heated”, since criticizing a person’s views is often experienced as a criticism of the person who propounds them. Indeed, different ways in which critiques are expressed are experienced as more or less aggressive, and this in turn influences how the critique will be responded to and in turn, the potential for arguing to learn. It is interesting to note that the type of critique that is experienced as most harsh is not an attempt to directly invalidate the claim, but rather stating that the argument being critiqued is not *relevant* (Muntigl & Turnbull, 1998). This

is understandable: critiquing content of views at least considers them as legitimate, whereas an “irrelevant” statement discounts its content as well as the person who expressed it.

The age-old opposition between reason and emotion was mentioned in introduction to this chapter. For arguing to learn, the aim is not for students to become emotionless machines, since emotion and motivation to learn are clearly linked. Rather, what is necessary is for students arguing together to be able to *regulate* the emotions that circulate in their interactions, in a way that preserves knowledge-oriented agency but neutralizes negative affects that would inhibit freedom of expression and shift the interaction towards relational conflicts. There is an equilibrium to be found here, between cognitive conflict and the interpersonal relationship: the more the cognitive conflict is deepened, the greater the threat to the interpersonal relationship; the lower the threat, the more the dialogue becomes insipid and loses its point. This highlights the fact that the establishment of a strong *collaborative working relationship* (Andriessen, Baker & van der Puil, 2011) is crucial for students working in groups to be able to deepen conflicts and learn from this, whilst preserving their relationships. For example, Isohätälä et al. (2018) found that students tended to avoid disagreement in order to preserve a generally positive emotional climate in their groups. The work of Polo et al. (2016) establishes links between types of educational talk (see above discussion of Walton’s work) and the general emotional framing of students’ interactions, this being of low intensity in the case of “cumulative talk” (Mercer Wegerif & Dawes, 1999) and of high intensity in the case of “disputational talk”.

The role of emotions in arguing to learn in collaboration is currently (in 2020) a burgeoning field of research in the learning sciences.

Summary: Argumentation and Learning

Many people have trouble arguing productively. They are not good at distinguishing evidence from theory and rarely consider alternative positions. And because the social cost of threatening a good relationship is rather high, people avoid arguing when they do not feel at ease. There may be important cultural differences here, but in the Western European and U.S. context, students must be explicitly socialized into collaborative argumentation in school.

The evidence shows that students can benefit from collaborative argumentation, but learning outcomes will be most effective when argumentation is:

- framed as a collaborative activity that benefits all learners,
- embedded in collaborative activity and driven by a desire for understanding and sharing with others (see Scardamalia & Bereiter, this volume), and
- embedded in an interaction that involves effective social regulation of the interpersonal relation and emotions that circulate between students.

Collaborative Argumentation in Electronic Environments

The learning sciences is discovering that much knowledge is learned more effectively in collaboration (see the chapters in Part 4 of this handbook). Nevertheless, we have just reviewed a large body of research showing that most people have difficulty arguing

collaboratively. Computer technology offers a potential solution. For example, computer-supported collaborative learning systems (CSCL; see Stahl, Koschmann, & Suthers, this volume) can support and guide productive argumentation, leading to deeper understanding. In this section, we describe several software systems in which students input their contributions to an argument on a computer. These systems aim to *scaffold* student argumentation in some way – by providing structure for the roles of each student and the relationships between them in a dialogue, by offering new and multiple ways of *representation* in argument maps, and by allowing students to manipulate the structure and content of the argument.

The topics that we address in this section are: (1) scaffolding argumentation with dialogue games; (2) scaffolding text-based argumentative discussions; (3) scaffolding arguments with diagrams; (4) scaffolding scientific argumentation in learning environments.

Scaffolding Argumentation as a Dialogue Game

Inspired by dialogue theory (Walton, 2000), *dialogue game theory* (Levin & Moore, 1980) suggests that we should structure participants' behavior by specifying roles and constraints. Participants are only allowed to make argumentative moves that appear on a list of moves that are appropriate at each point in the argument. Building on dialogue game theory, Mackenzie (1979) developed an argumentation computer game called *DC* that allowed the user to select a move and type in its content. The moves provided included “Question,” “Statement,” “Challenge,” “Resolution,” and “Withdraw.” The system then evaluated the contribution according to a preset list of rules. Rules defined when a move could or must be made and what happened as a result. The rules prevented each player from evading a question, arguing in a circle, or failing to support a claim. Dialogue games have evolved into argumentation scripts, or highly constrained (e.g. rule-based) forms of argumentation at the level of turn-taking in the dialogue (e.g. Asterhan & Babichenko, 2015). If well-designed, some types of scripts may serve formal argumentation as well as learning, although results are mixed, and students may appropriate the script rather than actually collaborate (Vogel, Wecker, Kollar & Fischer, 2017; Tchounikine, 2016).

Scaffolding Argumentation through Computer-Mediated Communication Forums
In the 1990s, text-based discussion forums were thought to be a good way for students to share ideas and also to engage in deep argumentation. Learning scientists were interested in the potential of *asynchronous* forums, because users do not have to be logged in at the same time and can post their responses hours or even days later. Asynchronous forums provide users with unlimited time to formulate well-elaborated contributions (Tiberghien & de Vries, 1997). Unfortunately, the results from using these text-based discussion forums have been disappointing, especially with respect to the frequency and quality of arguments. Andriessen (2005) provides an extensive overview of projects that used forums to engage students in knowledge co-construction discourse, including argumentation, but also forums that aimed to strengthen sense of community and participation. For example, in so-called *theoretical forums*, students were invited to investigate lines of reasoning that authors of scientific papers engaged in. The goal was to engage students in academic argumentation – to introduce students to the discourse of a scientific community, to help them find their own voice, and potentially to form a self-

identity as a scientist and a member of that community (Matusov, 2009). An example of such an issue was: *Discuss your ideas about the following statement: For the study of learning processes, phenomenography offers a more promising approach than instructional design, intelligent tutoring systems, or instructional psychology* (see Andriessen, 2005). Questions such as these, although authentic in that they are very similar to what cutting-edge researchers are working on, are now considered too abstract and not engaging for students who do not intend to become academic researchers.

In addition to the problem of authentic, engaging questions, there is the problem of interaction itself: how people react to each other in electronic discussions. According to current thinking, there is lack of intersubjectivity (people orienting to each other) in many electronic discussions: although participants may have a sense of others reacting to their contributions, what in fact often happens is co-alienation – the juxtaposition of incompatible arguments (Schwarz, Kolikant, & Mishenkina, 2012). From the viewpoint of group cognition (Stahl, 2005), resolving the socio-technical problem of engaging learners into deep discussion in a threaded chat system, will require a more detailed understanding of the collaboration involved in building social learning communities through the unique features of online communication.

Scaffolding Argumentation with Argument Maps

These systems use the graphical power of today's personal computers to visually display the relations between moves in an argument. Early systems that use visual argument maps to scaffold argumentation include Belvedere (Suthers & Weiner, 1995), CHENE, and Connect. CHENE (Chaines ENERgetiques; Tiberghien & de Vries, 1997) was designed to be used by two students collaborating to build an electronic circuit; C-CHENE (Baker & Lund, 1997) 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 (de Vries, Lund, & Baker, 2002) displayed every statement made by two students, and provided buttons for both students to agree or disagree with each statement.

Learning systems that use argument diagrams have been extensively reviewed (see Andriessen & Baker, 2013, for an overview). Overall, the results show some promise (e.g., Suthers & Hundhausen, 2003; Van Amelsvoort, Andriessen, & Kanselaar, 2007). However, students working in small groups with technology and engaging in argumentation presents significant challenges to most students' abilities, both socially and cognitively (Van Amelsvoort & Schilperoord, 2018).

Future systems that use argument diagrams should be clear about the learning goals and the role of the teacher and should make sure that the technology is compatible with the overall classroom context: how students are normally assessed, what experience they have had with collaboration, what their motivation is for the assignment (Andriessen & Baker, 2013).

Scaffolding Scientific Argumentation in Learning Environments

In everyday conversation, most of us commonly engage in challenging, counterchallenging, justifying, or agreeing, but according to the analytical criteria used by argumentation experts, our everyday arguments are generally mediocre (Pontecorvo, 1993). However, when it comes to science, very few of us feel qualified to challenge,

counterchallenge, or engage with scientific claims at all. Rather, we simply accept expert claims, and we generally do not use them in further activities to convince, challenge, or justify our viewpoints (Schwarz & Glassner, 2003). An important goal of science education in the 21st century is to prepare students to understand the nature of scientific argumentation, to be critical consumers of scientific research, and to be informed participants in critical national and international debates that are closely tied to scientific argumentation (whether global climate change, stem cell research, or genetically modified organisms). The way students engage in argumentation about scientific issues is closely linked to their ideas about science itself. Therefore, scientific argumentation should be combined with scientific inquiry to work on students' epistemological beliefs rather than on producing arguments only (Sandoval, 2003). Scientific work is part of a communal enterprise in which many scientists are engaged, grounded in a meaningful context. 'Making' science, and making it inclusive, requires more than making it accessible through a learning environment: it may be better taught through stories than through argumentation (Tzou, Meixi, Suarez, Bell, LaBonte, Starks & Bang, 2019). In such contexts, argumentation is a natural consequence of scientific collaboration and discussion (Sandoval, Enyedy, Redman & Xiao, 2019).

Conclusion

In a sense, all teaching is a form of argument, because the task the teacher faces is to persuade learners to accept a novel point of view (Laurillard, 1993). The research presented in this handbook mostly views learning as a process of active construction and of collaborative knowledge building. And in this sense, all learning can be thought of as an outcome of argumentative processes.

Based on the research summarized in this chapter, we draw seven conclusions.

- (1) Arguing to learn is a collaborative process of collective knowledge building. This approach is at odds with the traditional view of argumentation as oppositional. Arguing to learn requires a collaborative attitude and sufficient interest in what others have to say.
- (2) Students cannot simply be told to learn by arguing; arguing to learn requires significant scaffolding. Software developed for this purpose has given promising results, but not the final answers.
- (3) Argumentation has often been described using abstract schemas or grammars. However, real-world classroom interactions rarely reveal exactly these schemas. This is because such schemas are exclusively epistemic, concerning relations between pieces of knowledge, and do not take account of personal goals and socio-relational and emotional aspects of group work.
- (4) The role and nature of argumentation differs across different learning activities in the classroom, such as collaborative writing or a project-based science class. Further research is required to better help students to make the appropriate links between different activities involving individual or collaborative argumentation.
- (5) The role of argumentation in learning is deeply intertwined with the commonly held beliefs about knowledge in a community, its

epistemology. A view of knowledge as relative and always subject to change fits well with arguing to learn. However, this may be taken as a danger to established values and structures by those who uphold other views of knowledge (as certain, unchanging, or essential to national identity; see Carretero & Perez-Manjarrez, this volume). The classroom use of argumentation hence may be constrained by the epistemology and values of a community.

- (6) The type of medium has a major impact on arguing to learn. We have seen some examples of tool use that lead to results similar to argumentation in oral communication contexts, but also, we find possibilities for computer-based scaffolding that would be an improvement over a purely oral situation. The real determinant of the effects of argumentation is not the medium, but the overall design of the learning environment, including learning goals, authentic assignments, and the appropriate role of argumentation in the learning activities.
- (7) Collaborative argumentation in learning contexts is a powerful sign of a well-designed and well-orchestrated learning environment.

Currently, many learners feel that engaging in arguments with their peers is frustrating, because it takes time and effort; they simply want their teachers to give them the answers. Teachers also experience difficulties in fostering and assessing collaborative argumentation (Baker, 2009). But the research shows that if these difficulties can be overcome, collaborative argumentation is a powerful technique for fostering deeper learning, a productive classroom culture, and an identity as an empowered inquirer and learner. If argumentation in learning situations can be detached in some way from competition, losing or damaging face, and hollow rhetoric – and adequate support for argumentation is designed so that focusing on understanding, explanation, and reasoning is the rule rather than the exception – the virtual promises of arguing to learn and of computer support for learning may become a reality. If this were to happen, students would not want to be presented with answers anymore; they would want to argue toward them. Then they would experience autonomy and powerful learning.

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