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Putting the pieces together: Online argumentation vee diagrams enhance thinking during discussions

E. Michael Nussbaum · Denise L. Winsor · Yvette M. Aqui · Anne M. Poliquin

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Abstract We examine the effect of online Argumentation Vee Diagrams (AVDs) on the quality of students' argumentation during asynchronous, online discussions. With AVDs, students develop arguments on both sides of a controversial issue and then develop an integrated, overall final conclusion. In this study, students used AVDs individually before composing discussion notes, and then—at the end of the discussion—jointly created a group AVD using *Wiki* technology. Compared to a control group, the experimental intervention was found to significantly enhance the integration of arguments and counterarguments (specifically, compromises) and fostered opinion change. For AVDs to be effective, however, it was found to be necessary to include specific scaffolds on how to evaluate argument strength and/or to provide practice and feedback in using the AVDs.

Keywords Argument · Argumentation · Computer-mediated communication · Computer-supported collaborative learning · Cooperative learning · Critical thinking · Discussion groups · Group discussion · Internet · Web-based instruction

A frequent problem with online discussions is that students often superficially agree with one another rather than exploring alternative views (Koschmann 2003). Although interventions exist that promote disagreement (Baker 2003), that is only half the problem. Students also need to critically evaluate both sides of controversial issues and "put the pieces together" in formulating a final conclusion. Nussbaum and Schraw (2007) termed this process argument/counterargument integration. Rooted in contemporary models of argument (Walton 1996), integration can involve refuting arguments on one side ("refutation strategy"), finding a compromise/creative solution between two sides ("synthesis strategy"), or weighing advantages/disadvantages of the two sides ("weighing strategy"). This study examined the use of a graphic organizer called the argument vee diagram (AVD) in online course discussions.

E. M. Nussbaum (✉) · D. L. Winsor · Y. M. Aqui · A. M. Poliquin
Department of Educational Psychology, University of Nevada, Las Vegas, Box 453003,
4505 Maryland Parkway, Las Vegas, NV 89154-3003, USA
e-mail: nussbaum@unlv.nevada.edu

Theoretical context

Benefits of collaborative argumentation

There is a small but growing body of evidence that engagement in collaborative argumentation can promote learning (Alexopoulou and Driver 1996; Andriessen et al. 2003; Baker 1999; Bell and Linn 2000; Chinn et al. 2000; Driver et al. 2000; Heller et al. 1997; Reznitskaya et al. 2001; Schwarz et al. 2000; Teichert and Stacy 2002; Tien et al. 2002; Zohar and Nemet 2002). We define collaborative argumentation as students working together to construct and critique arguments (Bell 2002; Brown and Renshaw 2000; Nussbaum 2002). Engaging in effective argumentation requires students to distinguish ideas, elaborate and form connections between ideas, consider alternative perspectives, and resolve inconsistencies (Andriessen et al. 2003; Chinn 2006; Hoadley and Linn 2000). From a socio-cultural perspective, argumentation involves the social construction of knowledge, expressed as socially constructed arguments that meet socially determined standards of cogency (Goldman 1999; Vorobej 2006) and evidence (Toulmin 1958). Petraglia (1998) describes this process as *rhetorical constructivism*, where knowledge claims are constructed and grounded in reasons and evidence. Scardamalia and Bereiter (2006) refer to this process as *knowledge building*.

The goal of collaborative argumentation is to build knowledge, in contrast to adversarial argumentation, where the goal is to win an argument and persuade. From a problem space perspective, adversarial argumentation is more shallow and constrained; ideas are evaluated in terms of how they advance a particular perspective, rather than the construction of knowledge. Collaborative argumentation, on the other hand, advances a greater exploration of ideas (Keefer et al. 2000), and stronger learning outcomes (Chinn 2006). Although initially applied to discussions, researchers have also applied these concepts to production of written arguments (i.e., opinion essays), as well as electronic text. For example, Mallin and Anderson (2000) have called for less instruction in "persuasive writing" and more attention to reflective/analytic writing, where commitment to a standpoint is delayed in an essay until the merits of both sides of an issue have been considered.

In addition to knowledge building, collaborative argumentation promotes more complex and critical thinking (Wegerif et al. 1999). Indeed, critical thinking can be defined as the ability to identify, construct, and evaluate arguments (Finocchiaro 2005; Scriven 1976). Approaching an argument in a rational manner also includes weighing the evidence and judging the strength of the respective arguments. Sporadic attempts are often made to teach students this skill throughout their education (Nussbaum 2006) with increasing emphasis and sophistication as they enter their undergraduate years. However, little attempt is made to teach students how to systematically create and evaluate counterarguments except in traditional speech and debate classes, or in the context of persuasive writing.

Argumentation and CSCL

The recent advent of online discussions provides a new and authentic context to teach students argumentation skills (Andriessen et al. 2003). The asynchronous nature of many such discussions provides a "wait time" affording greater reflection on ideas (Hara et al. 2000; Hara and Kling 1999; Jonassen and Kwon 2001; Tolmie and Boyle 2000). Compared to face-to-face discussions, asynchronous discussions also afford participation from a greater number of students, including quiet or shy students (Larreamendy-Joerns and Leinhardt 2006), although such students still need a feeling of support and safety (Nussbaum et al. 2004).

Effective online environments require conceptual engagement (Dole and Sinatra 1998). Students must engage and feel a part of the learning community. Students may shy away from argumentation because it is typical for arguments to be seen as negative and adversarial. They may interpret disagreement as a hostile act that could disrupt social relationships (Lampert et al. 1996) or which could make them lose "face" if they lose an argument (Nussbaum and Jacobson 2004). As a result, researchers have found reluctance among students to disagree with one another during online discussions (e.g., Koschmann 2003; Marttunen 1998).

There are two approaches for dealing with this problem (Bell 2002). One is the *discussion norm* approach (Bielman 2000); instructors can work to build norms where respectful disagreement and the exploration of ideas are prized (Mercer 1996; Schwarz and Glassner 2003; Williams et al. 2001). Such approaches can incorporate modeling (Choi and Land 2006; Kim et al. 2007), providing examples of quality discussions (Rummel and Spada 2005), goal instructions (Nussbaum 2005), portfolios (Lee et al. 2006), reflective rubrics (Toth et al. 2002), and argumentation scripts (Jermann and Dillenbourg 2003). Such approaches are also useful in encouraging students to build on one another's ideas rather than to all respond (repetitively) to an initial question.

A second approach is to use computer-supported scaffolds to encourage students to construct different components of arguments, such as backing (Bell 2002), reasoning to link grounds to claims (Kenyon and Reiser 2006), counterarguments (Schwarz and Glassner 2003), or specific discursive moves (e.g., asking for support or coming to agreement; Baker and Lund 1997). For example, in the Belvedere system (Toth et al. 2002), students collaboratively construct argumentation diagrams regarding scientific investigations. Toth et al. found students (ninth graders) did consider more opposing evidence to their conclusions. However, a separate study by Cho and Jonassen (2002) found use of Belvedere did not enhance counterarguments and rebuttals (only reason generation).

Although not the dynamic sort of scaffolds that are provided by human tutors, these approaches reflect scaffolding because they provide assistance to enable students to do things many could not otherwise do on their own.. The argumentation-scaffolding approach is less closely tied to online discussions than the norm approach because many of the scaffolds focus more on knowledge representation than discourse (see van Bruggen and Kirschner 2003). There are, however, indirect relationships with discussion: Belvedere involves students in synchronous discussions for the purpose of constructing the diagrams; Bell's system (SenseMaker) has been used to prepare students for a face-to-face debate. Munneke et al. (2003) found creating individual argumentation diagrams before a chat debate broadened the number of ideas considered. There has been less attention in this literature, however, on using computer-supported argumentation scaffolds for asynchronous discussions.

A second limitation is that most of these systems have been based on the Toulmin (1958) model of argument, which posits that informal arguments have six specific components (final claim, grounds, warrant, backing, qualification, and rebuttal). This was an early and seminal model of argumentation developed in the 1950s that was intended to show the inadequacy of deductive logic for analyzing everyday arguments. Toulmin showed that such arguments are instead probabilistic, field-dependent (what counts as evidence is domain specific), and defeasible in view of new evidence. The Toulmin model has a number of problems, however. First, warrants (which link grounds to claims) are often implicit and hard to distinguish from backing (Fulkerson 1996; Leitão 2003). Second, the Toulmin model gives short shrift to counter-argumentation (Andriessen 2006a; Eemeren et al. 1993; Willard 1976), yet counterarguments are considered an essential component of critical and dialogic discussions. A more contemporary model of argumentation is the

Walton model (1996; Ebenezer and Puvirajah 2005), which identifies two dozen patterns of arguments, known as argumentation schemes. Associated with each scheme are critical questions that (from a normative perspective) discussion participants should ask in evaluating arguments. Many of these critical questions pertain to counterarguments, such as "Are there other consequences of an opposite value that should be taken into account?" (Walton 1996, p. 77).

Argument–counterargument integration framework

Nussbaum and Schraw (2007) have proposed a related, but more psychologically based framework, termed *argument–counterargument integration*. This model posits a number of argumentative operations or strategies (Baker 2002; Kim et al. 2007; Pontecorvo and Girardet 1993), the goal of these strategies is to integrate arguments and counterarguments into an overall final opinion. Nussbaum and Schraw (2007) identified three such strategies. In a refutation strategy, the arguer refutes arguments on one side (this reflects an adversarial approach). In a weighing strategy, the arguer considers both sides, and then evaluates which side has the stronger arguments (for example, do advantages outweigh disadvantages?). In a synthesis strategy, the arguer finds a final standpoint in-between different sides, e.g., finding a creative solution that realizes benefits while minimizing disadvantages, or recognizing that the wisdom of an alternative may depend on certain factors ("wise in some circumstances but not others").

The model is indirectly based on a Neo-Piagetian developmental theory of reasoning wherein reasoning organizes and synthesizes dissimilar ideas in working memory towards the creation of an integrated conceptual framework (Case 1985; Halford and McCredden 1998). The argument and counterarguments within this integration are the dissimilar ideas. In a study of argumentative writing, Nussbaum (2006) found that students use synthesis the most and weighing the least because of the number of separate (non-integrated) elements that must be coordinated in working memory. However, *pseudo-integration* was the most common outcome. In pseudo-integration, students picked a side and supporting argument that they "felt" was strongest, but did not give compelling rationales for why or which accounted for counterarguments.

Although the various strategies were originally conceived as psychological operations, they are also discursive operations (Baker 2002), that is, moves that may be made during a discussion. Students can respond to opposing ideas by refuting them directly, weighing their value or scope, or suggesting compromises or creative solutions. One major tenet of this article is that computer-supported argumentation systems need to address argument–counterargument integration more directly. As noted before, systems based on the Toulmin model do not promote the consideration of counterarguments in a balanced way (that is, weighing the merits of two sides of an issue in some depth before coming to a conclusion), even though this is an essential part of collaborative argumentation. Integration is also important in online discussions because many discussions are aimless (Andriessen 2006b); for students to learn from discussions, they may need an opportunity to summarize and evaluate what was discussed (Scardamalia and Bereiter 2006). Engaging in argument–counterargument integration may allow them to do this. (Cognitive scientists such as Palincsar and Brown 1984, and Kintsch 1998, have documented the importance of summarization and questioning to learning.)

Following the distinction introduced earlier, argument–counterargument integration can be facilitated in online discussions in two different but complementary ways. First, using

the discussion norm approach, the value of different integration practices, such as creative designing, can be discussed with students, along with modeling and feedback. Second, using the argumentation-scaffold approach, computerized scaffolds can be used to prompt students to engage in these operations. The following section discusses one such scaffold, argumentation vee diagrams.

Argumentation vee diagrams (AVDs)

In previous research, Nussbaum and colleagues (e.g., Nussbaum 2006; Nussbaum and Schraw 2007) investigated the effect of graphic organizers known as argumentation vee diagrams (AVD) on argument/counterargument integration. This research was conducted in the context of writing opinion essays. The present study explores the effect of an intervention using AVDs on asynchronous discussions. AVDs—adapted from a tool used in science education (Novak and Gowin 1984)—involve students listing arguments on both sides of an issue. As shown in Fig. 1, at the bottom of the figure (the "V"), students develop an integrated conclusion, which is then used to compose a discussion note. Various questions can be included at the base of the V to scaffold students' thinking.

Figure 1 shows the AVD that we initially developed for online use for the present study. Two critical questions were included, reflecting two of the three integration strategies in Nussbaum's model: (a) "Which side is stronger, and why?" (weighing strategy), and (b) "Is there a compromise or creative solution?" (synthesis strategy). We did not prompt for refutations because such arguments were already implicitly encouraged in prompting for counterarguments.

AVDs were provided to students in two ways. First, students received blank AVDs (in MS Word) and individually completed them before their online discussions. Other researchers have found individual brainstorming before group discussion improves discussion quality by facilitating a greater variety of ideas (Brown and Paulus 2002; Schwarz and Glassner 2003). After composing their initial notes, students were required to post additional notes indicating points of agreement/disagreement with others. Discussion groups contained three-to-five students.

The second way we employed AVDs was to have students—at the conclusion of their discussions—use *Wiki's* to compose a joint AVD and summary note. *Wiki*'s are a Web-page that anyone in the group can edit (Frumkin 2005; Rick and Guzdial 2006). Some research has shown that students learn more from discussions when they summarize the various points made during the discussion (Schwarz and Glassner 2003). This helps them elaborate, organize, and coconstruct their knowledge (Eggen and Kauchak 2004). However, in online courses, students are physically separated, making production of joint products difficult. *Wiki*'s solve this problem.

In addition, research shows that group roles (Webb and Palincsar 1996) can facilitate participation in group activities, as long as the roles promote metacognitive activities (Herrenkohl and Guerra 1995; see also Pilkington and Walker 2003). Our procedure used three different roles: (a) composer, who completed the initial group AVD, summarizing important points made in the discussion, (b) elaborator, who added clarification and any points the composer missed, and (c) integrator, who used the group AVD to compose a summary discussion note posted to the discussion board. Students were encouraged to continue to evaluate and modify points as they prepared the group AVD.

Although AVDs and the associated roles were intended to stimulate the consideration of counterarguments and argument/counterargument integration, another function was to provide greater structure to students' thinking. Such structure may be needed for many

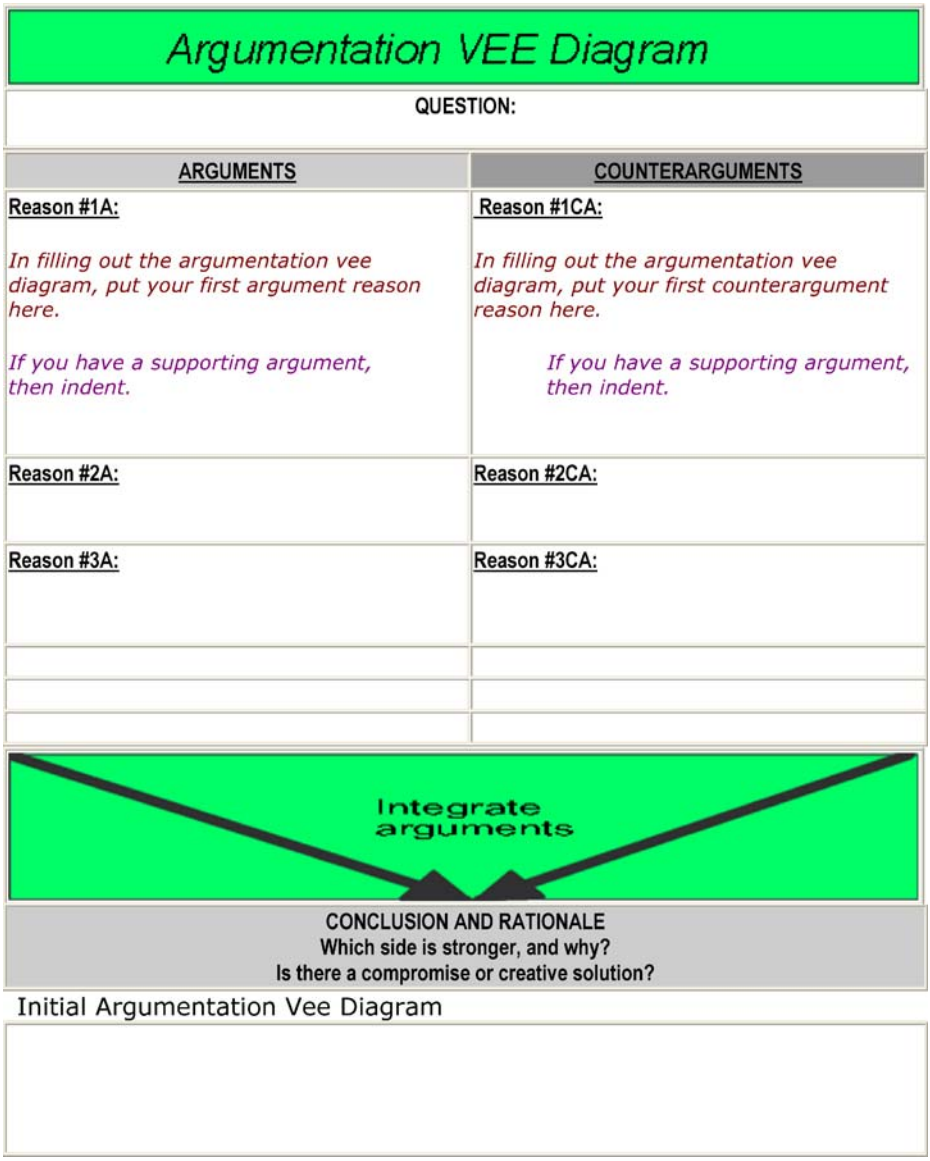

Fig. 1 Initial argumentation vee diagram

students who are inexperienced with online discussions or do not organize their writing well. Before writing their initial discussion notes, the organizers act as a prewriting planning device, which is important because planning is typically deficient in student writing (Mayer 1999). Then, after the discussion has proceeded, group AVDs serve as a summary device that, by laying out all the arguments and counterarguments in an organized way, serves to "make thinking visible" (Bell and Linn 2000); students can focus on the various points made by others, which in turn supports evaluating these points and

integrating them into their own thinking. (Although the beginning and ending activities are highly structured, the discussions that ensue in-between are not constrained.)

Finally, although our approach rests heavily on the argumentation-scaffold approach, we also wanted to combine the use of AVDs with the discussion norm approach. Prior research by Nussbaum (2006) using AVDs for planning argumentative essays (not online discussions) showed that AVDs cannot be used effectively unless students are given instruction and feedback on different argumentation instruction strategies. Otherwise, students will engage in *pseudo-integration,* picking a side they believe is strongest but without explicitly addressing counterarguments that have been raised. Students need strategies for engaging in integration. An aspect of our procedure was therefore to have the instructor give students feedback (via private mail notes) on the quality of their discussions notes, specifically on counterarguments that were raised but not addressed and integration strategies that could have been used.

Opinion change

In addition to examining whether students could successfully engage in argument–counterargument integration in an online environment, another goal of our study was to determine whether the AVD procedure would result in greater change in their opinions regarding the topic under discussion, compared to the control group. Chinn and Brewer (1998) have shown that students often reject counterevidence and simply continue to look for support for their preferred view, which is consistent with much other research documenting the presence of confirmation and belief biases (Mayer 1992). In respect to argumentation, Kuhn (1991, 2005) has shown that students often are deficient in metacognitive reflection, so that, instead of "stepping back" and evaluating their beliefs and theories, they instead just reason with their theories, as if the theories were necessarily true. Kuhn addressed scientific problems, but Kitchener (1983) found that ill-structured problems also tended to limit an individual's metacognitive ability toward effectively evaluating alternative arguments. Because ill-structured problems have no single correct answer, the resulting uncertainty causes students to often prefer their own positions rather than the perspective of others.

AVDs may promote opinion change by creating an affordance for metacognitive reflection. Our hypothesis is that students will be less likely to ignore counterarguments to their own position when they are asked to integrate those counterarguments into their own positions. The visual presentation of arguments and counterarguments would make such integration easier. We hypothesize that our AVD procedure will promote argument–counterargument integration and, in turn, opinion change. Our hypotheses certainly could be wrong. AVDs could be used in an unreflective manner where no integration occurs, or only pseudo-integration. But we predicted that the structure of the AVDs, in combination with discussion norms emphasizing reflection and integration, would produce positive effects.

It is not the purpose of this particular study to sort out the respective influence of argumentation scaffolds from norms, because we assume that learning effects of any import result from an interaction of several important variables; this is a working assumption of much design research (Design-Based Research Collective 2003). We conceived of the study as a design experiment (Brown 1992), where the intervention would evolve somewhat over the course of the study, and where the results could inform theoretical development, specifically theories of argument–counterargument integration. We wanted to see if our intervention was powerful enough to make students attuned to the affordances (Greeno 1994) that AVDs provide for metacognitive reflection and integration.

Methods

Although the study was conceived as a design experiment, to provide rigor it was also conducted as a quasi-experiment, using two sections of a distance education course on educational assessment. One section served as the experimental group, the other as a control.

Participants

Participants of this study were comprised of 87 undergraduate students enrolled in two sections of a distance education course on educational assessment for preservice teachers at a large, southwestern University. The participants were 81% female, 16% Hispanic, 12% African American, 7% Asian, and 65% Caucasian. The average age was 27.

Materials

Argumentation vee diagrams (AVDs)

We developed an AVD to be used by the experimental group for the online discussions (see Fig. 1 for the original AVD). The design of the AVD was developed in a separate study (Nussbaum 2006) involving essay writing (this study was not online), and we then adapted the design for online use. The top half of the AVD contained the question and spaces for arguments and counterarguments, divided into separate columns. Any supporting evidence or arguments could also be listed in the AVD. At the bottom of the figure, a V was formed that required students to develop an integrated conclusion, drawing upon the arguments and counterarguments.

Discussion board

The discussion board was an asynchronous tool available in the institution's course management system. At the beginning of the semester, members of the course were randomly divided into small groups (3–5 members) for the discussions in the course. Each group had their own private discussion forum and was restricted from seeing other groups' discussions. Through the discussion board, students were able to develop discussion threads by responding to each others' posts.

Group AVD wiki's

At the conclusion of the discussion, students used *wiki's* to work collaboratively on an AVD and create a summary note for their discussions. *Wiki's* are webpages that anyone in the group can edit (Frumkin 2005) using an online HTML editor. Each group had access to a *wiki* workspace that contained an editable AVD. The *wiki* also contained a version tracker that saved previous versions of the group AVD that could be reviewed at a later time. Students could also revert back to previous versions if errors were made.

Tutorials and instructional aids

To familiarize the students with the AVD and *wiki* technology, they were provided with instructions on how to complete an AVD and use the *wiki's*. We developed several working examples and provided step by step instructions using Macromedia *Captivate* technology

(Rapoza 2004). The main purpose of the tutorial was to provide guided instruction and real-time simulations on how to use the technology for this activity. Additionally, these specific instructions were also presented in static web pages that students could refer to at a later time, with a suggested timeline for the discussion activity.

Survey

A confidential survey was administered to the students in order to obtain feedback about the usefulness of the AVDs and the accompanying tutorials/instructional aids. The survey consisted of open-ended questions asking (a) if the directions were clear or whether there were any specific portions requiring more explanation, and (b) if the participant had any specific suggestions for improvement.

Discussion questions

Both distance education sections were given the same discussion questions. The discussion topics were: (a) Should students be graded on class participation, effort, and homework completion? (b) Should ability grouping be used to teach reading? and (c) Should states be required to have accountability systems for evaluating student performance? (See Table 1 for the full text of each question.)

Design and procedure

Students in the experimental group were enrolled in a distance education course taught by the first author and were asked to complete an individual AVD and a group AVD for three of their discussions. Our control group was taught by another instructor (fourth author); the participants were not exposed to an AVD at any point during their discussions. Although both sections were taught by two different instructors, they were taught the same way. Both courses were taught completely online. They had identical video lectures, assignments, and readings. Furthermore, students discussed identical questions and were required to post a minimum of two notes per discussion.

Each discussion lasted approximately one week. In both sections, each student generated a note answering the discussion question, posted at least one additional note that responded to another group members' post, and one member of the group summarized the discussion.

Before composing their first discussion note, students in the experimental group were asked to complete an individual AVD. Upon completion of the AVD—filling in the argument, counterargument, and integrated conclusion sections—the students posted their response to the discussion question. Their initial discussion note also included a copy of their individual AVD. After the students were given an opportunity to respond to the original question, they were instructed to discuss the issue by responding to other group members' posts.

After a couple days of discussion, the students were then instructed to use the *wiki* to collaboratively construct a group AVD and discussion note. To facilitate this, each member of the group was randomly assigned one of three roles (composer, elaborator, integrator), with students rotating through the different roles for the three discussion questions.

The composer for each group was responsible for summarizing important points that were made for the discussion and included these points in the group AVD. Next, the elaborator of the group modified the AVD by adding any missing information or clarifying points that were made by the composer. Throughout this process, other members of the

Table 1 Text of discussion questions

Topic	Text
Grading	Is it good educational practice to base a portion of a student's grade on such things as class participation, effort, or completion of homework? Advocates of this practice claim that doing so gives students an incentive to try. Opponents argue that grades should only reflect how much a student has learned. What do you think? Think of as many reasons as you can on both sides of the issue when developing your opinion.
Ability Grouping	A third-grade teacher, Mr. Garcia, is planning to group his students into three reading groups (i.e., high reading ability, moderate reading ability, and low reading ability) based on the results of a standardized reading test given to the students at the end of second grade. Is this good educational practice? Advocates of same-level ability grouping argue that it allows teachers to use materials and go at a pace appropriate for each student. Opponents of same-level ability grouping claim that students in low-ability groups and that it prevents the better students to act as models for the weaker students. What do you think? Think of as many reasons as you can on both sides of the issue when developing your opinion.
Accountability	The Federal government mandates that every state have an accountability system by which schools are held accountable based on scores on standardized tests. Average scores for each school in reading and mathematics are published on the Internet. Schools where scores do not steadily increase are considered "underperforming" and may be restructured. Also, some students in "underperforming schools" may be allowed to transfer. Advocates argue that accountability systems gives schools an incentive to improve, may encourage or require more services and options to be provided to at-risk students, and provides parents and policy makers with information on year-to-year growth. Critics argue that accountability systems tend to narrow the curriculum, could punish schools that need the most help (in cases where staff are fired or funding is reduced), and may use indicators that are not totally valid. In your opinion, should states be required to have an accountability system by which schools are held accountable based on how their students perform? Think of as many reasons as you can on both sides of the issue when developing your opinion.

group were also encouraged to review and modify the group AVD as well. The final step involved the integrator of the group. The integrator reviewed the group AVD and used it as a reference in order to compose a summary discussion note that was to be posted in the course discussion board. The purpose of the note was to conclude the discussion by providing a final argument that integrated arguments and counterarguments.

After the first discussion, the instructor (first author) reviewed the summary notes and group AVDs and provided written feedback to the students in the experimental group. The purpose of this feedback was to discourage "pseudo-integration" (see Nussbaum 2006) where students—in forming their final opinion—just picked the arguments they liked best and ignored counterarguments. Thus, students were encouraged to "think deeper about the other side" and "not to ignore any important counterarguments when performing your integration."

It also became apparent, after the first discussion, that students needed additional criteria and support for judging why arguments on one side might be stronger than the other. Therefore, for the second and third discussions, a series of additional questions were added to the bottom of AVD, just above the integration section (see Fig. 2). The questions simplified the integration process by having students identify the two most important arguments on each side, judge the extensiveness of any advantages/disadvantages, weigh the values involved, and then evaluate whether the other arguments might change their final

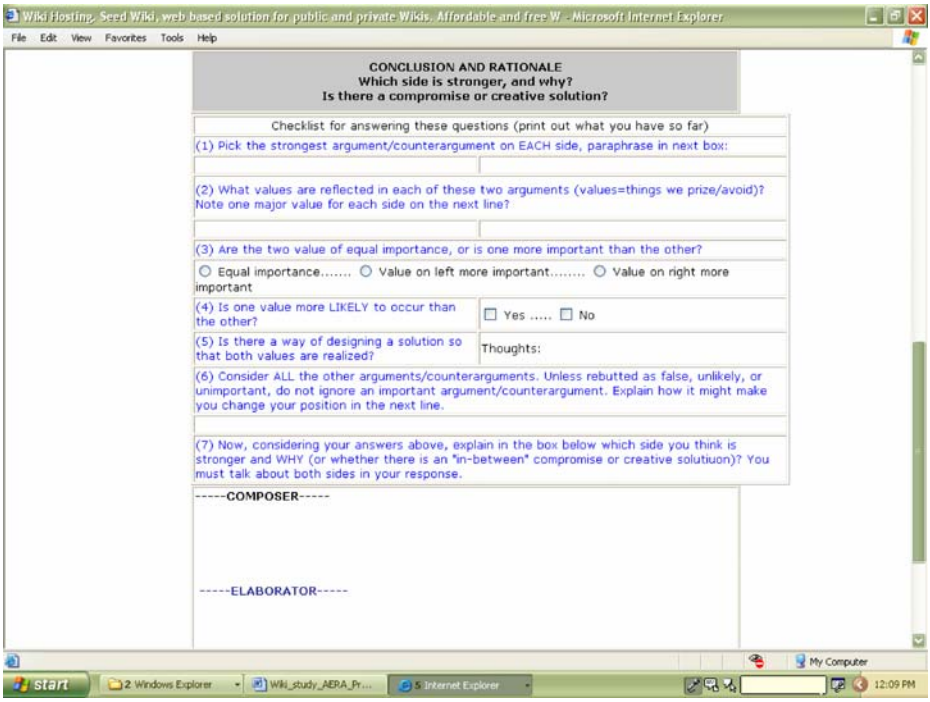

Fig. 2 Additional questions added to revised AVD

opinion, if at all. One question also asked if "there was a way of designing a solution so that opposing values could be realized?"

The survey was then administered to the students at the end of the study asking for critical feedback on the materials and procedures.

Coding and analysis

We coded each discussion note on: (a) number of arguments/counterarguments raised, (b) development of "it depends" final opinions that took into account both sides (compromises), and (c) generation of novel, creative solutions that realized advantages while minimizing disadvantages (creative solutions). Compromises could also involve some problem solving; the main difference between compromises and creative solutions was that the latter had to involve significantly novel ideas. Both compromises and creative solutions were considered forms of argument/counterargument integration in our prior research (Nussbaum & Schraw, 2007). We also examined whether students changed their opinion at some point during the procedure (change). We randomly selected 22 discussions to double score; reliabilities were satisfactory (r=.87 and up for all categories).

For the statistical analysis, we recognized that the scores for individuals in the same group were not statistically independent, because these students read one another's notes and attempted to influence one another. Fortunately, the degree of dependence can be measured by the *intraclass correlation*, which is the degree that the outcome measures are similar within a discussion group. This allowed us to control statistically for the effect of being in particular discussion groups by including the effect of "group" as a (random) term in a regression equation. We used multilevel statistical techniques (implemented with

MLwiN statistical software, Rabash et al. 2005), with participants at the first (lowest) level and discussion group at the second (higher) level. This in essence divides the error variance up into two portions: error associated with individuals and error associated with groups.

These techniques estimate regression parameters using maximum-likelihood estimation and computing the Wald z statistic. For this reason, z-scores, rather than t-scores, are reported (see Agresti 2002).

Results

For the first analysis, we compared the experimental group—which received the AVD intervention—with the control group on the five outcome variables. As shown in Table 2, there was a significant difference on both the compromise and change variables, both favoring the experimental group. As we will show in the next analysis, the change variable also showed interaction effects with time, so the main effect should not be interpreted. In regards to the compromise outcome variable, the experimental group made significantly more compromises (z=2.33, p<.05, β=0.29), about one-half standard deviation more (see Table 2). The deviance statistic (G^2), which measures how well the model fits the data, decreased significantly ($\chi^2(1)$=4.57, p<.05) from inclusion of the treatment variable, compared to a model containing only an intercept ("variance component model"). According to Rabash et al. (2005), this is important to consider for purposes of model building.

The second analysis—shown in Table 3—was a repeated measures model to determine if there were any increases in the outcome variables over time. This involved including Time (T) and Time by AVD Treatment (T × A) terms in the model. The G^2 statistic decreased significantly indicating a better fit—for number of arguments ($\chi^2(2)$=12.01, p<.01) and change ($\chi^2(2)$=11.31, p<.01). Both groups generated an increasingly larger number of arguments over time. More importantly, however, the experimental group showed a significant interaction with time (z=2.30, p<.05, β=0.70); the increase is means in shown

Table 2 Means (Standard Deviations) and multilevel main effects, by group

Group						
Outcome Variable	AVD (n=49)	Control (n=38)	ρ_I^a	B	β	G^2 [ΔG^2 [b]]
Number of Arguments	1.90	1.31	0.09	0.56	0.21	303.38
	(1.40)	(1.23)		(0.36)		[2.14]
Number of Counterarguments	2.56	2.10	0.00	0.46	0.14	346.51
	(1.94)	(1.26)		(0.38)		[1.25]
Compromises	0.71	0.47	0.13	0.28*	0.29*	116.08
	(0.47)	(0.50)		(0.12)		[4.57*]
Creative solutions	0.98	0.85	0.00	0.13	0.07	230.50
	(1.05)	(0.75)		(0.20)		[0.46]
Change	0.35	0.00	0.13	0.35**	0.53**	66.81
	(0.45)	(0.00)		(0.08)		[16.89**]

Discussion group included as a random variable (controls for effect of discussion group).

*p<.05;

**p<.01.

[a] Intraclass correlation for discussion group

[b] Compared to intercept-only model (χ^2 (1) test used)

Table 3 Multilevel regression repeated measure analysis for outcome variables (N=87)

Predictor	B	SE B	β
Number of Arguments			
Constant	2.70	0.59	
Time (T)	−0.63	0.24	−0.39**
AVDs (A)	0.32	0.77	0.12
T x A	0.07	0.32	0.06
G^2=291.36			
$\Delta G^{2\ a}$=12.01**			
Number of Counterarguments			
Constant	1.21	0.73	
Time (T)	0.42	0.32	0.21
AVDs (A)	−0.52	0.96	−0.16
T x A	0.51	0.42	0.35
G^2=334.71			
$\Delta G^{2\ a}$=8.54*			
Compromises			
Constant	0.15	0.21	
Time (T)	0.13	0.09	0.22
AVDs (A)	0.41	0.28	0.43
T x A	−0.06	0.12	−0.14
G^2=113.31			
$\Delta G^{2\ a}$=2.76			
Creative Solutions			
Constant	0.71	0.40	
Time (T)	0.06	0.18	0.05
AVDs (A)	−0.10	0.53	−0.05
T x A	0.12	0.24	0.15
G^2=229.04			
$\Delta G^{2\ a}$=1.46			
Change			
Constant	0.00	0.15	
Time (T)	0.00	0.07	0.00
AVDs (A)	−0.05	0.20	−0.08
T x A	0.20	0.09	0.70*
G^2=55.50			
$\Delta G^{2\ a}$=11.31**			

Discussion group included as a random variable (controls for effect of discussion group). See Table 2 for intraclass correlations.

*p<.05;

**p<.01.

[a] Change compared to AVD main effects model; χ^2 (2) test used.

in Table 4. The table shows that there were significantly higher levels of opinion change in Sessions 2 and 3 compared to Session 1. There was no opinion change whatsoever in the control group.

We had also hypothesized that opinion change would occur because of argument–counterargument integration. Because the previous analysis indicated significant effects of compromises (as one important aspect of integration), we examined whether compromises would predict opinion change, using a multilevel logistic model. Our hypothesis was confirmed (z=2.10, p<.05, odds ratio 4.16). Of those participants engaging in compromise,

Table 4 Means (SDs) for change variable, over time

Time	Group Ms		SDs/*N*	
	AVD	Control	AVD	Control
1	0.06	0.00	0.25/16	0.00/11
2	0.53	0.00	0.52/15	0.00/13
3	0.47	0.00	0.51/17	0.00/15

27.5% displayed an opinion change over the course of a discussion, as compared to 8.3% of those who did not engage in compromise.

Finally, although the repeated measures model for counterarguments did show an improved fit, none of the individual coefficients were significant, so that result is not further discussed.

Feedback survey

Among the experimental participants, 19 completed the open-ended, feedback survey in which they were asked if they found the AVD directions and procedures useful. Responses were analyzed qualitatively.

In regard to the sample AVDs and Captivate demonstrations, 79% reported they were clear and helpful. One participant remarked regarding the Captivate demonstration that by "laying everything out and [popping] up little windows showing what you do where," it was fantastic.

In regard to the AVD intervention, there were a number of themes that help shed light on why AVDs were useful.

1. Six students (31.6%) explicitly mentioned that AVDs resulted in discussions that considered a greater variety of views, and that the views were better argued and elaborated.
2. Six students (31.6%), including two mentioned in #1, noted that AVDs helped them organize and guide their thinking. One of these six, and two additional students (15.8%) noted it gave them a sense of their own opinion.
3. An additional three students (15.8%) noted that the question prompts added to the AVD integration section (starting with the second discussion) made them really focus on and "realize" the opposing view.

So, in summary, 79% of the participants made comments about how AVDs (with the question prompts) help structure their thinking and focus on opposing views. The question prompts may have been necessary to encourage students to process opposing views (and their own view, if they had one) with some degree of depth and elaboration.

There was some disagreement as to whether all three parts of the procedure (individual AVD, discussion, group AVD/summary note) were necessary. A couple students thought the individual AVDs were too complicated or "not broad enough to be useful." Two others thought the individual and group AVDs were duplicative. However, four others (21.1%) thought that all three parts built on one another and were useful, although several said it took at least one discussion to get the "hang" of doing the AVDs. One additional student said "individual AVDs—fantastic! The fact we could individually think through an entire process with some guidance (from the form) was great...." Overall, these comments are split on the usefulness of the individual AVDs; however, because the remaining students did not

complain about the individual AVDs, we might presume that they were generally helpful for students. But clearly a few found them unnecessary.

Golanics and Nussbaum (2007) found structured discussion interventions more helpful for students low in topic knowledge and/or ability, and this might explain these findings. The potential value of AVDs for many such students was nicely expressed by one participant:

> In the beginning of this class my discussion notes were rarely thought out and sloppily put together. Once I realized that having a discussion with my group was helpful and fun (and some probing from you), I was more inclined to write more.

The entire AVD intervention may not be necessary for students with advanced discussion and argumentation skills. But for many students with less advanced skills, the AVDs appeared to be a useful organizational device. It must be stressed, however, that in this study, use of the AVDs was embedded in a procedure that involved a certain amount of training and practice, and that the effects discussed above did not occur immediately.

Discussion

The focus of this research was to investigate the development and analysis of argumentation vee diagrams (AVDs) for use in online discussions as a framework to support and promote argument/counterargument integration in collaborative learning. Argument–counterargument integration is a framework that differs from usual adversarial argumentation approaches that focus on persuasion. The emphasis with argument–counterargument integration is on reflection and balanced reasoning. Ideally, various sides of an issue are considered before a conclusion is reached. In actuality, students approach discussions with various degrees of prior beliefs, but that underscores even more strongly why students must be encouraged to consider opposing views. Furthermore, students must ultimately learn to evaluate these views. Rather than choosing only one view, the framework allows students to develop "in-between" views that allow for contingent "it depends" responses and compromises. A major question of this study is how students can be supported and encouraged to engage in argument–counterargument integration.

Because discussions are also often unstructured and non-goal directed for many students, we sought to provide an organized, structured, and goal-directed context, in which students were assigned specific roles with explicit tasks in order to promote a discussion which incorporated and synthesized both arguments and counterarguments. We investigated three separate online discussion topics and found that using the intervention resulted in significant effects for compromise and change. By "compromises," we mean that students developed final arguments that reflected both sides of the issue, recognizing that each side is partially right (and under what conditions)—which is one important element of argument–counterargument integration. Over time, many students' opinions on these issues also began to change. In this section we will address possible implications of our finding.

Compromises

It is commonplace for students to view one condition of an argument and veer only slightly, if at all, from their original perspective. This is consistent with many studies showing a tendency to reject alternative perspectives (Voss 1988) and to choose preferred solutions that develop their own argument (Jonassen 1997). Online discussions must be explicitly

structured to encourage students to explore and integrate alternative perspectives (Jermann and Dillenbourg 2003). The AVDs help "making thinking visible" (Bell and Linn 2000) by systematically displaying arguments and counterarguments, and also may serve as a collective memory for the discussion (de Vries et al. 2002). AVDs thus became artifacts that can promote reflection. At the same time, we do not believe that our activity was overly structured, because participants had free reign to discuss the topic anyway they so chose in-between the two AVD activities. We hypothesized, however, that the AVD intervention would affect behavior during the discussions.

Our hypothesis was confirmed. We believe that, as a result either of the structure afforded by the AVDs, or the expectations conveyed by them or our feedback on their use, students who used the AVDs developed more compromises during discussion. This realized an important objective of AVDs: to promote argument–counterargument integration. Compromise, as we use the term, operationally involved making some concessions to the other side, acknowledging opposing factors, and attempting to somehow balance the two sides. For example, when discussing ability grouping, one student wrote: "I was not implying that students would not benefit from being placed into groups but I do think the results could vary....I can see where you are coming from and I agree to an extent." As another example, in discussing accountability, a student wrote:

> I agree that both sides have very valid points that help back-up their arguments.... However, I am not sure that siding completely with the advocates, is what is best for your child. You stated that, 'standards should be implemented to make sure that the job is done.'...How can schools in impoverished areas meet the same standards required of a school in a city like Napa Valley....Accountability is great in theory but we need to take into consideration that there are other factors that need to be considered....Standardized tests should not be eliminated but...I would prefer that they are just used as one method of assessing a student's range of knowledge and not as a means of punishing the teacher, the school, and most importantly the students.

The student suggests a compromise that would use multiple forms of assessment. The compromise is not highly fleshed out or novel (otherwise it would be a creative solution), but did involve some integration of both sides. This is likely to result in some opinion change. For example, the other student responded, "After thinking about it, I am able to agree a little," although he also pointed out that the government supplies poorer school districts with additional financial aid. (We discuss opinion change in more detail in the next section.)

Although AVDs functioned as a concept map for structuring and extending thinking, it was surprising that AVDs did not have much effect on generating creative solutions. This finding is in opposition with an essay study using AVD's (Nussbaum 2006) which found that students' ability to integrate and formulate arguments yielded more innovative thinking and produced creative solutions to novel scenarios. Perhaps the additional prompts that we added to the AVD in the present study did not focus strongly enough on this type of thinking. Preliminary results from a follow-up study that we are conducting suggest that AVDs can foster creative thinking with some additional instructional modeling. But in the present study, it was compromises (not creative solutions) where we found an effect.

Opinion change

The data indicate that the AVD intervention resulted in a higher frequency of opinion change. According to Dole and Sinatra (1998), the process of thinking deeply about two alternative conceptions, such as arguments and counterarguments, requires "high

engagement" (p. 121). It is hypothesized that these types of activities require metacognitive strategies and make it possible for belief change to occur. The AVD intervention appeared to encourage this type of deep engagement and metacognitive reflection (Ferrarri and Elik 2003; Kuhn 1991).

According to the survey data, the additional prompt questions that were added to the AVDs in Sessions 2 and 3 (see Fig. 2) were important in helping students to really focus on and think about the other side of the issue. These questions were added because we felt that students needed additional guidance in how to evaluate and integrate opposing sides. We do not claim that students necessarily engaged in the exact cognitive operations reflected in these questions, such as designing creative solutions, only that the questions helped students focus on and process the other side for an extended period of time. (The implication is that it may not be the exact questions that were asked that were important, only that some questions that were asked; see Davis 2003, and Chi et al. 2001, for evidence supporting the usefulness of generic prompts). The addition of these questions corresponded with greater levels of opinion change, which suggests the possibility of a causal relationship. Although the relationship between opinion change and adding the prompts is correlational, evidence for a causal relationship is supported by a qualitative analysis of student comments. We cannot discount the possibility, however, that the opinion change effect was caused by some other factor, such as greater practice in using the AVDs; perhaps greater procedural skill in using the AVDs freed up working memory resources for greater reflection (Rittle-Johnson et al. 2001). Additional research is needed to sort out what elements of the intervention are responsible for the effects, as well as to control for possible instructor effects.

In addition, the instructor in the experimental group also gave students feedback on their previous AVD integration, tending to point out arguments or counterarguments that students ignored when completing the integration section or writing their discussion note (e.g., "What about issue X?—you raised it but didn't address it in your final argument). This likely reinforced the AVD prompts (which also directed students to consider ALL the arguments and counterarguments), but the instructor's feedback was not singled out in the student comments. This fact makes it less likely that it was the feedback, rather than other aspects of the AVD procedure, that was responsible for the effects.

Norm building vs. argumentation scaffolding

Some might argue that we could have achieved our results using a norm building approach rather than with any argumentation scaffolding. In fact, we combined the two approaches. We did observe high levels of quasi-integration during the first discussion session (noting that one side seems stronger than the other one without addressing all the counterarguments), which was our motivation for adding the additional discussion prompts and for adding instructor feedback. Nevertheless, there may be ways of facilitating norms of argument–counterargument integration without using AVDs, such as presenting written examples of such discourse. Future research would have to explore whether such approaches are as effective as the intervention that we used. In any event, our study shows that it was found to be necessary to provide students with additional scaffolds on how to evaluate argument strength, so we are doubtful that a norm building by itself would be effective.

Individual AVDs

Finally, there was some disagreement among the students over the usefulness of completing individual AVDs prior to group discussion. We suspect that the usefulness of this

component might depend on the student, specifically on such factors as student experience with discussions, topic knowledge, or writing/reasoning ability. One possible way of using AVDs is that individual AVDs could be required initially in a course for a couple discussions (as prediscussion activities), and then their use made optional, depending on whether students continue to find them useful. The use of individual AVDs would introduce students to argument/counterargument integration strategies and stimulate deep processing, but then attention could shift to other aspects of discourse development, while retaining some focus on argument–counterargument integration with the use of group AVDs as a discussion summarizing activity. Future research studies should explore the constraints and affordances of other possible design scenarios.

Conclusion

In general, this study contributes to the growing research on both the role of argumentation in knowledge and opinion change (Bell and Linn 2000; Nussbaum and Sinatra 2003) and the subdiscipline in CSCL, computer-supported argument visualization (Kirschner et al. 2003). We claim that the field has made some progress in finding ways to stimulate counterarguments in online discussions; attention now needs to focus on how students evaluate counterarguments and engage in argument–counterargument integration. This study has shown that students can be taught to engage in argument–counterargument integration in an online environment and that this process can result in opinion change. Although we do not suggest that the AVD procedure is flawless, we do think it usefully supports the process of argument/counterargument integration and belief change in online environments.

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