

Re-appropriating a question/answer system to support dialectical constructivist learning activity

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Abstract Learning can be engaged by dialectic, that is, by identifying pros and cons that inhere in propositions, and more generally, by raising questions about the validity of claims. We report here on a classroom case study of dialectical constructivist pedagogy: Students created dialectical analyses of two lectures and four books as core activities in a freshman seminar “Information, People and Technology”. We adapted the functionality of Piazza, a free wiki-style question–answer course management infrastructure, and Toulmin argumentation structures to organize and facilitate these dialectical learning activities. In this paper, we motivate this approach, describe our implementation of it, and present interaction log data and content analysis of Piazza debates, and analysis of student self-reflections on learning activity and consequences, to assess issues in this approach, and directions for further instructional design and research.

Keywords Dialectical constructivism · Critical thinking · Scaffolding · Piazza

Introduction

An abiding challenge in education is helping students to develop appreciation and skill in critical thinking (Glaser 1985; Jonassen and Kim 2010). Critical thinking is a broad concept that includes thinking clearly and logically, and systematically regulating one’s own thinking to identify issues, analyze and synthesize relevant evidence and argumentation, and draw warranted conclusions (Basseches and Gruber 1984; Glaser 1985; Fisher 2011). Dialectical thinking and learning is a kind of critical thinking that emphasizes identifying, understanding and resolving conflicts (Brookfield 1987). It entails the deep

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engagement with ideas that is essential for learning (Jonassen and Kim 2010). It is both a very old pedagogy (Socratic dialog, Aristotle's dialectic) and a modern perspective (O'Donnell 2012). Nevertheless, in many contemporary educational approaches, dialectic skills and critical thinking ability are either not supported at all (lectures, problem sets), or is a hoped-for concomitant, but not explicitly supported (O'Donnell 2012).

Our goal in this project was to help students understand critical thinking, and to successfully enact and appreciate critical thinking practices, specifically to identify and analyze positive (pro) and negative (con) propositions in six course modules, regarding two lectures and four books. We wanted to engage more of the students in critical thinking and dialectical learning, and to do that more quickly in each discussion and across the weeks of the semester.

We wanted to investigate learning technology to support these dialectical learning activities. Our approach was to re-appropriate Piazza, a free wiki-style question-answer course management infrastructure (piazza.com), to organize and facilitate collaborative dialectical learning interactions in and outside of the classroom.

We present a classroom case study in which dialectical learning activities were introduced in a freshman seminar on "Information, People and Technology" (Yin 2013). Students collaboratively constructed and shared pro and con arguments regarding course topics and materials during a 12-week period. We made classroom observations throughout the course, logged and content-analyzed online activity, and administered two surveys to assess student experiences.

To preview, this intervention did seem to be effective in helping students to structure their own learning inquiries, and was experienced as useful and rewarding by the students. Students appeared to develop or better demonstrate critical thinking skills through the semester, and to recognize and appreciate this in themselves. In-class discussions in the course benefitted from preparatory online Piazza debates. Re-appropriating Piazza allowed us to provide students with an immersive dialectical constructivist learning activity, and to identify specific design challenges and approaches for further learning technology work.

Dialectical constructivism

Dialectic refers to methods of discussion and analysis in which a proposition and its antithesis are considered together in order to synthesize a resolution, or at least a more comprehensive solution. Dialectic is an indispensable tool in philosophy from the Greeks through to Marx and Hegel. It is also the foundation for pragmatic educational concepts like critical thinking and problem based learning (Dewey 1933; Pavlidis 2010).

Dialectical constructivist learning activity articulates more than a single perspective or position, and then comparatively debates, deconstructs, and analyzes strengths and weaknesses of the multiple perspectives or positions to synthesize new perspectives (Cooner 2005; Moshman 1982; O'Donnell 2012; see also Jonassen and Kim 2010). It can be contrasted with near-neighbor constructivist pedagogies such as *problem-based learning* (Hmelo-Silver 2004; Carroll 1990; Carroll and Rosson 2005), an exogenous constructivism in which learners address authentic problems with realistic methods, reconstructing relationships and practices of the real world in order to understand its concepts and techniques, or *endogenous constructivism* (O'Donnell 2012) in which students integrate and coordinate their knowledge and experience to create a reflective abstraction. A contemporary example of endogenous constructivism is the collaborative development of high quality question-answer pairs, as implemented through Piazza, a free

wiki-style question–answer course management infrastructure (piazza.com; e.g., Vivian et al. 2013).

Dialectical constructivism can be contrasted with other constructivist pedagogies in three respects. First, dialectical constructivism specifically emphasizes argumentation and debate among learners. The student’s role is to challenge and modify perspectives, not just to learn them, or even just to put them into practice (Carr 1988; Herreid 2004). Sanders et al. (1994) showed that college students could be systematically instructed to effectively and non-aggressively deconstruct arguments. In this project, we wanted to investigate whether argumentation and debate could be more pervasively appropriated by students as a general classroom practice, and also extended so that students are asked to compare and contrast arguments and perspectives, and not merely to assess their individual validity.

Second, relative to other constructivist pedagogies, dialectical constructivism emphasizes the synthesis of new perspectives. Exogenous constructivism emphasizes *adoption* and *enactment* of pre-existing (authentic) knowledge and practices; endogenous constructivism emphasizes the *coordination* and *reorganization* of pre-existing knowledge and practices (Moshman 1982; Land 2000). Dialectical constructivism also depends on bottom-up anchoring and appropriation, but it further engages conflicts in understanding (Piaget and Inhelder 1969) and in cultural-material values (Vygotsky 1978) to evoke sense making. As Kuhn (1999) put it, “The developmental goal is to put people in metacognitive and metastrategic control of their own knowing.” In this project, we wanted to investigate how students could deliberate, analyze, and resolve conflicting perspectives and in doing so, come to understand issues more broadly.

Finally, relative to other constructivist pedagogies, dialectical constructivism emphasizes that knowledge is problematic and contingent, that people are responsible for constructing it and critically assessing it, and that the challenge of problematic and contingent knowledge is unending (Dalgarno 2001; Land and Hannafin 1996). Articulating questions, recognizing information needs, positioning relevant information resources, and synchronizing theories and evidence builds critical thinking skills (Land 2000; Land and Hannafin 1997; Rakes 1996). In problem-based learning, for contrast, the focus is on learning and enacting authentic concepts and practices, but not necessarily on reflecting upon the limitations and ephemeral validity of the authentic materials. In this project, we wanted to investigate how students could be engaged to participate in critical analysis interactions spanning weeks, and carried out both in the classroom and outside the classroom (Carroll 2014; Carroll et al. 2015).

Re-appropriating piazza

Often in educational technology research, one needs to invest significant initial time and effort in order to implement a reliable and innovative technology-based learning activity. In this project, we used Piazza (piazza.com) to implement dialectical learning activities. Piazza is an online learning infrastructure intended to enable collaborative development of high quality question–answer pairs through a sophisticated user interface, functionally similar to that of Wikipedia, but better engineered from a human interface perspective; students integrate and coordinate their knowledge and experience to create a refined expression of what they have learned. This is an engaging and authentic learning activity; it provides a public achievement for those who participate directly, and a public resource to other class members. Piazza is used quite effectively in many lower division science courses at the Pennsylvania State University, and at several hundred other universities.

We re-appropriated Piazza: Based on walkthroughs, we concluded that Piazza’s support for collaborative wiki-style editing of question–answer structures was syntactically analogous to the functionality we needed to support dialectical learning activities in which student teams create and edit pro-con structures. Our mapping was simple: One team of students edited a pro position statement in Piazza’s “question” pane, and another team edited a con position statement in Piazza’s “students answer” pane. All students in the class were invited to post comments on the pro and con positions in Piazza’s “followup discussions” forum.

The pedagogical objective is for students to develop clear and logically compelling positions on both sides of the argument, a series of issues, each with a refined pro and con position. Engaging in this knowledge-building activity, and reflecting on their own argumentation is intended to help students appreciate, understand and learn how to create a comprehensive analysis of a complex issue, as opposed to merely selecting and defending a position. The skills we hope to highlight and develop are the same ones that professionals use when they develop design rationales (Moran and Carroll 1996).

To introduce the idea of a pro-con debate to students, we developed an example based on the disclosures regarding the US government’s Prism program by Edward Snowden during the summer of 2013 (Cho 2013). Figure 1 shows how the user interface features of Piazza were re-appropriated for our learning activity. One *pro* claim for the Prism program might be that it is reasonable to trade some personal privacy for greater safety and security. Backing for this claim might involve appeals to the utility of “bulk” collection and analysis of communication network data. An associated *con* claim might assert that allowing the government latitude in unsupervised privacy violations might entail greater infringements in the future. Other issues might analyze the distinction between *whistle blower* and *traitor*, and contrasting international perspectives. The Prism program was a good introductory example since most of the students were familiar with it.

The Piazza user interface basically provides text panes for student input with minimal labeling (see Fig. 1). Thus, it provides no support for expressing types and connections in students’ argumentation (e.g., distinguishing claims, qualifiers, warrants, evidence, backing, and rebuttals; Smith 1977). We introduced a manual tagging scheme for emphasizing types and connections adapted from Toulmin’s model of argumentation (1964); for example, notice the [Claim], [Warrant], [Backing], [Evidence] and [Rebuttal] tags in

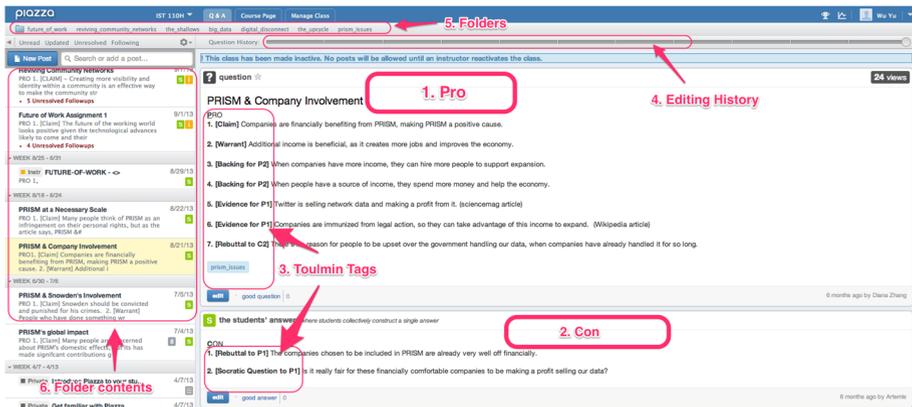


Fig. 1 Using piazza to support dialectical learning

Fig. 1. In our scheme, students link pro and con propositions by explicit indices; for example, notice the references to P1, P2 and C2 in Fig. 1.

We used Toulmin's model because it has been widely used in teaching and practice in rhetoric, informal logic, and design rationale (e.g., Moran and Carroll 1996). Prior literature suggests providing metacognitive guidance that involves embedding scaffolds for procedural, strategic, or metacognitive control might enhance the reflective process during learning (Land 2000; Lin et al. 1999; Scardamalia et al. 1989). We wanted to investigate whether and how explicit tagging and referencing could serve as a cognitive scaffold, helping students develop and think critically about argumentation.

Re-appropriating Piazza allowed us to create a fully functional prototype (e.g., with account management and student data security) for our learning activity merely by reinterpreting the existing wiki text panes in Piazza. We benefitted from Piazza's reliability, system support, and advanced features: students can post anonymously with respect to the views available to other students but have their contributions attributed in the instructor view; instructors and other users can post privately to specific other users, as well as publicly; posts can be pinned, archived, "resolved", and searched; users can save drafts, attach files to posts, bookmark favorite contributions and endorse the quality of contributions as "good"; the system provides awareness indicators such as the number of edits a post received since the user last logged into the system; instructors can push class announcements and create polls for the class; instructors can get a summary of class participation—overall accesses and posts per day, and cumulative accesses, posts viewed, and contributions by student.

The major mismatch between Piazza and our learning activity involved that fact that in Piazza interactions, posting a question, that is, placing text into a question pane, *causes* the associated answer pane to be displayed. For Q–A discourses, this is makes sense: One needs a question in order to create an answer. However, in pro-con discourses, it is reasonable to initiate argumentation identifying *either* a pro or a con proposition (though the former may be more obvious). Thus, in re-appropriating Piazza, we suggested to students that con teams could initiate an argument by posting a "pro-stub", a placeholder text in the question pane, in order to display the associated answer pane for their con proposition. Later, members of the pro team could edit the stub text to post their pro position.

The balance of this paper investigates two research questions:

Research Question 1: How can dialectical analysis of issues into pro and con positions backed by evidence engage students and help them to develop critical thinking skills?

Research Question 2: How can Piazza be effectively re-appropriated as a prototype to investigate dialectical constructivist learning, that is, can students use Piazza, and the Toulmin tags we suggested as cognitive scaffolds to carry out collaborative dialectical learning activities, and can their activity and experience guide and inform the design of further learning technology?

Methods: participants, procedures, analysis

The context for this study was a first year undergraduate honors seminar "Information, People, and Technology" with an enrollment of 15 students. The class was a general education course for honors college students at the Pennsylvania State University, and also served as the entry-point course for an interdisciplinary undergraduate major in

Information Sciences and Technology (IST). Five of the students were indeed starting the IST major. Five others were majoring in engineering; four were majoring in liberal arts; one was majoring in communication studies. Four of the students in the class were female (one from each of the majors mentioned above). The students were organized into four teams, before meeting the instructor in the first class, to maximize diversity with respect to gender and major.

A key requirement for honors courses in this university is to strongly emphasize critical thinking. In the Fall 2013 course offering, students were provided with an example dialectical analysis of issues regarding the Prism program based on Cho (2013). During the first class meeting, the instructor demonstrated Piazza and presented the Prism example (Fig. 1), emphasizing the concepts and utility of critical thinking in general, of pro-con dialectics specifically, and of distinguishing the argumentation types in Table 1, adapted from Toulmin (1964; n.b. Socratic Questions is a category we added, one not in the core Toulmin schema).

Subsequently in the course, students worked in teams, to collaboratively analyze two lectures presented by the instructor. These lectures addressed technological and social factors shaping the future of human work, and socio-technical approaches to enhancing community in American society; both lectures were designed to be argumentative. The students' Piazza analyses took place during the week following each lecture, mostly out of class. Instructor feedback on these first two activities focused primarily on guiding and encouraging the students in identifying and clarifying pro and con arguments, as opposed to assessing the quality of analyses and argumentation.

The major dialectical constructivist activities for the course were analyses of four argumentative books: *The Shallows: What the Internet is Doing To Our Brains* (Carr 2011), *Big Data: A revolution that will transform how we live, work and think* (Mayer-Schönberger and Cukier 2013), *Digital Disconnect: How capitalism is turning the Internet against democracy* (McChesney 2013), *The Upcycle: Beyond sustainability - Designing for abundance* (McDonough and Braungart 2013). These books were selected because they address current issues in computing and information technology as evidenced-based debate, and with clear point of view. These books present specific and provocative theses about technology, information and people without attempting to present a balanced case. For example, Carr (2011) argues that the use of the Internet is undermining human brains and intellectual abilities, and indeed, that these negative effects are clearest among young people. We anticipated that these books would be compelling, and hypothesized that

Table 1 Simplified Toulmin model of argumentation used to tag contributions to piazza debates

Claims: present the main point of your argument (e.g., You should not eat wild mushrooms)
Evidence: provide support for your claim (e.g., some of them are poisonous)
Warrant: connect your evidence to your claim. (e.g., eating poisonous things is dangerous)
Backing: support your warrant (e.g., when I have eaten something poisonous, I get sick)
Rebuttal: respond to the argument (e.g., delicious wild mushrooms look different than poisonous ones)
Qualifier: give limitations to a claim (e.g., if wild mushrooms have gills, don't eat them)
Synthesis: combine two pieces of evidence or backing that make more sense as one point. (e.g. recognizing types of wild mushrooms can help us avoid the poisonous ones)
Socratic Questions: thought-provoking questions to help make your point. (home can we distinguish poisonous from nonpoisonous wild mushrooms?)

students would learn more from them by explicitly constructing the implicit dialectic, that is, by concretely enumerating the author's arguments and *articulating counterarguments*. For us, this was also an opportunity to investigate how students adopt and use dialectical constructivist practices staged in the Piazza wiki infrastructure, and how they experience and reflect on learning activities designed to require them to think critically about what they learn from each book. The six course activities using Piazza, and their timing and duration during the 15-week semester, are described in Table 2.

Students worked in the same four teams throughout the semester. For any given activity, one team argued for the pro proposition (supporting and developing the authors' argument), and another team took the con proposition (challenging and rebutting the authors' argument). Members of the other two teams did not have team-level role assignments; they were asked to contribute to class discussions by ensuring that the pro and con teams made clear and compelling arguments, and were invited to contribute individual perspectives in Piazza by posting in the "followup discussions" pane, which appears beneath the "question" and "answer" panes in the Piazza user interface (it is not visible in Fig. 1).

For the first two course activities on Piazza, based on class lectures, each team played either a pro or con role. For the 4 book analyses, team role assignments were permuted so that each team played the pro role once and the con role once. The six dialectical learning activities were a significant component in the students' course grade (30 %).

Surveys

We conducted two surveys to assess student experiences and gather self-reports of the activities using Piazza during the semester. The first survey was instrumented about half way through the semester, after the students completed analyzing *The Shallows*. We asked the students how they organized team participation in Piazza discussions, how those discussions supported their learning, how their approach to the discussions may have evolved, how they used the Toulmin tags, how they participated in follow-up discussions, and how in class discussions were affected by Piazza work. Fourteen out of 15 students responded to the first survey. Table 3 presents the survey items.

One of the objectives of implementing dialectical learning model is encourage students to adopt, enact, and reflect upon dialectic and critical thinking skills. Based on student feedback from the first survey, a second survey was instrumented toward the end of the semester, after the students completed analyzing the fourth and final book, *The Upcycle*. The second survey focused specifically on how students perceive the Piazza-based dialectical learning activities in relation to their own critical thinking skills. Thirteen out of 15 students responded to the second survey. Table 4 presents the survey items.

Table 2 Course activity design

Topics	Semester weeks
The future of work	Week 1
Reviving community networks	Week 2
The shallows	Weeks 5 and 6
Big data	Weeks 7 and 8
Digital disconnect	Weeks 9 and 10
The upcycle	Weeks 11 and 12

Table 3 First student survey

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- Q1. How do you and your teammates carry out discussions for group assignments OUTSIDE of the classroom (for example, meet face to face, meet online, emails, one person starts and others edit and refine, etc.)? How do these activities contribute to your online Piazza work?
- Q2. What is your current impression of developing ‘Pros’ and ‘Cons’ as a tool for learning? How has this activity affected your critical thinking attitudes and skills?
- Q3. How has your approach to using Piazza to construct Pros and Cons CHANGED through the course so far?
- Q4. What is the value of Toulmin “tags” to your Piazza work - claims, evidence, warrants, backing, rebuttals? Why do you think no one has yet used the “qualifier” or “Socratic question” tags? How have you used the “Prism” example in Piazza?
- Q5. If you have posted “follow-up discussions”, what were your motivation(s)? For example, were you elaborating Pros and Cons of other teams or of your own team, adding further perspectives to the discussion, responding to earlier “follow discussion” posts, etc.
- Q6. How is in-class discussion affected by prior Piazza work, if at all? Do class discussions expand Piazza points, introduce other points, etc.?
- Q7. Please make any other comments you wish to!
-

The survey items all consist of one or more short open form questions. The surveys were analyzed by two of the authors, who iteratively grouped the answers into self-similar categories until the groupings stabilized in agreement (Strauss 1987). Because of the small number of students in the course, we only report these data descriptively, characterizing the most salient groupings through quoting typical responses, and citing overall counts.

Behavioral traces

We supplemented the survey with analysis of the behaviors of individual students and teams during the semester. These were fairly straightforward descriptive analyses. We profiled students’ actual use of the various Toulmin tag categories to structure their contributions to the Piazza discussions. We also carried out content analyses of students’ posts

Table 4 Second student survey

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- Q1. How, if at all, did this learning approach motivate you to read or think differently relative to—say—reading a book to understand its argument and conclusions, and then trying to state and apply the author’s concepts and methods
- Q2. How, if at all, do you see critical thinking contributing to your personal educational goals? How could the approach we used this semester be improved with respect to your own learning?
- Q3. How, if at all, did your team’s Piazza work contribute to your own critical thinking skills? For example—do you feel you are better now than in August at taking diverse points of view in reading and thinking; do you feel you are more skeptical about arguments and interpretations in books; are you just a more disgruntled person? (etc.)
- Q4. How did your own, and your team’s, Piazza practices change through the course of the semester, if at all?
- Q5. Please make any other comments you wish to!
-

to assess use of various Toulmin categories. We analyzed the structural complexity of the con arguments student teams produced through the semester. We also analyzed the quality of individual student posts to Piazza followup discussions, using the coding framework of Erduran et al. (2004), and the relationship between contribution of followup posts and course grades.

Results

We first describe self-reported experiences of the dialectical constructivist Piazza debate activity, drawing from the two surveys conducted during the semester. Students reported that the Piazza activity helped them structure their discussions and prepare for and engage in class. They felt the activity improved their critical thinking skills.

We turn then to behavior traces, to the arguments students constructed in these activities, including the role of Toulmin tags in helping students to structure their argumentation. We found that students primarily used only a subset of the Toulmin categories, and that their arguments showed some confusion about less frequently used categories. We also found that the con arguments students produced in the second half of the semester were more articulated than those they produced in the first half.

Finally, we analyzed followup discussion contributions of individual students, finding that these were in general good quality, and that the students who contributed more posts ended up with higher course grades. In anonymously attributing specific quoted statements, we refer to the fifteen students as P1 through P15.

Dialectical constructivism for developing critical thinking

Most students (10 of 14 in the first survey) felt positive about the pro-con debates. They reported that the debate format helped them structure their online discussion. Being assigned a pro-con position to develop arguments helped them think about issues more critically: *“having a predefined demarcation between the two sides in the debate contributes to structure, and that arbitrary assignment encourages greater mental flexibility and a better appreciation of the argument as a whole”* (P1).

One role the Piazza debates played in the students' learning was as a sort of warm up or preparatory exercise for the face-to-face in-class discussion. Nine of 14 students reported that constructing pro-con propositions in Piazza helped them to be more engaged in class: *“Piazza sets the stage for that day's discussions... [We] are able to prepare in advance and think about what they want to say in class that day”* (P14). Because of this advance preparation, the classroom discussions could be *“fast-pace and interactive”* (P6), could *“provide new or interesting points that complement the Piazza discussion”* (P1); *“classroom discussions definitely expand piazza points and further the arguments and analysis”* (P11). Indeed, students reported seeing the Piazza debate activity as a forum for initially working out arguments they expected to return to and develop further: *“I see that it is ok to post mere starting points as the real thoughtful discussion will follow [in class]”* (P2).

In the second survey, all 13 students reported having developed better critical thinking skills. They perceived themselves to be more motivated to think critically while evaluating arguments: *“It motivates you to read much deeper into the author's arguments to provide evidence and sound logical reasoning to support better either the con or pro position”*

(P9). Students reported challenging their own existing beliefs: “After reading *Upcycle*, I realized that I held the blatant assumption that you could only decrease how badly a product affected the environment was wrong” (P7). They reported building on their peers’ contributions in formulating their own arguments: “This method motivated me to think differently about reading a book, grasping its contents and restating them by providing me with the diverse viewpoints of my classmates” (P14).

Students reported that the dialectical constructivist activity motivated them to consider sources beyond the particular assigned book when analyzing an issue. “This learning approach motivated me to look for outside sources not just things from the book” (P8). Students also reported broader cognitive impacts of thinking critically: “I was able to see an issue from more than one perspective. This broadened my horizon as I realized there are more than one ways to approach a particular concept” (P14).

Toulmin tags for structuring arguments

Our re-appropriation of Piazza structured the students’ debate activity into pro argument (in the Piazza question pane), con arguments (in the Piazza students’ answer pane), and followup discussions. The pro and con arguments were further structured by being explicitly tagged with Toulmin categories (as in Table 1). For example, in the online debate for the book *The Upcycle*, the pro team proposed an argument, on behalf of McDonough and Braungart (2013) that a key insight to achieving sustainability in design is to focus on increasing positive consequences of designs, not (just) on reducing negative consequences. The warrant for this argument is that if we are pursuing the wrong goals we can never get a desirable outcome. Thus, if we focus on putting fewer pollutants into the air and soil, we merely slow down our own extinction, whereas if we make the soil and air cleaner than they were before, the earth may thrive.

1. [CLAIM] The only thing that stands between us and sustainability is our mindset. By thinking of “more good” rather than “less bad”, humanity will achieve environmental sustainability.
2. [WARRANT] Our mindset has a profound effect on our actions and potential.
3. [EVIDENCE FOR C1] Currently, we have the wrong attitude. We think in terms of “less bad”—less carbon released into the atmosphere, fewer pollutants into the soil, etc.
4. [EVIDENCE FOR C3] The Kyoto Protocols, arguably the most important international agreements on global warming, has declared its global warming goal: “to hold temperature increases to 2 degrees Celsius (3.6 degrees Fahrenheit)”. That’s not “prevent temperature increases” or “help improve the Earth”—that’s simply “be less bad”.
5. [SYNTHESIS OF C2 AND C4] The mindset of “less bad” prevents us from achieving anything more than zero-impact on the environment, which leads to lowered expectations and lowered efforts towards sustainability.
6. [EVIDENCE FOR C1] Instead of “less bad”, we should think in terms of “more good”. We should design everything to have a positive impact on the world, rather than a neutral one.
7. [EVIDENCE FOR C6] When McDonough designed the NASA Ames Research Center, he first considered his goals for the building, and then created a design. The resulting structure had 90 % less energy consumption than buildings of similar size, an

astronomically high figure that the NASA probably wouldn't have aspired to had it started with a "less bad" mindset. More importantly, the building had the kind of amenities that people appreciate (such as windows that open) that can only develop under a "more good" worldview.

8. [SYNTHESIS OF C3 AND C6] When our goal is "less bad", we impose an upper bound of a neutral impact. When our goal is "more good", we can escape that upper bound and accede to true sustainability, as well as comfort and people-friendly design.

In response, the con team argued that a more sound approach to sustainable design is to focus both on reducing negatives and on strengthening positives. The warrant they offered was that it is unrealistic to focus only on enhancing positives, and that some negative consequences are inescapable and must be managed.

The pro-con debate about *The Upcycle* was the final Piazza debate in the semester; the students were familiar with constructing dialectics. Early in the semester, arguments were often presented more generally. For example, the primary Claim identified by the pro team in the first Piazza activity was *The future of the working world looks positive given the technological advances likely to come and their ability to strengthen modern communities*. The future looking "positive" is rather vague as an outcome; the technological advances are not identified but are assumed to inevitably strengthen communities.

In the first survey 9 of 14 students considered Toulmin tags to be helpful specifically in focusing discussion and argumentation, *Tags greatly helped us be aware of what we are talking* (P3), and in guiding the construction and analysis of arguments: *I've found that the Toulmin tags have helped me to think my argument through logically in each post. Breaking it down into specific parts makes the argument easier to follow and understand for both the poster and readers/refuters* (P6). However, students also acknowledged that using the tags was an additional burden that they addressed because it was assigned to

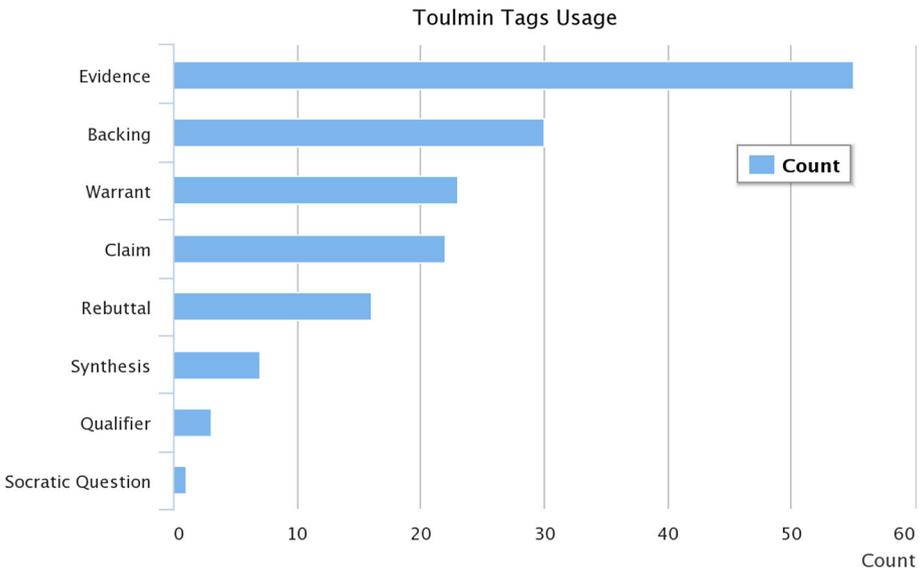


Fig. 2 Toulmin tags usage

them: *I think the various tags are fine in principle, but I know that we would not use them if we weren't forced to.* (P2).

Figure 2 presents a histogram of the overall frequencies with which students used the various tags throughout all of the Piazza discussions. Students made greatest use of concrete and fact oriented tags (Evidence and Backing); they made much less use of relatively more abstract tags (Qualifier and Synthesis). This could be due to a difference in transparency or utility of tags, thus, perhaps it is easier to see how to use fact-oriented tags, or perhaps they are more useful for what the students want to do. But it could also be because the more sophisticated concepts of qualification and synthesis were not emphasized enough in class. The only use of the Socratic Question tag occurred immediately after the instructor commented in one class that the tag had never been used.

We also noticed that students had characteristic difficulties using the tags. In the Toulmin system, Backing propositions provide support for Warrants, and Warrants explain how Evidence supports Claims. However, we observed that students often misused Backing to label support for Evidence, as illustrated below.

[CLAIM]—Big data has the ability to improve productivity and give companies the ability to maximize profit through deep data analysis

...

[EVIDENCE]—The movie Moneyball is all about how the Oakland Athletics baseball team shifted its methods from traditional opinionated scout and baseball analysis to data analysis based more on statistics than opinion.

1. [Rebuttal to P1] Technological advances will decrease face-to-face interaction, therefore worsening working environments.

2. [Evidence for C1] Communities will be more interactive, but only superficially. Genuine face-to-face interaction will decrease as technologies such as email become ubiquitous. Additionally, technology can isolate participants. *Blown to Bits* documents an instance of bullying over Facebook which provoked the suicide of a 13-year-old girl, Megan Meier (p16). While less extreme, many workplace emails come across as less courteous and pleasant than an equivalent face-to-face communication could have been.

3. [Rebuttal to P1] Technological advances can weaken modern communities because of new hazards and the need for regulation.

4. [Evidence for C3] Communities will be required to commit substantial resources to determining and enforcing appropriate regulations. For example, the presence of the Internet forces organizations to decide whether or not employees are allowed to use Facebook, and the enforcement of such decisions is often unpopular, unproductive, and ultimately futile. With billions of people on networks and massive amounts of data stored haphazardly, preventing crime and minimizing negligence will be no small feat.

5. [Rebuttal to P4] More connections do not imply quality connections. New technologies will diminish the quality of human connections and consequently the working environment.

(a)

1. [CLAIM] - The Internet has only accelerated the decline of a dying medium, while ushering in a new era of citizen journalism that will be beneficial for democracy everywhere.

2. [WARRANT] - Journalists should be free to report openly and honestly on any issue, which was not possible under the business model of traditional journalism; critical reporting will be possible in Internet journalism.

4. [BACKING FOR C2] - Open and critical journalism is crucial for a properly functioning democracy.

5. [BACKING FOR C2] - As stated by McChesney in *Digital Disconnect*, traditional journalism was already suffering from a conflict of interest caused by a broken business model. Advertising dollars and money provided by big business encouraged journalists to remain favorable, or at least neutral, when reporting on major companies.

5. [BACKING C2] - The Internet provides an open platform in which any citizen can contribute to national discourse and call attention to important topics.

(b)

Fig. 3 Tag usage for con positions: **a** an example from early in the semester; **b** an example from later

[BACKING]—This sabermetric approach resulted in a winning season that generated much revenue for the previously poor franchise.

In the pro argument above, the Backing proposition could be tagged as Warrant, or incorporated into the Evidence proposition, but it should not be tagged as Backing. These problems indicate that Toulmin's model itself presented some challenge to the students, and suggested simplifying the model to make it easier and more reliable for students to learn, while still helping them to explicitly articulate and structure their arguments.

Students were able to organize arguments with tags better later on in the semester, especially with respect to con positions. In the first three Piazza-based activities, students developing the con position often responded to the pro position point by point. For example, in Fig. 3a, the con position consists of a rebuttal to proposition P1 of the pro position (P1 is not shown), followed by an evidence statement supporting the rebuttal. Points 3 and 4 of the con position analogously present a counterpoint to proposition P1 and an evidence statement supporting the counterpoint. Point 5 of the con position is a rebuttal to P4 of the pro position (P4 also not shown). This point-by-point strategy is responsive to the pro position, but logically fragmented; it does not present a coherent con position as such, but rather *only* seeks to undermine the pro position. In the first three Piazza-based dialectical learning activities, all three of the con positions exemplified this point-by-point argument style.


[REDACTED] 1 year ago
 I agree that the quality of journalism has gone down and will continue to go down. But, because of new technologies such as social media, news and articles can be delivered much faster and to a broad range of citizens. While we used to get news from a long article, this can now be exposed in a short form tweet and elaborated in a link to a news article. I would argue that we are receiving much more news today and while the quality may be somewhat diminished, it is simply a shift that society will deal with like many other issues in this technological age. With so many more people able to produce news and journalism through blogs and social media, we now have a much larger basis of news contrary to the perception that is caused by the decline in newspapers and older news mediums.

[REDACTED] 1 year ago
 I believe that the overall quality of journalism hasn't gone down, rather the volume of words in the articles has been diminished. News quality may actually be higher quality than ever before since it is so much easier to find information about events. The propensity for news articles to create jobs has certainly decreased because of this information explosion, but it doesn't mean that our news is lower quality.


[REDACTED] 1 year ago
 I agree with Aaron that the overall quality of journalism isn't decreasing. In fact I believe that it is actually increasing. This is because we now have more technology available. With this, news agencies are able to acquire the latest stories more accurately and also at a faster pace. Even though there may be a decrease in jobs in the journalism sector, it should be noted that in any field, new technology always causes some jobs to be lost. However, the overall quality is not compromised.

(a)

[REDACTED] 1 year ago
 Some extra evidence for C7 in the Con section of this discussion. Interestingly enough, constant attachment to cellular devices can generate a disorder known as Nomophobia (which doesn't have anything to do with gnomes...despite its phonetic resemblance).
<http://www.wired.com/geekmom/2012/09/smartphone-stress-syndrome/>
 I find her message quite compelling and it resembles many of the solutions to similar issues that you will come to realize once you have read *The Shallows*.

(b)

Fig. 4 Anonymized examples of follow-up discussions: **a** a threaded followup discussion; **b** a followup discussion contribution citing an outside reference

In the latter three Piazza-based activities, a more autonomous con strategy emerged in which students stated an original con claim and then presented argumentation supporting that claim. In other words, students developed the con position as a self-standing argument, and not merely a point-by-point reply to the argument the pro team had presented. This is illustrated in Fig. 3b. Ten of the 11 con arguments constructed in the latter three Piazza-based activities exemplified this more coherent argument style. This strategy shift was student-initiated; the instructor did not suggest it, or point it out during the semester.

Followup discussions for adding perspectives

As reported above, the pro-con propositions and Toulmin tags helped students structure their arguments, and helped them prepare for better in-class face-to-face discussions. Students also made use of Piazza's "followup discussions" forum to continue developing or debating issues; in the first survey, 12 of 14 reported that followup discussions allowed them to elaborate the pro-con analysis: "*When posting follow-up posts I've found that I'm usually building upon the discussion by trying to bring something new to the table that supports one position or another*" (P6).

Students expressed support or disagreement with pro-con arguments in followup discussions, as illustrated in Fig. 4a. Students also elaborated the pro-con argumentation, often leveraging the hypertext linking affordance of online discussions to introduce further evidence, as in Fig. 4b. This seemed to be an emergent practice in the sense that it became more frequent through course of the semester. In the first three Piazza-based dialectical learning activities, students posted 27 followup discussion contributions, 5 of which included citation of external sources. But in the final three Piazza-based activities, students posted 24 followups, 10 of which explicitly referenced to external sources. This was student-initiated in that the instructor did not overtly refer to this practice during the semester.

We investigated followup discussion posts, adapting Erduran et al.'s (2004) analytical framework for assessing quality of Toulmin argumentation. We coded the 51 followup discussion posts using the four levels of Erduran's framework, defined in Table 5, and illustrated below.

Level 1: *As big data is used for trivial things like pop tarts placement ... we are given the free time for our creativity to run wild in a sense.* This claim was categorized as level 1 because the claim and the claim's relationship to evidence is unclear: the student seems to

Table 5 Analysis framework for assessing quality of follow-up discussion, adapted from Erduran et al. (2004)

Level 1	Argumentation consists of arguments that are a simple claim with weakly supporting data
Level 2	Argumentation has arguments consisting of one or more claims with data, warrants or backings but does not include counter-claims or rebuttals
Level 3	Argumentation has arguments including a series of claims or counter-claims with either data, warrants or backings with the occasional weak rebuttal. The whole argument is less structured and some parts of the argument need elaboration to make it stronger
Level 4	Argumentation shows arguments with a claim with a clearly identifiable rebuttal position and well structured. Such an argument may have several claims and counter-claims

be arguing that *because* big data is (sometimes) used for trivial things (like determining product placement on store shelves), human creativity can be engaged (though perhaps not productively directed, cf. “run wild”). The logical connection between the two propositions is not compelling; it isn’t really clear what the claim or evidence is.

Level 2: “*I can see one day in the future when small businesses will have access to big data. I believe that this is a positive thing because these businesses will be able to obtain vast amounts of information about their target markets and thus be able to more efficiently plan their business operations.*” The argument is articulated to the extent that the author explicitly describes how big data could strengthen businesses by helping them better understand markets, adjust operations, serve customers, and increase profits. However, the student did not consider possible complication, downsides, and rebuttals, for example, new challenges for businesses in managing customer data security, or emerging and conflicting conceptions of the ownership of customer information, including the possibility that businesses might have to pay for this information in the future.

Level 3: “*The attitude towards sustainability seems like a great idea, but it is very unrealistic as money seems to run the world. As long as companies are making money, there is no need for them to change their methods. So the only way to shift from the idea of less bad and more good is to make ‘more good’ also come with ‘more money’.*” This argument analyzes the economics of managing waste. It acknowledges that sustainable approaches are a “great idea”, but argues that they will not be adopted until it is proven that they are cost effective, that doing more good yields more money. The student acknowledged the tension between sustainability and economic profit, but did not analyze it very deeply. For example, the argument might have articulated the tension between short-term and longer-term value creation and planning horizons.

Level 4: “*Advances in technology will make it more convenient to store information than to memorize it, so humans in general will probably become worse at memorizing and then recalling information. However, that is not necessarily a negative development. ... before writing, all information was stored orally, in memory.... The gas burner is better than I am at starting a fire and keeping it alight. Similarly, the Internet is better than I am at remembering things. Why wouldn’t I take advantage of that so that I could pursue more interesting activities than memorization?*” This was categorized as a level 4 argument because it states and cites evidence for a clear claim that is explicitly related to a rebuttal position (in this case, drawn from one of the books). The student explicitly states the argument from *The Shallows* that Internet technology could change life in ways that ultimately undermines certain human capabilities, such as “*memorizing and then recalling information*”. The student then develops the argument that such undermining of specific skills is not necessarily a bad thing, citing as precedent how the invention of writing and printing undermined oral skills, and how, in general, humans delegate lower level functions, such as starting a fire, to technological tools. Finally, the argument suggests that rote memorization and recall is an example of a lower level skill, and that delegating it to the Internet can free people to “*pursue more interesting activities.*”

Erduran et al. (2004) reported high inter-rater reliability for this coding scheme (>0.8). One of the authors (who did not know the students in the class) coded the 51 followup posts that students contributed into the four Erduran categories. Thirty-eight followup discussion posts were coded as level 3 or 4 (Table 5). This is encouraging, since the followup discussion posts were contributed individually by students and not explicitly scaffolded by the pro-con debate structure, or by the use of Toulmin tags.

Although contributing followup posts and the quality of posts with respect to Erduran et al.’s (2004) framework were not bases for course grades, we found that number and

Table 6 The number of posted piazza follow-up discussions by A and B Students

Grade	# Students	# Posts	Avg. level	Std.
A	9	39	3.13	2.5
B	6	12	2.08	2.0
Overall	15	51	2.88	0.91

quality of posts differentiated students by course grade. Nine students received some sort of A grade in this course, and 6 received some sort of B. “A” students posted more than twice as frequently as “B” students ($t(49) = 2.94, p < 0.010$), and their posts were a whole level higher in average quality than “B” student posts (3.13 vs. 2.08, $t(18.46) = -3.98, p < 0.001$). Table 6 summarizes these results. This is an encouraging pattern for connecting course outcomes to dialectical constructivist student behaviors.

Discussion

Our first research question was how dialectical analysis of issues into pro and con positions backed by evidence could engage students and help them to develop critical thinking skills. Students found the Piazza debate activity engaging and beneficial with respect learning and practicing critical thinking skills. They reported that this dialectical learning activity helped them to have better discussions with their team members, and to better prepare for class. They gained appreciation for critical thinking as a way of learning.

Students reported that they felt their own critical thinking skills improved through participation in this activity. Consistent with this self-report, we observed that student teams used a more sophisticated strategy for con arguments in the second half of the semester, developing more self-coherent arguments, and not merely responding point-by-point to pro positions. Students were able to use the tags as a cognitive scaffold to produce fairly complex arguments. Our analysis of individual argumentation (that is, in Piazza’s followup discussion forum) emphasized that students were able to create coherent and dialectical analyses (that is, including tradeoffs and rebuttal arguments), often adducing evidence outside the course materials to followup discussion arguments.

The instructor of this course, who had taught the course several times before, and had been trying to incorporate more critical thinking into the course, also felt that this activity caused much more dialectical interaction in the class meetings than in previous years. Critical thinking also became more of an explicit topic, talked about by the students with the instructor and among themselves. These initial results are encouraging, but of course limited; they need to be replicated and extended beyond our single class and instructor.

We observed that while students made good use of the relatively concrete Evidence and Backing tags, they rarely used the more abstract and logical sophisticated Synthesis and Qualifier tags. We also noted some misuse of tags (e.g., Backing and Warrants). One immediate direction for further investigation is whether the tag system could be simplified and be as or more effective as a scaffold for creating arguments. For example, it may be that students initially would benefit from articulating Claims, Evidence, and Rebuttals, and, at least initially, not focus on separately articulating *how* Evidence supports Claims (i.e., Warrants), or the evidence for assumptions about how Evidence supports Claims (i.e., Backing).

Our second research question was how Piazza could be re-appropriated for dialectical constructivist learning, and how it could serve as a research prototype to enable design investigation of technology support for dialectical constructivist learning. Our re-appropriation of Piazza as a prototyping medium for this project was successful in the sense that the dialectical learning activity we created engaged and benefitted the students.

Piazza also functioned as a design research prototype. We described earlier how pro-con arguments can be initiated by identifying either the pro or con position, but that question-answer dialogs are always initiated with a question. Identifying this contrast led us to imagine a design different from Piazza, in which pro and con propositions could be posted in any order.

Observing and interacting with students using Piazza through the semester helped us identify further design issues: A key feature of our intervention was to articulate pro and con positions through the re-appropriation of Piazza's question and answer panes. This was useful and effective, but working with the vertical alignment of these panes (Fig. 1) helped us to imagine concretely the possibility of horizontally aligning pro and con panes, so that students could, for example, see at a glance whether each pro proposition had a corresponding con proposition.

We observed that our students developed fairly complex pro and con statements, possibly more complex than the succinct questions and answers typically associated with Piazza (Vivian et al. 2013). Students reported using other tools, such as Google docs, to coordinate development of their pro-con positions. This led us to imagine providing better synchronization support for text panes, and an integrated chat tool so that students could directly negotiate their teamwork.

These experiences with Piazza helped us to conceive of a new technology design to support the dialectical learning activity, shown in Fig. 5. This design supports concurrent editing interactions, it allows pro and con claims to be created in any order, it aligns corresponding pro and con claims horizontally so their relationship can be seen at a glance, and it adopts simplified Toulmin categories (pro claim, con claim, and evidence/backing for claims) that are indicated graphically instead of through textual tagging. It also incorporates a chat tool (not shown in the figure). We plan to study this Critical Thinker prototype in a future offering of the freshman seminar, but here we emphasize that we were able to develop this design specifically through the guidance that Piazza provided as a re-appropriated prototype.

An important direction for this research is to explore how pro-con analysis, and other dialectical constructivist learning activities, can be developed in other course contexts. We studied an introductory information science and technology course, but many other courses in that curriculum teach design rationales, in which technical artifacts are analyzed with respect to issues, design alternatives, decision criteria and tradeoffs, weights of supporting evidence, and so forth (Burge et al. 2008; Moran and Carroll 1996; Wang and Hannafin 2005). These rationales are similar to pro-con dialectics. Thus, one could imagine courses in programming, information design, and usability engineering, among others, adopting dialectical learning approaches analogous to the one described here.

Pro

Con

+ Add a Pro & Con pair ...

The developing technologies of the modern era will help create stronger and more interactive communities that lead to an even more connected job network.

Technological advances will decrease face-to-face interaction, therefore worsening working environments.

^ +

^ +

Communities are an integral part of the work environment as they foster idea-sharing development and appeal to humans' innate need for social interaction.

Communities will be more interactive, but only superficially. Genuine face-to-face interaction will decrease as technologies such as email become ubiquitous. Additionally, technology can isolate participants.

Technological advances will weaken modern communities by greatly magnifying workers' stress.

^ +

^ +

Technological advances, especially in terms of smartphones and social media, allow for more efficient and mobile communication and connection in the working world.

Technological advances such as smartphones do indeed lead to more connections and more availability for every worker. However, 24/7 availability does not lead to more job satisfaction or a stronger community.

Fig. 5 Screen shot from current Critical Thinker prototype. Reasons are graphically embedded under pro and con claims, emphasizing their rhetorical relationships. Corresponding pro and con claims are aligned horizontally, making it easier to see this relationship at a glance

Conclusion

This exploratory study re-appropriated Piazza, a commercial question–answer system, to investigate dialectical constructivist learning activities in a freshman honor seminar in information science. Students reported and demonstrated benefits in their ability to create dialectical analyses of technical material and to enact critical thinking. The Piazza prototype helped to identify and articulate several design issues for supporting the learning activity, and helped to inform the design of a subsequent prototype. This study demonstrated how freely available software, like Piazza, can be re-purposed to support advanced educational objectives, like dialectical constructivist learning.

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