Intern. J. Comput.-Support. Collab. Learn (2017) 12:9–33
DOI 10.1007/s11412-017-9250-1

# A more reflective form of joint problem solving

**Richard Alterman**[1] · **Kendall Harsch**[1]

Received: 30 September 2016 / Accepted: 22 February 2017 / Published online: 7 March 2017


**Abstract** This paper explores the emergence of joint problem solving in online environments where the participants work together but at different times and from different places. Collaborations of this sort have been referred to as loosely coupled collaborations. The focus is on *venue* which is the virtual substitute for physical copresence under these conditions. Venue is fundamentally a social construct. It functions to "localize" participation dynamics, communication and register, the creation and sharing of domain objects, and situation-dependent knowledge. Within venue, the reflective parts of joint problem solving become more prominent. Within venue, small teams of students align their views, coordinate their efforts, share their understanding and work, and jointly problem solve.

**Keywords** Different time and place collaboration · Joint problem solving · Loosely coupled collaboration · Venue

## Introduction

The initial conception of a face-to-face joint problem space has the participants in the same physical space in front of a simulator, working together step-by-step, managing their understanding and action so as to jointly converge on the correct understanding of a concept or method or technique (Teasley and Roschelle 1993; Roschelle 1992). By collaborating with one another, the learners can leverage differences in viewpoint and skill to make greater

✉ Richard Alterman
ralterma@brandeis.edu

[1] Computer Science Department, Volen Center for Complex Systems, Brandeis University, 415 South Street, Waltham, MA, 02453, USA

individual progress and construct deeper and more accurate understandings (Dillenbourg 1999; Stahl 2006).

For the collaborations investigated in this paper, the participants work in a more open space, where the here-and-now composition of physical copresence, which undergirds communication and coordination in a face-to-face collaboration, is no longer available. The learners must create out of whole cloth a point of collaboration in a virtual locale – a *venue* – to anchor periodic close joint attention. A patchwork of interactions occurring within a venue are sufficient for the participants to manage their collaboration and jointly make sense of significant elements of their assigned tasks.

In the case study, the students work as a team to complete four online collaborative writing assignments, alternating between wiki- and blog-site. Their main task is to improve their understanding of the assigned reading and complete the required writing. At issue is the kind of joint problem solving process that can develop for managing the collaboration/tasks. Because of the costs of online communication and coordination, the learners are more selective about the problems they choose to jointly solve. The balance of contributions and reflections are different than for joint problem solving when copresent. There is a shift in joint problem solving towards a more reflective form of collaboration.

The virtual learners "localize" into a venue their work for different kinds of joint problem solving. Several different venues are operative simultaneously during the online collaboration. Venues can be of different types. For the wiki-based assignments, two types of venue were created; for the blog-based assignments, there was a single kind of venue.

A review of the literature develops the notion of close collaboration in learning. The idea of venue is presented in contrast to affordance and place. The previous work on wiki- and blog-based writing is used to further develop the notion of venue. The focus of the case study is on a detailed qualitative analysis of the online direct communication among the learners. Three selections of transcript from the data that was collected – two from the wiki and one from the blog – are used to illustrate the in-depth analysis.

## Close collaboration in learning

Suppose two students are standing in front of a whiteboard collaborating on a proof in number theory. The participants are collocated, and their interaction is contemporaneous and simultaneous. They take turns talking and writing, jointly attending to the shared externalization of their individual thinking (Whittaker et al. 1991; Tang 1991). Their activity is a collaboration because the students have a common goal and their learning results from an interaction where the contributions, prior knowledge, and status of the participants is relatively balanced (Dillenbourg 1999).

Because the students work closely together, they are in a joint problem space (JPS) (Teasley and Roschelle 1993). The learners "make a conscious, continued effort to coordinate their language and activity with respect to shared knowledge" (p. 26). The "students' work is based on a shared conception of the task." One part of the JPS is the problem solving task. A second part of it is the infrastructure work they do to maintain the collaboration as they work together, creating and sharing knowledge, monitoring their progress, and repairing breakdowns that impede the progress of the collaboration (Roschelle and Teasley 1995). The participants "simultaneously attend to and develop" content and relational spaces (Barron 2003). In the content space they reason out the logic of their proof based on their developing understanding of number theory. In the relational space, they manage the dynamics of their interpersonal relationship as they collaborate,

There are many interacting elements of a small group collaboration of this sort that contribute to structure and flow of joint problem solving (Stahl 2006): the social situation (Goffman 1964); the availability and affordances of the tools, technology, and knowledge objects that are available and in use (Suthers 2006); the communication channel and the linguistic context (Hymes 1964); the social regulation of the collaboration; (Järvelä and Hadwin 2013); the organization, guidelines, deadlines, and requirements of the learning activity as they are spelled out in the assignment; and elements of identity, role, and ownership (Cameron and Anderson 2006).

## Copresence in a close collaboration

Copresent actors perceive they are present with each other and that they are paying attention to each other (p.17: Goffman, 1963; Nowak, 2001):

> . . . persons must sense that they are close enough to be perceived in whatever they are doing, including their experiencing of others, and close enough to be perceived in this sensing of being perceived.

Statements like "Did you see/hear/smell/taste/feel that?" show that copresence can be established by the participants in any of the five sensory modalities.

Physical copresence is the rudiment of a social situation, and spatial and temporal proximity are the constitutive elements of physical copresence. As it occurs in physical time, the sequence and position of each verbal contribution is the basis of achieving reciprocal understanding (Clark and Brennan 1991; Schegloff 1992) and mutual knowledge (Clark and Marshall 2002). The spatial location of shared physical objects, the orientation of the participants to each other in relation to those objects in physical space, and the collective management of territory – literally the stance of the participants (Goodwin 2007) – play a significant role in the interpersonal communication and collaboration of the participants (Kruger et al. 2004; Scott et al. 2004).

Various studies have shown that it is more difficult to regulate conversation, agreements are harder to achieve, and interpersonal considerations are reduced in a virtual collaboration (Wainfan and Davis 2004). The two examples discussed below demonstrate some of the difficulties. The first example shows that without copresence, mutual knowledge becomes problematic. The second example, joint attention, is focused on the complexity of co-referencing shared domain objects in virtual environments.

To illustrate the relationship between copresence and mutual knowledge, imagine two people, Abbi and Benedict, are sitting across from each other at a table and there is a candle between them (Clark and Marshall 2002). Abbi and Benedict mutually know the candle is between them because they use the copresence heuristic. The cognitive assumptions that underly physical copresence include temporal and spatial elements of the physical context and the cognitive features of how individuals operate under such conditions. Thus, because Abbi and Benedict are rational and can see each other simultaneously attending to the candle between them, it is mutual knowledge that it is between them. Suppose Abbi and Benedict are connected via a video chat link. They are both still rational but the video chat link makes uncertain whether both participants are reciprocally attending to the candle.

In a virtual environment, mutual knowledge can be differentiated into levels (Dillenbourg et al. 1996). One participant can reason that another participant had access to the a piece of information (level 1), perceived that information (level 2), understood that information (level 3), or is in agreement that the information is mutually known (level 4). For Abbi and

Benedict, because the copresence heuristic is no longer operative, they can only reason that they are at level 1 with a high degree of certainty.

Joint attention depends on the ability to point to and verbally describe local objects of interest with mutual gaze information playing a significant role in monitoring the attention of collaborators (Schneider and Pea 2013). Two collaborators, Brunhilda and Egon, are working in front of a whiteboard. Brunhilda can point to something on the whiteboard and she can see whether Egon is attending to the object she is pointing to. If partner Egon does look at the object she is pointing to, Brunhilda and Egon are jointly attending to the same object. In a virtual environment, how does Brunhilda know Egon is attending to what Brunhilda is pointing to?

In the work on Virtual Math Team (VMT), teams of students are working together to learn Euclidean geometry at the same time but from different places (Stahl 2009). The learners share a virtual whiteboard and chatroom. In one of the VMT transcripts, in order to establish a co-reference to a diagram on the whiteboard one student says "wait – can someone highlight the hexagonal array on the diagram? i don't really see what you mean ..." (Stahl et al. 2011). In another segment of chat, when one learner asks "How do you color lines?", another participant describes the location of the paintbrush on the shared whiteboard. Highlighting makes things stand out, but being able to highlight entails learning. Adding pointers might seem to be a simple solution to this kind of problem, but pointers introduce additional complications (Greenberg et al. 1992) concerning issues like floor control of a single pointer or the effective management of multiple pointers. The point is that in a virtual environment being able to point to a shared domain object requires more work to achieve, and thus it introduces a bias among the participants to try to work together with a reduction in close collaboration.

Because of the increased costs of creating common knowledge and jointly attending to the same object – which are two of the mainstays of close collaboration – there is an incentive to try to achieve collaborative goals with reduced amounts of sharing. The participants still need to work together, but the coupling is looser because of the reduction in common ground.

## Venue

The term *venue* will be used to describe a virtual substitute for the copresence that exists in face-to-face encounters, where actors are reciprocally aware of each other as participants in a social situation. A collaborative project on a single platform will have multiple open venues during the period of joint action.

Venue is fundamentally a social construct that establishes a channel of communication; the spatial and temporal properties of venue are largely derived from the affordances of the technology. The close joint problem solving the virtual collaborators do occurs within a venue. Each venue provides a linguistic context and a style of collaboration. It is easier to refer to things within a venue than to things outside of it. The participants "recognize" each other as collaborators. Facts are more likely to be common knowledge amongst the collaborators within the venue than across venues.

Social technology like wiki and blogging sites provide conditions, affordances, and constraints on the joint problem solving (Suthers 2006), but the technology is not the whole story on how the collaboration works for the learners. The use of the technology is embedded in a larger context.

Suppose collaborators have have access to two modes of interaction: a shared display and a MOO environment – a MOO environment is a multi-player chat-based one virtual

environment – that includes a chat function (Dillenbourg and Traum 2006). How does the shared display function with regards to mutual understanding? Either the whiteboard complements the use of the chat, vice versa, or both. All three are a possibility given the affordances of the technology. Which one becomes the dominant method of communication depends on factors in addition to the affordances of the technology. A venue is not the same thing as the affordance of the technology.

A venue has some place-like properties. Place is rooted in "sets of mutually-held, and mutually available, cultural understandings about behavior [sic] and action" (Harrison and Tatar 2008; Harrison and Dourish 1996). One does not sing or dance while presenting a paper at a conference. It is ok to be in the front room of your home looking out but not on the outside peering into the front room of somebody else's home. It would be odd to wear a bathing suit to the opera. In each of these cases, the circumstances are unexpected because the location, the place, does not provide the "appropriate behavioral framing" for the action.

Within the behavioral framing of a venue, the collaborators do have expectations about the range of topics discussed, likely participants, and alternate roles available in a venue of a particular type. The balance of primary and secondary participation for joint problem solving in a venue is different than how place functions in the natural world. A primary participant makes contributions to the collaboration, and a secondary one only observes it. Online, there is a shift to a more reflective form of collaboration from the more action-oriented collaboration that existed with physical copresence. Because the learners are never working together at the same time, their interaction is always mediated by texts that record in some kind of format the contributions of others. Thus the available context for action versus review/reflection are the same, and the line between reading in a venue the most recent contribution and reading a set of older contributions is blurred.

*Wiki Writing*

The construction of a Wikipedia article is a significant example of how a lot of small contributions from people can add up to a significant contribution of some sort (Shirky 2008). Articles are created from hundreds of contributors (if not more) who make a small number of edits to the wikitext page. Co-editors of a wiki article can collaborate by discussing issues on a talk page or by editing the wikitext page. Despite the fact that a preponderance of the edits can be small, the article can be substantial. Especially in the early days, the construction of a Wikipedia article was relatively unmanaged.

In practice, the conditions of wiki writing in an open community and closed one like a blended class are completely different: the technology base and affordance are the same, but different venues will be created. A Wikipedia article "writes itself" because of the long tail of the Internet. There are enough contributors in the whole wide world connected by the net for a collection of individuals to altruistically produce a quality argument (Shirky 2008). In the closed environment, individual performance, getting a good grade, is what motivates work for most students; minimizing effort is another.

The wikitext page is a "shared artifact, where people have access to the contributions of others, where they can locate their own contributions, . . . " (Cress 2013, p.417). Consecutive contributions to the wikitext are not necessarily about the same topic nor directly relevant to each other. One kind of contribution adds new information to an article without modifying the existing information or article structure (external assimilation); a second requires modification to the information or structure of the article (external accomodation) (Cress and Kimmerle 2008). Learner participation is increased when there is at least some partial

development of the article (Kimmerle et al. 2011). Other factors that increase participation are when there is some overlap and/or conflict between what the contributor knows and the information contained in the article (Moskaliuk et al. 2012; 2009).

Changes to the article are broadcast and not directed at one particular current or future participant. This is not like the close collaboration of the two students working on a proof in number theory who must negotiate and reach common understandings to make joint progress. On the wikitext page, there is less evidence available that one participant has understood satisfactorily the contribution or position of another.

For the data collected in the case study, there are regular occasions where it is more effective and efficient for the learners to directly address one another in order to develop a common understanding of some portion of the assigned reading or decide on the best way to organize the participants' collaborative work and writing. Direct comparisons of viewpoint and negotiation enable the learners to align their views and thereby improve learning and make more rapid progress with their assigned tasks.

The results were mixed in a study by Forte and Bruckman (2007) of secondary students doing wiki writing in a closed class with a fixed number of students. Most of the problems for the leaners revolved around questions of coordination and ownership. Progress was slow when the students disagreed or when they tried to recover from errors. The students experienced frustration, were socially unprepared to use in the wiki in a collaborative fashion, and preferred to work independently.

Several options exist for improved coordination for wiki-based work. One feature of wikis is that they can be easily pre-formated for a variety and range of collaborative learning activities (Larusson and Alterman 2009). An alternate scheme is to have the instructor assign roles that make the duties and responsibilities of each student more explicit: students tend to take responsibility and enact their assigned roles, focusing their participation on more constructive and productive activities (Cesareni et al. 2016; Soller 2001).

Without a pre-defined structure for collaboration and/or assigned roles, the students must be self-organizing: the participants can engage in joint problem solving in order to divide their labor and manage commitments (Järvelä and Hadwin 2013). As a by-product of their deliberations, they can choose to configure the network of wiki pages themselves to simplify their work (Larusson and Alterman 2009). Roles could also emerge (Yeh 2010); however, whether or not the emergent roles best serve the collaboration and learning of the group is an open question (Mercier et al. 2014).

Each of these approaches to organizing work on the wiki will result in some fundamental differences in the kinds of venues that emerge among the participants.

*Blog writing*

In an educational setting, there are a variety of uses of blogs (Sim and Hew 2010). For example, students can use a blog environment to participate in a knowledge community, to collaborate as they do their homework, or to share reflections and personal feelings.

Student blogging functions like a discourse community (Brown et al. 1993; Wertsch 1991). Students write posts that they share with the rest of the community. After the posts are shared, other learners can read and comment back-and-forth on each other's contribution. Drafting is a example of a strategy that can add more collaboration to the mix for student blogging: students post a draft of their work for a first deadline and then can comment on each other's drafts while they revise their initial post until the final deadline (Alterman and Gunnarsson 2013). The collection of posts, and the discussions attached to them, is a repository of accumulated knowledge within a community (Oravec 2002; Williams and

Jacobs 2004); as such, it can used to support other kinds of learning activities like writing essays (Alterman and Larusson 2010). or project work (Alterman and Gunnarsson 2013).

On a blog-platform, each learner controls their own set of posts; contrast that to wiki-writing where there is a single knowledge object, the wikitext, which is owned equally by all the participants. As an author of their own work, the students convey content from their point of view in their own style and voice (Cameron and Anderson 2006). Each blog post simultaneously maintains relevance to the course material while "retaining the self-directed, internal focus of the owner". The primacy of identity and ownership in blog-based collaborative writing is in marked contrast to the more collective nature of wiki-based collaborative writing.

In a blog environment, students spend more time reading than discussing each other's contributions (Deng and Yuen 2011). Students perceive reading each other's posts as very helpful for understanding the course content (Ellison and Wu 2008). Based on their reading of each other's posts, students can promote content by giving thumps-up or merit badges. Promoted content is of significantly higher quality than content that is not promoted, content that is repeatedly promoted is of higher quality than content that has fewer promotions, and good and poor promoters can be identified (Gunnarsson and Alterman 2014).

Blogging is more loosely coupled than wiki-based writing (Alterman and Larusson 2013). Each blog is a different viewpoint on the learning activity. By reading and discussing each other's work, the students converge on some understandings of the course material. The students create common knowledge as a result of their blogging activity but the degree of certainty (Lee 2001) is less than the near 100% certainty of Clark and Marshall (2002) notion of mutual knowledge.

The venues created for blog-based collaborative writing will vary depending on other conditions and regulations that are attached to the task in which the collaborators engage. Whether the blog is open or a closed community, the purpose of the assignment, details on the organization of each post, whether the learners are organized into small teams that also work together on other assignments, and the requirements and deadlines for the assigned work are examples of factors that influence the formation of venue.

## Case study

The data for the case study comes from a one-semester class of 116 students, mostly undergraduates from a variety of majors, in a course on Internet & Society. The students were assigned four books to read during the semester. The students were given one collaborative writing assignment per book to be completed on the class website working in small groups. Each student created a pseudonym when they first logged into the system and was randomly assigned a team to work with throughout the semester; the use of pseudonyms allowed the student to remain anonymous. There were 19 small teams of students, ranging in size from five to seven students. Each team completed four collaborative writing projects during the semester, alternating between wiki-based and blog-based collaborative writing.

The primary data material includes automatically collected transcripts from the 19 student groups across each of the platforms; the transcripts contained over 7,000 lines of chat (100,000 words). The in-depth analysis of communication within each team was the primary form of analysis. An event log file of student activity was also available; these data could be accessed using database queries, thus it was also possible to produce of some of the students' online activity. Each visit to a wiki or text page, post, or conversation was used as a measure of student reading (e.g., Gunnarsson and Alterman, 2013).

**Wiki-based** For the first and third books, the collaborative writing was wiki-based. Each student was responsible for a 500-word summary of one chapter of the book, and the group as a whole was responsible for a 1,000-word summary of the main argument of the book. In addition to being responsible for a chapter summary, each student was assigned the role of discussant on a different chapter and editor on a third. Contributions made to the book review text were made via the wikitext. Each team also had a single discussion space, which is also referred to as a talk page. For the case study, the talk page was like a Google Doc in the following sense: any point in the document could be an insertion point for a new contribution to the discussion. The students could mark a new topic with a heading and separate a topic from other topics of discussion by blank space. Available to the students was a list, in chronological order, of prior contributions to the wikitext.

**Blog-based** For the second and fourth books, the interaction was blog-based. The assignment for the blog-based collaboration was to write a 1,000-word editorial about an issue raised in the book. The students were required to include a quote, demonstrate understanding, include a concrete example, have an opinion, and make a persuasive argument. There were no assigned roles.

The assignment was broken into two phases: a draft phase and a comment phase, each lasting roughly one week (Alterman and Larusson 2013). During the draft phase, students were required to complete a first (reasonable) draft of their the assignment without the benefit of access to the work of teammates. At the end of the draft phase, the drafts became available to other members of the team. During the comment phase, students were required to comment on the posts of at least two teammates while reworking their own drafts. Students were graded on the quality of their final post and their participation as commenters.

## Methodology

The methods were chosen so that the researchers would examine closely the actual online interaction amongst the participants in the context in which it was occurring, looking for some simple examples and patterns of how students share problems without marginalizing the noisy parts of the data. Studies like Latour (1987) and Lave (1988), and Barker and Wright (1954) show how practice, cognition, and behavior inextricably depend on context.

The general focus is on how the participants manage their joint problem solving in a virtual different time and place collaboration space. For field data, the temptation to preselect some data as central and to marginalize other data should be resisted. Selecting rigorous categories entails abstraction which hides the complexity and messiness of the field data (Garfinkel 1994). The methodological goal is to generate a "noisy" theory that captures the context, complexity, and uncertainty of collaboration in an online different time and place environment. (Shweder 1990, p. 10):

> The implication, of course, is that genuine success for psychological science will come when we stop trying to get beyond the "noise" and start trying to say interesting things about some of the more interesting robust and patterned varieties of it.

Shweder was a cultural psychologist who was interested in producing psychological science, but the general thrust of his argument holds here. Analysis that depends too heavily on coding schemes hide some of the complexity of field data where there is a a lot of noise. The goal here is to stay in the weeds with the analysis and have a noisy theory.

The data records the activities of students engaged in uncertain collaborations. There are two sources of uncertainty for the participants. The first is due to the improvisational nature

of work: "... the organization of work is a complex, ongoing interaction of people with each other and with technologies that are available to them" (Suchman and Trigg 1991). The interaction amongst the students as they improvise their online work fits Sawyer's criteria of *collaborative emergence* (Sawyer 2013): the learning activities were unpredictable; actions were contingent on prior ones; the interactional effect of any given action could be changed by subsequent actions of other participants; and the process was collaborative, with each participant potentially contributing equally.

The other source of uncertainty results from the lack of physical copresence, which make factors that contribute to the formation of any social situation more problematic: factors like communication, the lack of immediacy in establishing reciprocity, and limits on the capability of the participants to co-monitor their shared situation.

The analysis induces some functional specifications of how the collaborative interaction works (Sawyer 2013; Suchman and Trigg 1991; Jordan and Henderson 1995). Inductive analysis of this sort can be characterized by three phases (Ten Have 2007, p. 40:):

1. establishing a regular pattern of (inter)action;
2. describing the normative orientations of participants, as demonstrated in "deviant cases"; and
3. providing a function specification of the organization, discovered in 1 and 2, in the wider matrix of interaction.

There were several iterations through the three phases with different questions to investigate, on different mixes of old and new samples of data. Recurrent patterns of interaction were identified as well as those that seemed to deviate from the script. As the analysis continued new questions emerged, which resulted in additional loops through the data. As the work progressed, functional specifications were produced, explored, and reworked.

Prior to the analysis of the data, all of the work of the students had been double-graded by the several teaching assistants for the class. On the wiki assignments, both the overall quality of the review and the quality of each chapter summary were assessed. The teaching assistants shared comments on the dynamics of each group's collaboration. Students with low participation were identified. The blog-based assignments were also double-graded. The grades of each student and the average grade of each team were computed. The feedback from the teaching assistants included an assessment of the quality of the editorial post that each student wrote and the quality of the comments they wrote on their teammates' posts. At the beginning of each grading period, the instructor would meet with the teaching assistants to discuss grading. The head teaching assistant oversaw all the grading, was familiar in detail with the work of all the students and their teams, and is a co-author on this paper.

The qualitative analysis sampled the data, and each sample included the complete transcript of an individual team working on an individual assignment for the wiki work, or the complete team discussion of an individual student's contribution for the blog-based collaborations. Initially a random mix of poor, good, and average groups was selected; the criteria of poor, good, or average was based on the double-gradings of each assignment. New examples were added to the mix on a regular basis. The analysis regularly switched back and forth between data collected from the wiki platform and data collected from the blog-platform. Sometimes the analysts worked in a joint session. Other times they worked individually before comparing their analyses.

The focus was on the talk amongst members of each team as the did their work. Early on it became obvious that because of the distributed nature of the interaction, the agreements on problems to solve were largely assumed; those commitments lacked the near certainty of grounded propositions in a face-to-face conversation (Clark and Brennan 1991). More

often than not an uptake was the only evidence available to the participants (uptake: Suthers et al., 2010). Given the lack of copresence and practice, the students improvised and scavenged to continue the cooperation, and used weaker forms of commitment to make progress. Although the focus was on the talk, the analysis included other contextual elements. Factors like the timeliness of work, the time between relevant contributions, and the layout of comments on the talk page for wiki work were other parts of the context that were subject to examination.

Both new questions and refinements of old questions were part of the development of the analysis. A sample of the kinds of topics that emerged is as follows:

1. What is the difference between face-to-face joint problem solving and the collaborative tasks done on two alternate different time and place platforms?
2. How did the students deal with the lack of copresence?
3. Online how were joint problems established? Once a joint problem was established, how did talk continue?
4. How did collaborative talk on the two platforms differ?
5. Within a platform, were there alternate points of collaboration? How did they differ?

Towards the end of the analysis, some sorting exercises were done where the analysts tried to sort interchanges (uptakes) by the objective of the problem that was created. We cut out snippets of conversation and organized them into piles. Sometimes we did this bottom up, trying to identify a common problem solving objective. Other times we did this top-down, trying to sort the snippets into categories we identified. At the most abstract level, the snippets were organized into two piles:

i. The problem has a *content objective*, if the focus is on the assigned reading or if it is a discussion of how to do the writing task.
ii. The problem has a *infrastructure objective*, if it refers to coordination between teammates or a requirement of the assignment.

At the end, one of the authors went through the entire data set and did a sorting of each uptake into one of four categories (discussed below). Although not central to the argument, this exercise gave the analysts some feel for obvious trends in the data.

## Venues and problematization

Learners convert a lengthy assignment into a set of tasks to be either individually or jointly problem-solved. It is not a given that everything that is problematic in the assignment is converted into a problem to be jointly worked on. Some problems are handled individually. Other problems are proposed for joint consideration but are not taken up by another student. Because of the distributed nature of the collaboration, a JPS that is created remains open throughout the assignment period.

Within a problem space and venue, problems are identified and collaboratively opened by the participants. A proposal for collaboration with a particular objective is made by one of the participants who has identified a problem that could be handled collaboratively. A second participant accepts the proposed project with a relevant contribution. An "uptake is the relationship present when the participants' coordination takes aspects of prior or ongoing events as having relevance for an ongoing activity" (Suthers et al. 2010). The uptake of a previous contribution to the discussion "transforms that taken-up object by foregrounding and interpreting aspects of the object as relevant for ongoing activity." Together the

proposal and initial uptake constitute a problematization of some part of the collaboration. Thereafter, the problem is one in which the participants are jointly responsible for addressing. Collaborating learners work together in the JPS that is created with a shared objective to make progress on the problem of joint interest in a particular venue.

The assignments were designed to help the students develop a better understanding of the texts and to build writing skills. Ideally the focus of most of the student work was related to these learning objectives. Other parts of the assignments were problematic because of inherent difficulties of doing the work in a virtual environment. Finally, requirements of assignment were also problematic: they defined conditions and constraints on the process and procedures employed by the individual learner or the group.

These four aspects – understanding the reading material, producing a well-written text, collaborating virtually, and the requirements of the assignment – constitute the major axes of difficulty around which the joint problem spaces emerged during the course of student work. Each of the joint problems that were created were related to one or more of the four axes.

Regardless of platform, the students spent more time on content issues (working on their reading of the text or their writing) than they did on infrastructure issues like coordination work or deadlines. The students spent proportionally more time on infrastructure issues when using the wiki-platform than when using the blog-platform.

## Wiki-based collaboration

### A central argument venue

In the following example, a group is working on the first wiki-based assignment. At some point, one of the participants, HornBlower, writes on the talk page the heading CENTRAL IDEA. This establishes a point of collaboration and a venue for the group on this topic. The heading is a simple mechanism to establish such a "place."

Below that heading, HornBlower explains that he wants to start a conversation on the central idea of the book (see 1). HornBlower's contribution in part introduces a regulatory process and in part begins the process of finding the central idea of the book: a proposal to identify the central idea of the text (1a), an initial idea (1c), and a method to regulate the collaborative decision-making process (1b) are all parts of the proposal made by HornBlower.

(1) (a) We need come to a consensus on what we think the central idea of the book is.
(b) To get the conversation going I'm throwing out generic central idea. Feel free to weigh in this
(c) "Social tools are dramatically changing our society in ways that can be both positive and negative" ⋆ I really do agree with the above sentence as the central theme with the caveat that it should be technology enabled social tools. Throughout the book, Shirky is providing examples on both WHY and HOW technology inspired social interaction is changing everything around us. This includes the gathering and disseminating of information including education, communication etc.
HornBlower

*To make referencing easier, the a, b, and c designations were added by the authors of this paper.*

When no one responds to HornBlower's initial proposal, he tries again by accepting his own proposal: "Sounds good to me. Is everyone else in agreement?" HornBlower agreeing to his own proposal does not result in the creation of a joint problem space: somebody else has to do an uptake.

Eventually Hammer does an uptake (see 2), first contributing to relational space (2a), then asking for a more specific explanation (2b), and finally offering an alternate summary of the central argument (2c). Hammer's contribution ends with a request for a response (2d), which is the first part of an adjacency pair. Together the proposal and the initial uptake constitute a `problematization` of some part of the collaboration. As a result of problematization, the participants have created a joint problem space where the students can work together to identify the central idea of the book.

(2) (a) I agree with what you're saying, but (b) I think we could make it more specific. (c) I believe that Shirky's main argument is that society is changing not because of the adoption of new technology but because of the changes in behaviors as a consequence of lower barriers of coordination and transaction costs, making once unfeasible forms of group action possible.
(d) What do you think?
`Hammer`

Swallow joins the negotiation and makes a counterpropsal on thesis statement of the central idea (3):

(3) It was a good starting thesis, but I agree with Hammer.
... I propose the central idea as follows: "Technologically enabled social tools are changing society by lower previously existing barriers."
`Swallow`

The very next contribution is another one by Swallow . Swallow creates a second venue for the establishment of the "central idea of the text" (4).

(4) I have written the full summary for the book using many of the ideas originally written, just re-organizing them and filling them out more. PLEASE EDIT MY WORK, ESPECIALLY FOR GRAMMAR AND SPELLING I have the text of what was here before saved in an external source if you feel like that should be used instead.
`Swallow`

By posting a draft of the full summary, some of the joint action moves to edits on the wikitext page. Explicitly moving some of the joint problem solving to the wikitext page changes how the group jointly problem solves. On the wikitext page, the students do not talk about what they should do; they do it. To a certain extent this is part of the design of a wiki, but the decision to manage the collaboration this way must be made by the group.

The data show that general participation in writing the wikitext for the central argument was uneven. All team members were active readers of the review as it developed, regardless of whether they directly were making contributions: over the two wiki-based assignments, the average number of reads of the wikitext was 148.5 reads per group.

By itself, does co-editing the wikitext constitute working in a JPS? As a result of the interaction on the wikitext page the students can assume only level 1 of common knowledge (level 1: Dillenbourg et al., 1996). The interaction is very indirect: the evidence is weak or nonexistent that when one student edits another student's text that the second student is either agreed to, or even aware, of that edit. The students converge on a "final text," but evidence that their understandings have converged is not strong.

On the talk page, the group communicates directly to each other, organizing their activity and negotiation of alternate points of view. After the students begin to use the wikitext to mediate their collaboration, the talk page continues to serve an important function. Some of the contributions on the talk page are notifications that help the team to monitor their progress, e.g., "I'll try to thin out the summary to make it more concise." Other parts of the "talk" have to do with planning how to produce the best artifact. One topic of discussion that leads to joint problem solving is whether and how to include examples (5).

The problem that Hammer identifies concerns how many, if any, examples to provide (see 5a). HornBlower's response is an uptake which establishes a joint problem space (5b). Together, Hammer's proposal and HornBlower's response is a problematization of an issue related to the rhetorical structure of the central argument text. Swallow 's response weighs in on the decision-making process (see 5b).

(5) a. . . . I'm not really sure if providing examples are necessary since most of them are mentioned in the chapter summaries. Wouldn't it be better to focus on the key points? . . .
`Hammer`

b. I don't feel that including the examples in the central argument are out of place necessarily.
`Hornblower`

c. . . . I like the decision to weed out some of the examples and removing the chapter references. I think this looks pretty good now - nice job, team. (*relational space*)
`Swallow`

The new problem objective is a concern with the rhetorical form of the central argument summary: at issue is the integration of examples. At some point Hammer quotes the "guidelines" on the talk page, and the length of the summary becomes another problem that is jointly monitored and 'solved' (see 6a):

(6) a. "I've made some edits to Swallow's summary. I'm not really sure if providing examples are necessary since most of them are mentioned in the chapter summaries. Wouldn't it be better to focus on the key points? The guidelines for the summary are: '1000 word summary of the central argument of the book, best reviews will produce cogent and substantial summaries of the central argument of the book, identifying key points in the argument of the text' "

b. "Just removed the references, so we're now at 99 words",

c. "Someone just added another paragraph, we're over 1000 again"

d. "EDIT, I've thinned out the summary down to 985 words.
`Hammer`

The students begin to monitor their progress by reporting on the current length of the summary in a texting style; see examples 6b-6d. Each of these examples has two parts. The first part notifies the other team members of some action that was recently taken on the wikitext page, and the second part updates a key parameter for one of the requirements of the assignment. Writing 1,000 words, no more and no less, is a requirement of the assignment and this team problematizes it. The function of the talk page here is mostly as a monitor: the team uses the talk page to share updates on some joint task that is being solved elsewhere. Is this a joint problem space? Yes. The students have a shared conception of the problem to make the summary the appropriate length. They use the talk page to repair and monitor divergences in their individual knowledge of the situation – when one participant adds a

paragraph to the central argument, the other students are less likely to know that if it is not reported on the talk page.

**Summary** The summary of the central argument is marked by a heading and delineated by the white space that separates this venue from other venues established on the talk page. Within this space various problems associated with the construction of the central argument summary are addressed. Participants make textual contributions that are signed and persist throughout the several-week period of work.

A linguistic context is established as a part of this venue. Each contribution more easily refers to other comments made within this venue than to comments or thoughts introduced in other venues. Within this venue, contributions are made in a sequence; contributions between venues are not in a discernible order. The active participants in this venue are more likely to jointly track events in this venue than in venues where they are less active participants; each venue can have a different set of active and less active participants.

As the action continues within the venue, further problems are identified, proposals are made, and uptakes occur. Communication starts as a discussion and later shifts to a more telegraphic style of communication as the students monitor their work to finish off the central argument summary. By taking the initiative within this venue, alternate students take leadership roles: first, HornBlower by organizing the group to commit to the task of finding the central idea of the book (see 1), then Swallow when he shifts the decision making on writing a central argument to the wikittext (see 4), and finally, Hammer when he initiates the task of monitoring the length of the central argument summary (see 6a).

For this group, there are a total of 11 contributions to the talk page under the heading of "central idea," with 9 of them coming from three teammates. Four objectives for joint problem solving were created.

i. Identify the central idea of the text. This objective is related to the axis of understanding.
ii. Agree to a method for agreeing to the central idea of the text. This objective is related to the axis of infrastructure.
iii. Negotiate on whether to include examples, and if, so how many. This objective is related to the axis of writing.
iv. Manage the length of the summary of the central argument text. This objective is related to a requirement of the assignment.

Despite the few number of contributions to the talk page, the joint problem space created is significant for the collaboration over multiple objectives.

### A chapter summary venue

The primary participants for each chapter summary, in order of primacy, were the author, the discussant, and the copy editor. Other students could choose to participate, but these participations were not required by the assignment, and therefore, in general, tended to be less central to the joint problem solving that emerged. Because of the pre-defined organization there were fewer problems to be solved with regards to procedural elements of this part of the collaboration.

Billy is the discussant on the chapter summary written by Robert.

(7) a. Hello Robert, this is Billy. I found your summary to be a fascinating explanation of the chapter. You gave some excellent examples to back up your points about collective action and the speed offered by various modern social tools.

b. I was wondering if you could talk a little more about flash mobs, specifically regarding their specific purpose. Why not just a regular street protest - what makes flash mobs so unique and successful? Also, what do you think about the three levels of awareness that Shirky mentions in the chapter? I find his opinions about shared awareness to be a fascinating approach to understanding the benefits of our modern social tools.

The first part of Billy's feedback is a contribution to relational space: Billy directs his comments to Robert, introduces himself, and then compliments Robert (7a). In 7b, Billy has a question on "flash mobs" and a comment on Shirky's "three levels of awareness." In 7b, meaning making (Stahl et al. 2006) is the objective of the question Billy has about "flash mobs." Billy's comment on levels of awareness implicitly recommends this part of Shirky's model for inclusion in Robert's chapter summary. In itself 7b does not constitute the creation of a joint problem space; for that to occur another participant has to "join" the problem solving and further clarify the objective.

Robert is the author of the chapter summary. Robert continues the conversation and begins with a contribution that maintains the relational space (8a).

(8) (a) Great question! (b) Well i think flash mob is more successful because the government or people in the public will not even know if protest is taking place. I called flash mob the surprise protesting. This give participators advantage to get their message out and people will definite listen to them. I think that chapter 7 was more about collectively actions with the use of the internet to enhanced it. (c) I total agreed with Shirky awareness, I think Shirky is right on point on how internet has revolutionize society and the means of communication. (d) What do you think about my thoughts on the flash mob?

Robert's response completes the problematization with regards to the meaning of a flash mob. In 8b, Robert clarifies what he thinks are the differences between a flash mob and a regular street protest, and in 8d, he asks for a confirmation that Billy agrees. In 8c, Robert responds to Billy's solicitation of his opinion of Shirky's model of awareness. While Robert is being responsive to Billy's question on this topic, his response is an uptake that functions as an acknowledgement that he "heard," a demonstration that he knows what Billy is talking about and agrees with Billy, but it does not constitute an engagement in joint problem solving on this particular issue.

Billy confirms Robert's "solution" to the "problem" of the difference between flash mobs and regular street protests (9a) and makes another compliment (9b).

(9) Hi again Robert, Billy here again. (a) I agree with your sentiment about the surprise factor in regard to flash mobs - they don't give government the time or ability to control them. (b) Your thoughts about flash mob, collective actions, and (now) awareness are right on point.

Robert and Billy are fulfilling their assigned roles. They directly address each other and are more formally polite. Engaging in joint problem solving is implicitly part of the script for their assigned roles. Assumptionsabout the degree of certainty of shared knowledge are dependent on the assignment of roles and the sequence of conversation within the venue for this chapter summary; knowledge shared in other venues used by the team are less likely to be inferred as a part of the shared knowledge held between Robert and Billy.

## Blog-based

Each editorial post establishes a new venue. All the venues are of the same type. In general, teammates provide supportive feedback, mixing positive relational feedback with critical commentary. In contrast to wiki-based assignments, ownership and identity work differently during the blog-based assignments, and it is reflected in the venues that are created.

Ownership is related to credit, grades, and responsibility, which are significant issues for the students. Part of what makes constructing the central argument text on the wiki platform difficult is the issue of ownership. Everybody will be graded but the distribution of work within the team effort will depend on many factors – including skill, workload, and assertiveness – not just grade fairness. Equally troubling for the students writing a summary of the central argument is how "contribution" is measured. Clearly a fair amount of the work is happening "off stage" on the wikitext page. Those who are doing most of the work in constructing the central argument text will know each other from their work on the wikitext. To what degree the instructor will be able to track that is unclear to the students. Ownership of the chapter summary text is less ambiguous. The author of the chapter is the most likely "beneficiary" of a good grade, but students playing other required roles will also be graded on their efforts, and a part of the overall grade that affects everyone in the group depends on the quality of each of its parts, including the individual chapter summaries.

Because ownership and identity are significant features of blog-based writing in general (Cameron and Anderson 2006), the division of labor and the relationship between good work and good grade will seem fairly "natural" for the students. The students are more likely to use a expression like "my" that indicates ownership: the number of "my" statements for the blog-based assignments was 32% greater than the number of "my" statements on the wiki-based assignments. Another simple measure of the difference between the two platforms with regards to identity and ownership is the usage of the terms "you" or "your" where one student says to another a statement like "you should . . ." or "your argument . . .". "You" and "your" statements assume that a particular individual is identifiable as the referent of the pronoun and is the owner of some object or action. A count of "you" and "your" statements shows that there were more than twice as many "you" and "your" pronouns on the blog assignments than on the wiki assignments.

Because students own their work, most students are sensitive to the "feelings" of their group-mates. For this reason, students put effort into maintaining the relational space. Their contributions on each post show the students are aware of issues that revolve around ownership by bracketing their comments with contributions that are "polite" and "complimentary." Below are shown the openings of each of the comments on the draft posted by MovieStar.

(10) a. I think you have some really good ideas in your editorial, including the parallel economies and the idea of crossover which Lessig talks about in the "Economy Lessons" part.
b. You've got some **great ideas!** Your first paragraph lacks a strong point and introduction for your essay.
c. It's clearly unfinished but, as others have noted, you do have some **great ideas.**
d. You have some **good ideas.** Through illustration of Stack overflow's experience and it show you have done some research on the company. The connection you have made between stack overflow and the arguments in the book is also **very articulate.**
e. Your editorial has a central argument now so that's **great**.

Each begins with a compliment and modifiers like "really," "great," "good," "very," which are highlighted above for emphasis. MovieStar's response to these comments opens with an equally polite statement:

(11) Thanks for the feedback, I just cleaned out the intro paragraphs.

All the commentary is centered on the work of a single student, who may be unsure or sensitive about sharing his/her draft thoughts with his/her peers. Compared to the central argument examples shown above, the degree of overt politeness and civility stands out. Some of the politeness and generosity were also at work for the chapter summary discussion. But for the chapter summary, the students also identified themselves by their formal role. Here, no formal identification is required; the author of the post is center stage and everybody else is a commentator.

### Within the discussion of a single post

A single comment can potentially address an issue regarding one or another of the content `axes` of the editorial assignment (either the writing of the argument or the demonstration of understanding of the reading) or a requirement of the assignment; it turned out that infrastructure was not an issue for the blog-based assignments. The collection of comments can be more or less cohesive with one another. If everybody talks about the same thing, the commentary is focused on a particular objective. The more this varies, the less cohesion there is in the commentary. Some times the comments are a helter-skelter of this and that. This reflects either the difficulties inherent in commenting on a poorly written or weakly reasoned editorial draft or the lack of participation within a group or both. The students spent more time reading each other's comments (secondary participation) than producing them (primary): Over the two blog assignments, the average number of reads was 96, and the average of comments produced by each group for each assignment was 18.

Contributions can be shallow and polite (see 12).

(12) a. Good example and analysis. It is great that you have combined the principles in book with the example you want to discuss!
`ponny`

b. Thank you for your feedback. Let me know if there's any ways I can improve this draft.
`Woodpecker`

c. Very good editorial. I like the analysis of Twitch, and the fact that you incorporated many quotations and concepts from the book. It is also great that you separately talked about the commercial aspect of Twitch and the sharing aspect of it.
`CrimeWave`

Other comments are more substantial and lead to joint problem solving. The complete contribution of Fiddledeedee, on MovieStar 's draft editorial is shown in 13.

(13) I think you have some really good ideas in your editorial, including the
(a) **parallel economies and the idea of crossover which Lessig talks about in the "Economy Lessons" part.** The examples of Microsoft and IMDb that you use in the second paragraph are good.
(b) But the *requirement* of the editorial on part II of Remix is to do an analysis of some Internet-based economy (like Wikipedia) that is not discussed in the book.

Therefore,
(c) I think if you choose an appropriate example of **Internet-based hybrid economy**, explain the example in more details, and link your example to the economy lessons you talk about in the last two paragraphs of your editorial, the editorial will look much clearer and convincing.
(d) Besides, the beginning paragraph looks a little bit abrupt. Since the editorial is for Remix, you should start the whole editorial by mentioning Remix and Lessig's framework of three types of economies.
(e) Also, the *requirement* for each editorial is to provide at least one quote from the book, so don't forget the quote:)

The main focus of Fiddledeedee's comment was on strengthening the argument of MovieStar's post, specifically on the topic of hybrid economies; this topic is boldfaced. The comment begins with a contribution to relational space followed by an identification of the main topic of the draft editorial (see a). Both b and e discuss the requirements of the assignment (see italics). Both c and d concern writing and the construction of a persuasive argument.

The theme of strengthening the argument of the editorial becomes a major thread in the remainder of the commentary on this post (see 14). Each of these comments are authored by a different student. They all focus on strengthening the argument of the editorial with regards to *sustainable hybrid communities*.

(14) a. . . . I really think you need to flesh out your argument that you want to have for your essay. I think it would be good if you explained what Hybrid economies are, and explained your examples (Microsoft and Red Hat) in greater detail. . . .
`Saxophone`

b. It seems that your main argument is that sustainable hybrid communities are difficult to establish and that Stack Overflow is a decent problem introduced as a claim with backing of how to accomplish one. This is a very interesting idea. . . .
`Redwood`

c. . . . Through illustration of Stack overflow's experience and it show you have done some research on the company. The connection you have made between stack overflow and the arguments in the book is also very articulate. I think you could elaborate more about me-regarding and thee-regarding. And maybe more points about 3 types of successful hybrid that lessig points out and how it connects to the experience with stackoverflow.
`Prudence`

The objective of strengthening the argument of MovieStar's post becomes *problematized* when Saxophone uptakes the idea of greater detail in the examples and provides further advice on the details (see 14a). In terms of the JPS, Fiddledeedee's contribution introduces knowledge into the space, and Saxophone's contribution accepts that knowledge. This acceptance also implies that Saxophone is able to monitor the space for divergences in meaning. In 14b Redwood refers the main argument as being about *sustainable hybrid communities*, offering advice about how to improve the argument, focusing on the case of Stack Overflow. In 14c, Prudence enters the joint problem space created by Fiddledeedee and Saxophone and advances the state of the problem by adding a suggestion that the editorial add text on *me and thee-regarding* and discuss further the three types of hybrid economies from the book. In all of these exchanges, the students work together to strengthen the argument of MovieStar's editorial.

The close of this discussion is shown in example 15.

(15) a. Thanks for the feedback, I just cleaned out the intro paragraphs. I am trying to make an argument, as Redwood says that sustainable hybrid communities are difficult to establish, more so for the sharing economies than are trying to introduce a commercial entity/aspect, and that Stack Overflow is an example of how it can be accomplished. I am just thinking I need more examples or more points.
**MovieStar**

b. Your editorial has a central argument now so that's great. . . .
**Redwood**

MovieStar responds to the three previous comments, indicating that she has been monitoring the space for divergences in meaning, and accepts the current state of the problem, i.e., that her editorial needs more examples with greater detail. Further, she accepts Redwood's recapitulation of her central theme. Redwood closes with a confirmation that a focus on Stack Overflow will provide concrete details for MovieStar's argument (15b).

The collection of comments on MovieStar's post share a common focus. In the terms of joint problem spaces, Fiddledeedee raises an issue which the other groupmates take up as the topic of discussion. Through collective problem-solving, the state of the problem, strengthening MovieStar's argument, is advanced. The bias created by the opening comment in the determination of the objective of each of the blog-based joint problem spaces is a feature of this style of interaction.

### A joint problem space across multiple posts

The students read across venues to support their individual work at understanding the assigned text and to verify, develop, and strengthen the argument of their own editorials. Examples like 16 show that the students are making comparisons between their work and the work of their teammates.

(16) a. I had similar idea with you and thought that peer network only works when everyone benefits from the case.

b. I did not really pay attention to the cons part of RW while reading the book and your editorial definitely help me understand that.

c. This is well structured editorial. I think is the best I have seen so far. It is straight forward and I really like your analysis on yelp and also citing your source

d. I think a lot of people do not know what the five changes Lessig mentions in the book, so it would be great if you make that five changes clear.

Within a group, themes can and do emerge across the separate venues. The themes can be either on the content of the assigned reading or on the best way to write the editorial. The existence of cross-post themes is evidence that joint problem solving is occurring "off stage," but it does not follow the pattern of problematization that occurs within a venue. The students are collaborating but not directly.

Example 17 shows comments on two different editorials written by members of the same team on Lessig's book Remix. Each of these comments focus on how to include examples in an editorial post. Discussing an example was a required part of the assignment; finding a good example makes the "theory" more concrete and understandable. Although the comments are discussing different cases, the focus on cases shows the students are in a joint problem space where the participants are working on the application of Lessig's ideas to specific cases, both as a way to understand Lessig's ideas and as a problem to solve in the

writing of a strongly reasoned editorial. Taken together, 17a and 17b, show that the students in this group were jointly problem solving on these issues even without the mechanics of problematization that occurs within a single venue.

(17) a. This is well structured editorial. I think is the best I have seen so far. It is straight forward and I really like your analysis on yelp and also citing your source. I think the "Yelp" analysis should be on the fourth paragraph not the last one. Find a way to link it in your editorial then add a sentence or two to your conclusion
`Regency on Pirate's draft editorial`

b. I like the way it starts from basic knowledge and goes on to examples that you have. I have no experience with Reddit nor I do not have enough information about the Reddit, but I can tell this definitely is a great example of hybrid economy where commercial economy merged into sharing economy. Also, it seems like Reddit is doing some promotions and advertisements for their income not only with golds. I think it might have been better to talk about how Reddit can make profit and run the economy; but, still, this is a great editorial!
`ShadeShadow on CloudBurst's draft editorial`

## Discussion

The participants were parsimonious in their invocations of joint problem solving. Because of the attendant high costs of collaborating virtually, the participants had a predisposition to minimize points of collaboration, but when the work to collaborate was perceived to be more effective and less costly than working alone, the learners would collaborate.

The selectivity of the students when it came to deciding to engage in joint problem solving is an indicator that the balance of primary and secondary participation was different for virtual collaborators than it is for collaborators who are physically copresent. There are other tradeoffs between primary and secondary participation which make secondary participation less work regardless of whether the collaboration is in real space or virtual.

For primary participation, think of the space of possible interactions to continue in a joint problem space as an open frontier of directions to extend the collaboration: at any given point in time, an actor $A_i$ may choose one or another thread to continue. This is a function of the goals/tasks of $A_i$, the quality of $\texttt{thread}_j$, and the cost of continuation.

For example, the costs of mutual modeling are part of the cost structure of a primary participation-based collaborative learning situation (Dillenbourg et al. 2016). For two learners to directly engage each other in collaboration, the students need to model the skills, tasks, knowledge, goals, and/or plans of their partners. Which ones, and to what degree, vary depending on the abilities and efforts of the collaborators, and also the quality of the interaction. As the learners move forward in their collaborative problem solving, each primary participant must independently maintain a model of his/her partner(s) in order to assess factors like the intent, value, and/or objective of each new contribution.

The work/benefit calculation works differently for the secondary participant. The context for the conversation that occurred is available in the recorded transcript of action at the venue. In principle, any of the things the primary participants jointly saw or said is recordable and reviewable. The costs of partner modeling were paid by the primary participants, but the cost of reviewing can be expensive for the secondary participant. The secondary participant $\texttt{secondaryP}_i$ weighs the relevance of all open conversations to current goal/task

of $\texttt{secondaryP}_i$ and the assessed relative value of that thread of conversation modulo the cost of reading it. Methods like skimming, coupled to very specific tasks and goals that motivate and orient the search for relevant materials, can reduce some of the costs associated with secondary participation.

For a collaboration with virtual elements, there is a heavy tax on joint problem solving. The inherent costs of primary participation and engagement, in conjunction with costs of virtually communicating and connecting with other participants, make the costs run high for close collaboration. It does occur, but there is an incentive to minimize. Consequently, there is a shift from a collaboration that is more action-oriented when copresent to one the is more reflective online. Because the learners are never working together at the same time, their interaction is always mediated by texts that record in some kind of format the contributions of others. The line between reading in a venue the most recent contribution and reading a set of contributions is blurred; the context is always readily available on the text page of the wiki collaboration or in the discussion of a single post. Much of the convergence occurs "off stage" where the partners can read and reread each other's contributions. Does the reduction in close collaboration lead to a corresponding reduction in either progress or convergence toward the ideal understanding or skill?

Suppose small groups of students are working on a problem together in a lab. The ideal is that when learners are tightly coupled in their interactions there will be a convergence of effort and understanding amongst the learners. But the ideal depends on factors like how well the learners are matched and engaged, and thus, even if the students are co-present, an assumption that all students benefit and learn, making progress as individuals, is unwarranted. The here-and-now does not guarantee that the participants pay attention or that progress in the convergence of understanding is large. It could be the case that while doing the homework alone outside of class, the class makes more progress at convergence of understanding, knowledge, and skill than during an in-class lab or problem-solving session. There clearly are tradeoffs among the different scenarios.

With the move from copresence-based collaboration to a virtual one, the mechanics of how the students manage to move forward in concert with one another clearly is different for good reason. The transformation from a context which works like a spatio-temporal container to a venue-based virtual collaboration fundamentally changes the dynamics of joint problem solving.

The face-to-face encounter is more interactive, which facilitates communication. The different time and place version is more reflective, which invites deeper and more independent thought; it also greatly expands the opportunities for secondary participation.

The model developed in this paper characterizes the online collaborative interactions that convert problematic elements into joint problem spaces where the participants can jointly attend to a particular problem with a particular objective. Without the anchor of "here" and "now", the joint problem spaces are more fractured and splintered. A little bit here, a little bit there, and collaborators can develop significant points of exchange, coordination, and reciprocity in support of learning. The small bits of jointly focused interaction are sufficient to make for a collaboration. The participants achieve joint problem spaces, but they are small, piecemeal, and distributed in both time and place. There are still joint problems but they are fewer of them and they are of varying types. In many cases it suffices to agree to the problem without actually explicitly finding the solution together.

A key element to what transpires is the formation of venue. Venues localize parts of the collaboration. Within the social context provided by a venue, communication, referencing,

assumptions about common knowledge, participation, and role, and focus on joint problems are easier to sustain. Primary and secondary participation within a venue has a different mix than what occurs when joint problem solvers are co-present.

Within a venue, team members identify problems and create objectives for joint problem solving. A proposal for a collaboration with a particular objective is accepted by a second participant with a relevant contribution. Together the proposal and the initial uptake constitute a problematization of some part of the collaboration. The problems that were created were related to one of the four problematic axes of the assignments.

For the wiki-based collaborations, there were two types of venues: one for central argument summary and a different one for a chapter summary collaboration. For blog-based assignments all the venues were of the same type.

For wiki-based writing, within a venue, each contribution to the "conversation" was more likely to be coherent with either the preceding or following contribution. For blog-based writing, the collection of comments on a single post could have a common theme or they could be a mix of different topics.

The conditions of ownership, identity, and participation varied with each type of venue. For the central argument venues, ownership was less transparent: roles/identity/participation were self-selective and emergent. For the chapter summaries, the students often identified themselves by their assigned roles; and their role defined which parts of the task they "owned." For blog-based collaborative writing, ownership was implicit in the style of discourse: each student was the central participant and the "master of ceremonies" for the discussion of their own post.

For both wiki-based and blog-based platforms, joint problem spaces did emerge over more than one venue. The collaboration over multiple venues was even more dependent on secondary participation. It required additional work to "harvest" the arguments, insights, and examples from multiple points of coordination.

## Concluding remarks

One thing that the Impressionist movement in art taught us was that seemingly unreal "broken" brush strokes, simple renderings, can convey complex and intense feelings for the observer (Impressionism 2016). Is it possible that such an aesthetic principle can also be at work for a problem-solving, cognitively oriented situation? Perhaps collaboration does not require the participants be in "each other's face." A few relevant contributions here-and-there, now-and-then, like broken brush strokes, are sufficient to convey the seeds of complex understandings that can be cultivated upon reflection. The convergence between the participants' individual understandings are lower but coordination is more effective with the overall quality and character of the entire ensemble of understandings being more consistent and coherent.

This paper has made the case that for team-based learning activities on different time and place social platforms, joint problem spaces can and do emerge. The balance of primary and secondary participation is altered from that which occurs face-to-face. The action is more piecemeal and reflective and is distributed across multiple venues. Facts are more commonly known within a venue than across venues, and it is easier to refer to other objects, events, and action. Venues are similar with regards to the mechanics of problematization and the "localization" of participation dynamics, linguistic context, and the creation and sharing of situation-dependent knowledge. Venues can and do vary with regards to identity, ownership, relational space, register, and communication norms.

## References


Alterman, R., & Gunnarsson, B. (2013). The blogosphere as representational space. In *Proceedings of the 10th International Conference on Computer Supported Collaborative Learning*. International Society of the Learning Sciences.

Alterman, R., & Larusson, J. (2010). Aggregation in the blogosphere. In *Proceedings of the 9th International Conference of the Learning Sciences on ZZZ-Volume 2* (pp. 294–295). International Society of the Learning Sciences.

Alterman, R., & Larusson, J.A. (2013). Participation and common knowledge in a case study of student blogging. *International Journal of Computer-Supported Collaborative Learning*, *8*(2), 149–187.

Barker, R.G., & Wright, H.F. (1954). *Midwest and its children: The psychological ecology of an American town*. Row, Peterson and Company.

Barron, B. (2003). When smart groups fail. *The Journal of the Learning Sciences*, *12*(3), 307–359.

Brown, A.L., Ash, D., Rutherford, M., Nakagawa, K., Gordon, A., & Campione, J.C. (1993). Distributed expertise in the classroom. *Distributed cognitions: Psychological and educational considerations*, 188–228.

Cameron, D., & Anderson, T. (2006). Comparing weblogs to threaded discussion tools in online educational contexts. *International Journal of Instructional Technology and Distance Learning*, *2*(11), 3–15.

Cesareni, D., Cacciamani, S., & Fujita, N. (2016). Role taking and knowledge building in a blended university course. *International Journal of Computer-Supported Collaborative Learning*, *11*(1), 9–39.

Clark, H., & Brennan, S. (1991). Grounding in communication. *Perspectives on socially shared cognition*, 127–149.

Clark, H., & Marshall, C. (2002). Definite reference and mutual knowledge. In Josh, A., Webber, B., & Sag, I. (Eds.) *Elements of Discourse Understanding* (pp. 10–63). Cambridge University Press.

Cress, U. (2013). Mass collaboration and learning. *Handbook of design in educational technology*, 416–424.

Cress, U., & Kimmerle, J. (2008). A systemic and cognitive view on collaborative knowledge building with wikis. *International Journal of Computer-Supported Collaborative Learning*, *3*(2), 105–122.

Deng, L., & Yuen, A.H. (2011). Towards a framework for educational affordances of blogs. *Computers & Education*, *56*(2), 441–451.

Dillenbourg, P. (1999). What do you mean by collaborative learning?. In Dillenbourg, P. (Ed.) *Collaborative Learning: Cognitive and Computational Approaches. Advances in Learning and Instruction Series* (pp. 1–19). Elsevier Science.

Dillenbourg, P., Lemaignan, S., Sangin, M., Nova, N., & Molinari, G. (2016). The symmetry of partner modelling. *International Journal of Computer-Supported Collaborative Learning*, *11*(2), 227–253.

Dillenbourg, P., & Traum, D. (2006). Sharing solutions: Persistence and a samples of questions that were considered follow in multimodal collaborative problem solving. *The Journal of the Learning Sciences*, *15*(1), 121–151.

Dillenbourg, P., Traum, D., & Schneider, D. (1996). Grounding in multi-modal task-oriented collaboration. In *Proceedings of the European Conference on AI in Education* (pp. 401–407).

Ellison, N., & Wu, Y. (2008). Blogging in the classroom: A preliminary exploration of student attitudes and impact on comprehension. *Journal of Educational Multimedia and Hypermedia*, *17*(1), 99–122.

Forte, A., & Bruckman, A. (2007). Constructing text:: Wiki as a toolkit for (collaborative?) learning. In *Proceedings of the 2007 International Symposium on Wikis,* (pp. 31–42). NY, USA: ACM New York.

Garfinkel, H. (1994). *Studies in ethnomethodology*. Polity Press.

Goffman, E. (1963). *Behavior in public place*. Glencoe: the free press, New York.

Goffman, E. (1964). The neglected situation. *American Anthropologist*, *66*(6_PART2), 133–136.

Goodwin, C. (2007). Participation, stance and affect in the organization of activities. *Discourse & Society*, *18*(1), 53–73.

Greenberg, S., Roseman, M., Webster, D., & Bohnet, R. (1992). Issues and experiences designing and implementing two group drawing tools. In *Proceedings of the 25th Hawaii International Conference on System Sciences, 1992*, (Vol. 4 pp. 139–150). IEEE.

Gunnarsson, B.L., & Alterman, R. (2013). Understanding promotions in a case study of student blogging. In *Proceedings of the 3rd International Conference on Learning Analytics and Knowledge* (pp. 57–65). ACM.

Gunnarsson, B.L., & Alterman, R. (2014). Peer promotions as a method to identify quality content. *Journal of Learning Analytics*, *1*(2), 126–150.

Harrison, S., & Dourish, P. (1996). Re-place-ing space: The roles of place and space in collaborative systems. In *Proceedings of the 1996 ACM Conference on Computer Supported Cooperative Work* (pp. 67–76). ACM.

Harrison, S., & Tatar, D. (2008). Places: People, events, loci–the relation of semantic frames in the construction of place. *Computer Supported Cooperative Work (CSCW)*, *17*(2-3), 97–133.
Hymes, D. (1964). Introduction: Toward ethnographies of communication. *American Anthropologist*, 1–34.
Impressionism (2016). Impressionism — Wikipedia, the free encyclopedia. [Online; accessed 29-September-2016].
Järvelä, S., & Hadwin, A.F. (2013). New frontiers: Regulating learning in cscl. *Educational Psychologist*, *48*(1), 25–39.
Jordan, B., & Henderson, A. (1995). Interaction analysis: Foundations and practice. *The Journal of the learning sciences*, *4*(1), 39–103.
Kimmerle, J., Moskaliuk, J., & Cress, U. (2011). Using wikis for learning and knowledge building: Results of an experimental study. *Educational Technology & Society*, *14*(4), 138–148.
Kruger, R., Carpendale, S., Scott, S.D., & Greenberg, S. (2004). Roles of orientation in tabletop collaboration: Comprehension, coordination and communication. *Computer Supported Cooperative Work (CSCW)*, *13*(5-6), 501–537.
Larusson, J., & Alterman, R. (2009). Wikis to support the collaborative part of collaborative learning. *International Journal of Computer-Supported Collaborative Learning*, *4*(4), 371–402.
Latour, B. (1987). *Science in action: How to follow scientists and engineers through society*. Harvard university press.
Lave, J. (1988). *Cognition and practice*. Cambridge: Cambridge University Press.
Lee, B. (2001). Mutual knowledge, background knowledge and shared beliefs: Their roles in establishing common ground. *Journal of Pragmatics*, *33*(1), 21–44.
Lessig, L. (2008). *Remix: Making art and commerce thrive in the hybrid economy*. Penguin.
Mercier, E.M., Higgins, S.E., & Da Costa, L. (2014). Different leaders: Emergent organizational and intellectual leadership in childrens collaborative learning groups. *International Journal of Computer-Supported Collaborative Learning*, *9*(4), 397–432.
Moskaliuk, J., Kimmerle, J., & Cress, U. (2009). Wiki-supported learning and knowledge building: Effects of incongruity between knowledge and information. *Journal of Computer Assisted Learning*, *25*(6), 549–561.
Moskaliuk, J., Kimmerle, J., & Cress, U. (2012). Collaborative knowledge building with wikis: The impact of redundancy and polarity. *Computers & Education*, *58*(4), 1049–1057.
Nowak, K. (2001). Defining and differentiating copresence, social presence and presence as transportation. In *Presence 2001 Conference* (pp. 1–23). Philadelphia, PA: Citeseer.
Oravec, J. (2002). Bookmarking the World: Weblog Applications in Education. *Journal of Adolescent & Adult Literacy*, *45*(7), 616–621.
Roschelle, J. (1992). Learning by collaborating: Convergent conceptual change. *Journal of the Learning Sciences*, *2*(3), 235–276.
Roschelle, J., & Teasley, S.D. (1995). The construction of shared knowledge in collaborative problem solving. In Computer supported collaborative learning, pages 69–97. Springer.
Sawyer, R.K. (2013). Qualitative methodologies for studying small groups. *The international handbook of collaborative learning*, 126–148.
Schegloff, E. (1992). Repair after next turn: The last structurally provided defense of intersubjectivity in conversation. *American Journal of Sociology*, 1295–1345.
Schneider, B., & Pea, R. (2013). Real-time mutual gaze perception enhances collaborative learning and collaboration quality. *International Journal of Computer-Supported Collaborative Learning*, *8*(4), 375–397.
Scott, S.D., Carpendale, M.S.T., & Inkpen, K.M. (2004). Territoriality in collaborative tabletop workspaces. In *Proceedings of the 2004 ACM Conference on Computer Supported Cooperative Work* (pp. 294–303). ACM.
Shirky, C. (2008). Here comes everybody: The power of organizing without organizations. penguin.com.
Shweder, R.A. (1990). Cultural psychology – what is it?. In Stigler, J.W., Shweder, R.A., & Herdt, G.E. (Eds.) *Cultural psychology: Essays on comparative human development* (pp. 1–43). Cambridge University Press.
Sim, J., & Hew, K. (2010). The use of weblogs in higher education settings: A review of empirical research. *Educational Research Review*, *5*(2), 151–163.
Soller, A. (2001). Supporting social interaction in an intelligent collaborative learning system. *International Journal of Artificial Intelligence in Education (IJAIED)*, *12*, 40–62.
Stahl, G. (2006). *Group cognition: Computer support for building collaborative knowledge*. MIT Press.
Stahl, G. (2009). *Studying Virtual Math Teams: Explorations of Group Cognition* Vol. 11. Springer Verlag.

Stahl, G., Koschmann, T., & Suthers, D. (2006). Computer-supported collaborative learning. In Sawyer, R. (Ed.) *The Cambridge Handbook of the Learning Sciences*. New York, NY: Cambridge University Press.

Stahl, G., Zhou, N., Cakir, M., & Sarmiento-Klapper, J. (2011). Seeing what we mean: Co-experiencing a shared virtual world. In *Proceedings of the 2011 Connecting Computer-Supported Collaborative Learning to Policy and Practice: CSCL 2011 Conference*, Vol. 1.

Suchman, L., & Trigg, R. (1991). Understanding practice: Video as a medium for reflection and design. *Design at work: Cooperative design of computer systems*, 65–89.

Suthers, D. (2006). Technology affordances for intersubjective meaning making: A research agenda for cscl. *International Journal of Computer-Supported Collaborative Learning*, *1*(3), 315–337.

Suthers, D., Dwyer, N., Medina, R., & Vatrapu, R. (2010). A framework for conceptualizing, representing, and analyzing distributed interaction. *International Journal of Computer-Supported Collaborative Learning*, *5*(1), 5–42.

Tang, J. (1991). Findings from observational studies of collaborative work. *International Journal of Man-machine studies*, *34*(2), 143–160.

Teasley, S., & Roschelle, J. (1993). The construction of shared knowledge in collaborative problem solving. *Computers as cognitive tools*, 229–258.

Ten Have, P. (2007). *Doing conversation analysis*. Sage.

Wainfan, L., & Davis, P.K. (2004). *Challenges in virtual collaboration: Videoconferencing, audioconferencing, and computer-mediated communications*. Rand Corporation.

Wertsch, J. (1991). *Voices of the Mind: A Sociocultural Approach to Mediated Action*. Cambridge, MA: Harvard University Press.

Whittaker, S., Brennan, S., & Clark, H. (1991). Co-ordinating activity: An analysis of interaction in computer-supported co-operative work. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems: Reaching Through Technology* (pp. 361–367). ACM.

Williams, J., & Jacobs, J. (2004). Exploring the use of blogs as learning spaces in the higher education sector. *Australasian Journal of Educational Technology*, *20*(2), 232–247.

Yeh, Y.-C. (2010). Analyzing online behaviors, roles, and learning communities via online discussions. *Educational Technology & Society*, *13*(1), 1.