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Mashing-up wikis and forums: a case study of collaborative problem-based activity

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Mashing-up wikis and forums: a case study of collaborative problem-based activity

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A lot of studies have investigated the isolated use of threaded discussion and wiki technologies to facilitate collaboration in online learning settings. Nevertheless, the integration of both technologies into a potentially superior collaborative learning tool has not been explicitly investigated. This manuscript reports on an effort to undertake the merging and cooperation of wiki and threaded discussion technologies into a more sophisticated technology that better supports collaboration during problem-based activity in computer supported collaborative learning (CSCL) settings. Two customized collaboration technologies were investigated for their affordances to support students' cognitive processes and interactions during the construction of a group solution to an authentic problem. We found that one technology – WikiSplit – was particularly successful in promoting diversity of ideas (forum mode) while allowing learners to periodically update a group-owned document with syntheses of their emerging and shared understandings (wiki mode). We discuss how the integrated use of both a forum and a wiki, packaged together as one tool, can support and mediate desirable CSCL interactions during problem-based activity.

Keywords: collaborative learning; collaborative artifact construction; CSCL; wikis; forums; visualization techniques

Introduction

Both threaded discussion and wiki technologies have been widely employed and researched in e-learning settings, mainly seen as isolated collaboration tools. Typically, within a course management system (e.g. Moodle, Blackboard), threaded discussion (i.e. learners posting messages onto a discussion forum) is the dominant form for knowledge sharing and collaboration in online learning settings. Although threaded discussion is seen as an effective means for promoting participation and diversifying of ideas (e.g. Bruning, 2005; Lapadat, 2004), it is often associated with problems pertinent to collaborative learning. In particular, threaded discussion can suffer from incoherence (i.e. ideas not being tied together and drifting away from the original intention of the thread) and lack of convergence (i.e. synthesizing and summarizing) (e.g. Herring, 1999; Hewitt, 2001; 2003; Suthers, Vatrapu, Medina, Joseph, & Dwyer, 2008). For e.g. Stahl (2001, 2006) explained that the tree hierarchical structure imposed by standard threaded discussion tools is too restrictive for

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collaboration as it prevents learners from being able to bring several ideas together in a summary or synthesis. Moreover, in typical course management systems discussion tools and group artifacts (i.e. a group document, a sketch) are disjoined (displayed on entirely different screens), which is not conducive to online discourse about artifacts (i.e. artifact-centered discourse; Suthers & Xu, 2002).

Recently, wikis are becoming a common tool for engaging students in collaborative construction of shared artifacts. The existence of a group-owned document with editing capabilities – which necessitates negotiation among participants – seems to be what makes wikis useful in supporting the creation of complex, cohesive artifacts authored by many individuals. Several researchers and practitioners have advocated the use of wikis for online collaboration (e.g. Cress & Kimmerle, 2008; Rick & Guzdial, 2006). Yet, other researchers argue that the kinds of communication supports in typical wikis do not adequately serve rich collaborative learning situations (e.g. Larusson & Alterman, 2009; Pifarré & Staarman, 2011).

Using a repeated measures design, Ioannou (2011) investigated the different kinds of interactions evident in wiki and threaded discussion technologies during student collaboration in asynchronous courses at the university level. The authors found that groups in a wiki (in our case MediaWiki) tend to be more collaborative (i.e. working on every piece of the problem and solution together), whereas groups in a threaded discussion tend to be more cooperative (i.e. sharing the workload). Moreover, the study revealed the expanding nature of a threaded discussion and the condensing nature of a wiki. Last, the authors discussed that while some meta-communication was present (more in MediaWiki than in the threaded discussion), such as meta-cognitive reactions to previous contributions and negotiating consensus, students reported it was difficult to accomplish (Ioannou 2011). Based on the observed patterns of interactions, Ioannou suggested that using wikis as extensions to threaded discussion tools holds promise for improving collaborative work in computer supported collaborative learning (CSCL) settings.

Research Questions

The above-mentioned findings set the basis for the present investigation, examining how wiki and threaded discussion technologies can work together – packaged as a more sophisticated technology that brings together the unique affordances of each individual tool – to better support the collaboration processes during problem-based activity. Specifically the study sought to:

RQ1: What is the nature of the cognitive process and interactions evident during the construction of a group solution in the context of a problem-based activity?

RQ2: What is the evidence on how two customized collaboration technologies – undertaking the merging and cooperation of wiki and threaded discussion technologies – facilitate problem-solving?

Theoretical approach

From a sociocultural perspective, the individual development and mental functioning (thought processes) have origins in previous social interaction within the individual's sociocultural context (Vygotsky, 1978; Wertsch, 1991). Mental functioning such as critical thinking, reasoning, problem-solving, and creativity are the result of the internalization of social interaction. In this sense, knowledge emerges from the

active dialog and interaction among those who seek to understand, before it is internalized as individual knowledge (Bonk & Cunningham, 1998; Scardamalia & Bereiter, 1989; Vygotsky, 1978; Wertsch, 1998). As such, social interaction is a powerful force in the learning process, as it supports thinking and knowledge construction (Wertsch, 1998). Moreover, advocates of the sociocultural perspective argue that the human thought and behavior are mediated by physical artifacts and symbolic artifacts (psychological tools and signs), the most important of which is language.

Drawing upon this idea, CSCL researchers pay particular attention in the study of distributed interactions (and shared discourse) within a technological setting. They pay attention into how physical or digital artifacts (i.e. digital text, diagrams, media, discussion boards, chat rooms, or webcams) and symbolic artifacts (discourse, spoken or written texts, diagrams, and equations) help people regulate their thinking and interactions and guide their activity. Many CSCL studies examine groups' discourse and the role of digital artifacts in communicating meaning and building knowledge (e.g. Stahl, Koschmann, & Suthers, 2006). Different technological tools seem to afford different opportunities for collaborative activity, depending on how well they promote or limit communication and social interaction, mediation by artifacts, and artifact construction (i.e. Dwyer & Suthers, 2005, 2006; Hmelo-Silver, 2003, 2004; Hmelo-Silver, Liu, & Jordan, 2009; Roschelle, 1996; Suthers, Vatrapu, Medina, Joseph, & Dwyer, 2008). The present study draws on sociocultural perspectives to study the cognitive process and interactions evident during the construction of a group solution in the context of a problem-based activity mediated by two different collaboration technologies.

Methods

A case study approach (Yin, 2003) which is seen as an appropriate method for the analysis and interpretation of the interactions between the participants in CSCL environments (see for eg. Hmelo-Silver, Liu, & Jordan, 2009; Onrubia & Engel, 2009; Stahl, Koschmann, & Suthers, 2006;). Two groups of university students were studied, working in two different virtual settings, with the end purpose of exploring in depth the temporal evolution of the collaborative processes and the supporting and mediating role of the technology.

Participants and setting

The participants were 23 graduate students in two sections of an educational psychology course. All participants were pre-service teachers, with mean age roughly 25 years old, pursuing a MA in Teacher Education. The course sections were taught by the same instructor who covered the same instructional content and activities. Toward the ending of the course the instructor randomly assigned these students into groups of 3–4 (i.e. three groups in each course section). Their task was to collaboratively analyze a case vignette by applying concepts leaned in the course and to produce a consensus, group solution to the problem embedded in the case. To assure quality, the case vignette was adopted from a book specialized in the case method (Dottin & Weiner, 2001). The duration of the activity was 10 days. Student collaboration was carried out virtually, in a different virtual setting for each course section. In one course section, the groups collaborated in WikiThreads and the

activity run between 2 and 12 of December. The three groups of the other course section collaborated in WikiSplit and the activity (same one) run between 12 and 22 of December.

In the analysis, we focused on and contrasted two groups: the highest achieving group from the three WikiSplit groups and the highest achieving group from the three WikiThreads groups. As in other case studies, we selected two groups that would provide rich content for analysis and contrast (e.g. Hmelo-Silver, Liu, & Jordan, 2009). We selected these groups, after consulting with the instructor of the course (second author) because they appeared engaged in the collaboration process and they generated group solutions of very high quality.

Virtual setting 1: WikiThreads

WikiThreads is a customization of the original MediaWiki – the open-source platform originally written for Wikipedia. The original MediaWiki includes a wiki group-owned document with editing capabilities, a wiki discussion page associated with each document in which collaborators can identify problems and negotiate consensus, and a history record for each page tracking all modifications across time. In the WikiThreads customization, the LiquidThreads extension for MediaWiki was installed to implement a threaded discussion page system on the wiki discussion pages; this included features such as a reply option, bolting of new messages among other (google MediaWiki Extension:LiquidThreads). Like in MediaWiki, in WikiThreads the discussion tool and group artifact (e.g. the group-owned document) are linked, but are displayed on different screens (tabs) as in Figure 1.

Virtual setting 2: WikiSplit

WikiSplit was implemented as a Moodle block for Moodle 2.0 (or later), splitting the Moodle screen between the threaded discussion forum and the wiki and allowing concurrent use of both the forum and the wiki. In WikiSplit the discussion
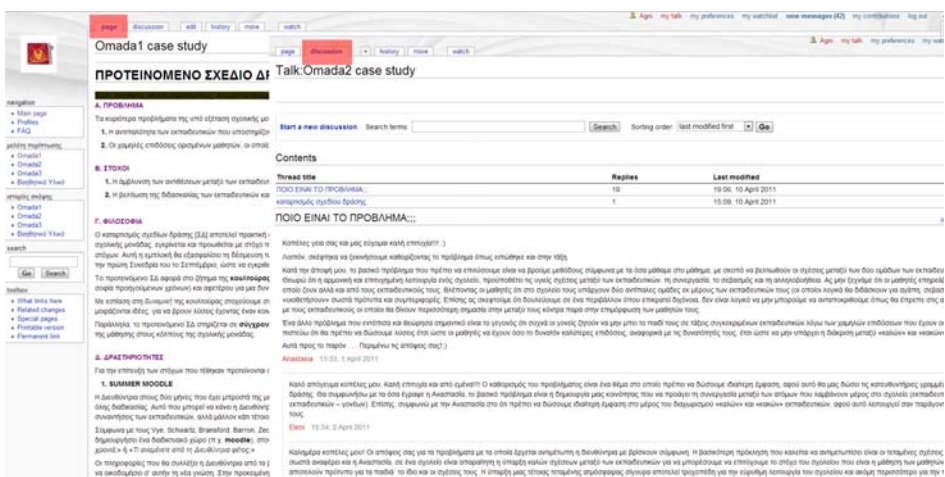

Figure 1.   WikiThreads – wiki mode on the left (page tab), forum mode on the right (discussion tab).
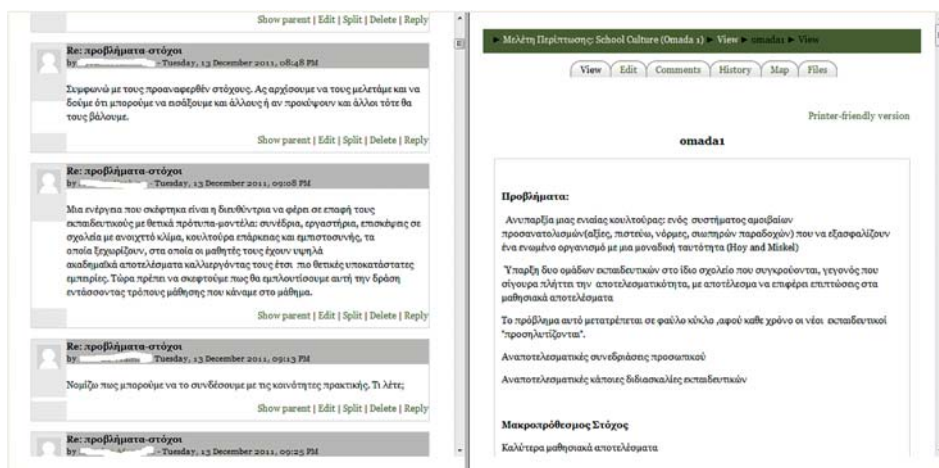
Figure 2.   WikiSplit – A new block for Moodle (forum on the left, wiki on the right).

tool and group artifact (e.g. the group-owned document) are linked together and are displayed on the same screen as in Figure 2.

Both WikiThreads and WikiSplit customizations aimed the merging and cooperation of wiki and threaded discussion technologies into a potentially more sophisticated technology that brings together the strengths of each individual tool (e.g. the expanding nature of a threaded discussion and the condensing nature of a wiki) to better facilitate the collaboration processes during problem-based collaborative activity.

Data collection

Data included groups' online discussions and interactions in both forum mode and in wiki mode contributed throughout the duration of the activity (10 days) in WikiSplit and WikiThreads. It should be noted that no documents were posted in the virtual spaces.

Data analysis

In order to investigate the two research questions of the study, the analysis was conducted in two levels – from coding the group's discourse to exploring and understanding the collaborators' interactions and contributions as they occurred chronologically.

We first employed Chi's (1997) quantitative content analysis method to analyzing verbal data to codify occurrences of collaborative knowledge construction in each groups' discussion data (forum mode). We used a coding scheme (see Table 1) which was shaped in our previous work (article in preparation) on the basis of Gunawardena, Lowe, and Anderson's (1997) and Onrubia and Engel's (2009) coding schemes.

Like in Gunawardena, Lowe, and Anderson's (1997) and Onrubia and Engel's (2009) coding scheme, the coding scheme is organized in phases, representing the progression of collaborative knowledge construction; and each phase represents a

Table 1.   Collaborative knowledge construction coding scheme (forum mode).

Code	Phase	Description
Phase 1	Sharing/adding	A statement of observation, idea, or opinion; defining, describing, identifying the problem.
Phase 2	Negotiating meaning	A statement of agreement (statement of agreement with other participants, corroborating statements provided by other participants); a statement of disagreement (statement of disagreement with other participants, restating a participant's position, advancing arguments in support of an opposing statement, drawing on the literature or to the participant's background to support an opposing statement).
Phase 3	Elaborating	A statement building on previous statements/ meanings; clarifying.
Phase 4	Evaluation of proposed synthesis	A statement presenting a synthesis with the prospect of reviewing it and finalizing it.
Phase 5	Consensus/application of co-constructed knowledge	A statement presenting a summary of agreements; a statement presenting an application of the new knowledge; a metacognitive statement showing the impact of the online interaction on the construction of the new knowledge/cognitive schemas.

higher level of sociocognitive complexity than the previous. In *Phase 1*, students engage in stating their positions and sharing information, individual thoughts and informative comments, without questioning any thoughts presented by their peers. Students do not get involved in explicit processes of negotiation of meanings, as such, the joined activity gets the character of a parallel monolog rather than a discussion (see also Onrubia & Engel, 2009). In all subsequent phases students engage in processes of interaction and negotiation with other participants and collaborative knowledge construction is evident through ideas uptake and inquiry. In particular, in *Phase 2* students get involved in explicit processes of negotiation of meaning where new postings have explicit and implicit references to earlier contributions expressing agreement or disagreement. In *Phase 3*, students elaborate on or clarify contributions previously presented by other group members (or their own) aiming to complete or complement the presented information with new information. In *Phase 4*, students contribute more complex presentation of meanings (e.g. a proposed solution plan) based on a *constructive synthesis* of previous contributions aiming to evaluate the proposed syntheses and make progress in the process of constructing shared meanings. Finally in *Phase 5*, students explicitly reach consensus on joined meanings and/or contribute metacognitive statements illustrating their understanding that their knowledge or ways of thinking (cognitive schema) have changed as a result of their online interaction Overall, the coding scheme of Table 1 addresses occurrences of collaborative knowledge construction amongst the collaborators (Gunawardena, Lowe, & Anderson, 1997; Onrubia & Engel, 2009).

The whole message/posting was taken as the unit of analysis. During coding, the message was considered in the thread of messages it was placed and in relation to the overall discussion (i.e. in context; see Stahl, 2006 for a discussion of how the text position and time of an utterance are important). Each message was categorized with one, and only one, of the categories for the phases of collaborative

knowledge construction. As in Onrubia and Engel (2009), when in doubt about the category that should be applied, the contribution was coded in the lower category, and in clear cases of two applicable categories, the contribution was coded in the higher category. Messages that only aimed the monitoring of the team progress, planning the task, using the technology, and in very few cases (<1%) socializing were coded as "Monitoring or Other Talk"; this also included any statements contributed by the instructor. For reliability control, two independent judges codified the entire corpus of threaded discussion data. Disagreements were less than 10% and were elaborated between the judges until 100% agreement was reached.

Following the verbal analysis of the discussion data, we aimed to understand the process of the collaborative construction of the consensus group artifact (wiki mode), in relation to the joined meanings emerging from the interaction between the participants during their discussion (forum mode). This analysis relied on the history record of the group-owned document (both in WikiSplit and in WikiThreads) which helps one understand the evolution of thought as collaborators add, edit, and delete wiki text. To avoid any mistakes from reading the wiki history, a script was developed to print the history in choronological order, presenting even the most insignificant types of revisions such as spellings. See, for example, Figure 3 where the researcher can detect green for expansions of the text, red for text deletions, and unmodified text as uncolored.

The history of the group-owed document was first inspected by two judges to decide on an appropriate coding scheme that could systematically describe the construction of the group artifact, in this case a written product. We were able to identify, for both analyzed groups, four levels of contributions, which are given in Table 2.

Coding for levels I and II was trivial. However, coding for levels III and IV required for the "expansion" contributions to be examined in relation to the ongoing discussion on the forum. Specifically, in Parallel Construction (level III), the group member contributes on the group-owned document by juxtapositioning extracted parts from the discourse on the forum, while the focus of the discussion may have already changed. Then, in Integrated Construction (level IV), the group member's contribution on the group-owned document is a result of the ongoing discussion on the forum and emerging understandings, with a clear depended link between the knowledge construction process (forum mode) and the artifact construction process (wiki mode). As such, to be able to code for levels III and IV we needed to look at both the wiki and forum data concurrently and as they occurred chronologically.
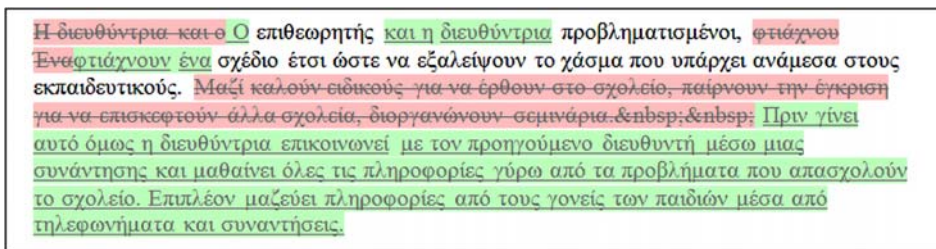

Figure 3.   History reader script.

Table 2.   Group artifact construction coding scheme (wiki mode).

Level	Code	Description
IV	Expansion – Integrated Construction	A contribution directly linked to the ongoing discussion. The group artifact is actively constructed in relation to joined meanings emerging from the interaction between the participants.
III	Expansion – Parallel Construction	A contribution not directly linked to the ongoing discussion but presenting ideas extracted from the discussion at a previous stage.
II	Rephrase/Content Editing	This contribution includes minor changes to the existing text such as adding/deleting sentences, adding references, or rephrasing the existing text in a way that slightly changes the meaning of the text. It does not include adding big parts of text or completely changing the meaning of the previous text (expansion).
I	Formating/Spelling	This contribution involves changes in punctuation, spellings, grammar, wording, creating titles/subtitles, or adding fonts and styles.

To achieve this goal we used the CORDTRA visualization technique (Chronologically oriented Representations of Discourse and Tool-related Activity). In general, CORDTRA can be used to integrate across multiple sources of data and multiple coding schemes and allows the researcher to gain an understanding of how collaboration unfolds and how the technology is used. Also, CORDTRA allows the study of discourse and tools over a somewhat extended period of time – hours to days (see Hmelo-Silver, Liu, & Jordan, 2009 for details on this visualization technique and how to build and interpret the diagrams). As illustrated in the CORDTRA diagrams of Figures 4 and 5 (for WikiSplit and WikiThreads, respectively), the coding schemes of Tables 1 and 2 were juxtaposed on a single timeline. The time of the contribution runs at the top of the diagram – in our case capturing the 10 days duration of the activity. Each scatter on the visual represents a collaborator,
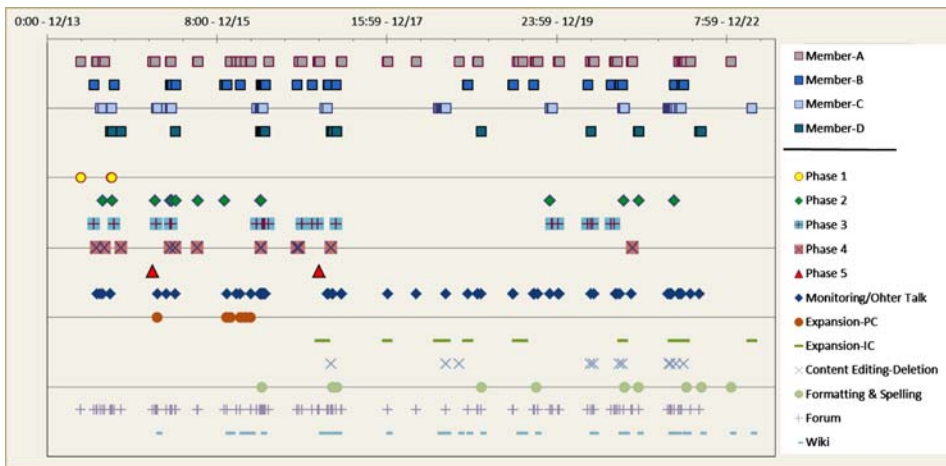

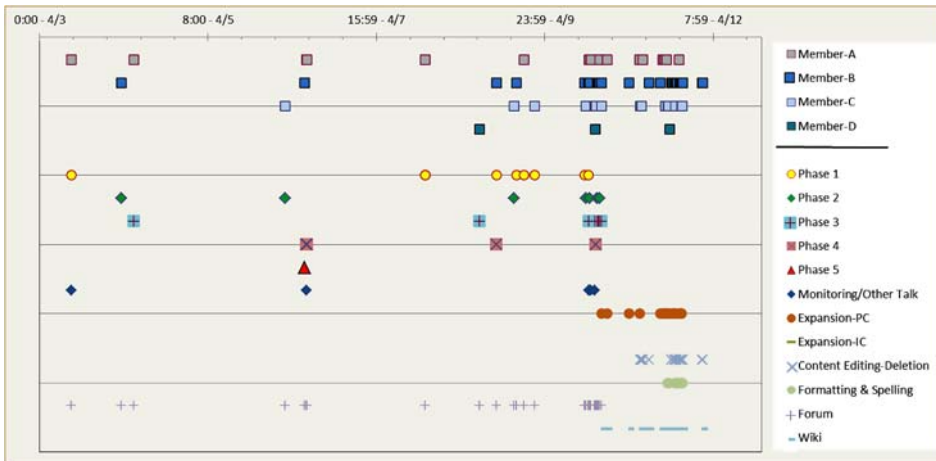Figure 4.   CORDTRA of WikiSplit group.

Figure 5.   CORDTRA of WikiThreads group.

the working mode (wiki or forum) and the coded contribution. Contributions made by the instructor (<2% of the discourse) were not plotted on the CORDTRAs.

The CORDTRA for each group was developed in two phases. First, we generated an (incomplete) CORDTRA including all the coded discourse from the forum (i.e. Collaborative Knowledge Construction Coding Scheme), as well as the level I and II wiki contributions which were trivially identifiable. The time-stamp for the wiki expansions were also added onto the diagram but a code was not attributed to them (either level III or level IV). At this point, the CORDTRA provided visual information that was helpful at guiding further analysis (see also Hmelo-Silver, Liu, & Jordan, 2009). In particular, after looking at the CORDTRA, we zoomed into the discourse around the missing codes, which allowed us to understand whether an expansion was a Parallel Construction (level III) or an Integrated Construction (level IV).

Similarly to the application of the Collaborative Knowledge Construction Coding Scheme, when in doubt about the category that should be applied, the contribution was coded in the lower category (e.g. level I rather than II), and in clear cases of two applicable categories, the contribution was *coded* in the higher category (e.g. level IV rather than III). Also, for reliability control, once the CORDTRA for each group was generated, two independent judges performed the above-mentioned analysis with more than 95% agreement; 100% agreement was achieved after the discussion of the disagreements between the judges.

Results

As described earlier, we focused on and contrasted two groups – the highest achieving group in WikiSplit (Figure 4) and the highest achieving group in WikiThreads (Figure 5), decided based on their engagement in the collaborative processes and the quality of their group solutions. At a first glance, the contrast of the CORD-TRAs indicated that these high-achieving groups had some important differences that we further explored below.

The first obvious difference was in the overall amount of talk and activity, with the WikiSplit group having more interactions than the WikiThreads group. We computed frequency counts to quantify this difference. There were a total of 106 contributions in WikiSplit – 56 in forum mode and 50 in wiki mode, expulsing monitoring and other talk. Yet, there were only 70 contributions in WikiThreads – 29 in forum mode and 41 in wiki mode. Besides the difference in the overall amount of talk and activity, these numbers also suggest that the group work in the WikiSplit was better balanced between the discursive activity and group artifact construction (56–50 vs. 29–41).

A quick inspection of the CORDTRA pointed to another obvious difference – the WikiSplit group members were more involved in negotiating meaning, elaborating on and clarifying previous contributions and contributing more complex presentation of meanings and syntheses of the discussed ideas (Phases 2–4). On the contrary, the WikiForum group members were more active in presenting their individual thoughts (Phase 1) often creating a parallel monolog rather than a discussion (see also Onrubia & Engel, 2009).

Yet, a more interesting result evident from the CORDTRAs is that the WikiSplit group talked more (forum mode) while using the group artifact (wiki mode). Specifically, it appears that this group jumped right into the construction of their group artifact from the begging of the activity and worked in both modes concurrently by going back and forth between the wiki and the forum. This observation suggested the need to zoom into the group's discourse and wiki activity, while using the CORDTRA as a pointer to interesting patterns. In doing this more in-depth examination of the data, we found that in WikiSplit discussed ideas and meaning making (forum mode) were integrated into the artifact construction process (wiki mode). This finding is supported by the increased presence of Integrated Consecution codes in Figure 4. In fact, in the early stages of the group artifact construction, all contributions were parts extracted from the discussion at a previous stage (i.e. Parallel Construction). Soon after a first draft was in place, all contributions became the result of the ongoing discussion and the development of joined meanings emerging from the interaction between the participants on the forum (i.e. Integrated Construction). Respectively, we also found evidence that drafting the group artifact promoted further discursive activity on the discussion page. That is, very often the process of drafting the solution generated questions or new perspectives which then appeared in forum mode to be discussed and agreed upon. In sum, this in depth, chronological analysis of the WikiSplit group allowed us to see a clear time-depended link between the ongoing discussion (forum mode) and the group artifact construction (wiki mode). Perhaps, this also explains the relatively higher, in fact intensive, talk coded as monitoring and other talk. This kind of talk corresponds to statements related to monitoring the team progress, planning the task, using the technology (i.e. took-related talk), and socializing (<1%). Normally then, constructing a group artifact while discussing about it would require some monitoring talk as in Figure 4. Overall, the WikiSplit group appeared very engaged in the process and the activity was very collaborative, rather than cooperative, in nature (i.e. students worked on every piece of the problem and solution together, see Roschelle, 1996).

On the contrary, these patterns were not present in Figure 5. The WikiThreads group had a late start with their group artifact moving onto wiki mode only towards the end of the activity. The group-owned document developed by extracting parts

from the discussion (i.e. Parallel Construction) while making minor revisions to the content (i.e. content editing-deletion). Unlike what we saw in WikiSplit, in WikiThreads the discussion was completely abandoned once the collaborators started working on their group-owned document and hence, Integrated Construction (level IV) codes were non-existed. Furthermore, it is noticeable in Figure 5 that one of the group members (member D) was completely disengaged with only three contributions towards the end of the activity. Thus, this group was working mainly with three group members which might, in part, explain the smaller number of overall activity in Figure 5.

Discussion and conclusions

Our in depth analysis and contrasting of two groups allowed us to examine how collaboration unfolded in terms of cognitive process and interactions (RQ1) and how the technologies WikiSplit and WikiThreads facilitated the task (RQ2) in a CSCL setting.

In sum, the WikiSplit appeared successful in promoting diversity of ideas (forum mode) while allowing learners to periodically update a group-owned document with syntheses of their emerging and shared understandings (wiki mode). In other words, discussed ideas and meaning making were integrated into the artifact construction process, while further discursive activity continued to occur. Although WikiSplit implements the idea, the argument is not new; Suthers (2001) argued that collaborators should be able to carry on a discussion with reference to a visual artifact that they can manipulate. Yet, as he explained, in typical course management systems, discussion tools and shared artifacts are displayed on entirely different screens, which is not conducive to online discourse about artifacts – so called "artifact-centered discourse" (Suthers, 2001, 2002). In WikiSplit the discussion tool and group artifact (e.g. group-owned document) are linked and displayed on the same screen and we believe this setting encouraged and mediated the above-mentioned interactions.

On the other hand, in WikiThreads group members did not use the discussion page for meta-level reactions. Instead, the discussion page was used to negotiate aspects of the problem at hand, and once students started drafting their solution on the group-owned document, they did not engage in further discursive activity on the discussion page. This result is fully consistent with previous work by Ioannou (2011) with using MediaWiki for collaborative activity on case vignettes in CSCL settings. This finding maybe suggesting that when discussion tools and group artifacts are not displayed on the same screen, their coordinated use by the group members is less likely to occur, which hinders the overall collaborative process.

Furthermore, with regard to the nature of the collaboration, some authors have argued that writing tasks in CSCL environments tend to become more cooperative than collaborative activities (e.g. Onrubia & Engel, 2009). Previous work by Ioannou (2011) showed that this is particularly true when threaded discussion tools are used; whereas in wikis, writing tasks can be collaborative. Larusson and Alterman (2009) also argued in favor of using wikis to support the collaborative part of a CSCL activity. Our present findings with the WikiSplit technology reinforce the merging and cooperation of wiki and discussion tools, suggesting that their "good marriage" can best mediate collaborative interactions (rather than cooperative work) in CSCL settings.

Future work

While lots of studies have investigated the isolated use of threaded discussion and wiki technologies to facilitate collaboration in online, learning settings, the integration of both technologies into a potentially superior collaborative learning tool has not been explicitly investigated. In this work, we aimed to advance the research in this area and we believe the study provided useful information that can help advance the technologies currently used for collaborative problem-based activities in CSCL settings. We are aware that our findings are tentative and require replication. Although firm conclusions cannot be drawn solely based on a case study, the currently presented work can indicate future research paths in terms of how to best integrate existing interfaces and tools available in a web-based course. This work could be directed at collaborative knowledge construction within mashup environments that allow the dynamic assembling of multiple Web2.0 tools (Wheeler 2009). Such focus would allow researchers to explore how different technological tools can facilitate different phases of collaborative knowledge construction in CSCL settings.

Below, we identify some implications of this work for future research and practice:

Suggestions to practitioners

- Using wikis and forums in isolation is restrictive to collaborative learning. Using these technologies in cooperation affords new opportunities for cognitive process and interactions mediated by technology.
- The study provides evidence that WikiSplit encouraged and mediated desirable CSCL interactions such as that, discussed ideas and meaning making were integrated into the artifact construction process and the process was more collaborative overall, rather than cooperative.

Suggestions to researchers

- A number of Web2.0 technologies are now available to support collaboration in online learning settings, but come with several limitations. Their merging and cooperation may hold promise for collaborative learning and should be further explored.
- In the context of this study, contacting the analysis in two levels – from coding the group's discourse to exploring the interactions chronologically – was important in understanding the role of technology. This practice can be applied and extended to more studies in the area.

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