A Case of Wikis and Contradictions: Activity Systems, Classroom Community, and Instructional Design for Collaborative Online Learning

Lisa Marie Johnson, Ashford University
Roderick Sims, University of Southern Queensland

Abstract: An activity system, a combination of community, rules, outcomes division of labor, and context, is a means to analyze the interactions which take place within a bounded community, such as that found in online collaborative classrooms. Elements in an activity system which impede the use of a technology within that system are known as contradictions. With the current emphasis on online classroom community and collaboration, this study employed an ex-post facto qualitative exploratory design, where data from student engagement with a wiki (an online collaborative tool) was analyzed in conjunction with reflective comments to assess the interactions in terms of an activity system and component contradictions as well as course design factors. The Classroom Community Scale (CCS) was employed to analyze wiki usage and interactions, generating scores on two dimensions: Connectedness and Learning. Findings suggested that as the activity system developed, a combination of community, rules, outcomes, division of labor, and context gave rise to contradictions in the use of the wiki technology due to the inherent features of the wiki technology itself. The results extend the understanding of instructional designers of online learning with respect to the selection of wikis as a medium for collaborative instructional strategies to facilitate a strong sense of classroom community in collaborative online learning contexts.

Keywords: Activity Theory, Classroom Community, Collaboration, Instructional Design, Wikis

Introduction

One of the key affordances of the online environment for teaching and learning has been the potential for participants to develop, through the networks of communication and interaction, a sense of community. Inherent within these environments are the tools for communication, such as the threaded discussion, blog and wiki, although the extent to which they contribute to the formation of a community of learning remains unclear. Studies by Drouin (2008), Palloff and Pratt (2007) as well as Rovai and Whiting (2007) have shown that students benefit from increased retention and learning of course content in those online courses which develop strong classroom community, and there-fore instructional designs for online learning that facilitate the development of classroom community are important.

For example, with respect to threaded discussions, Graff (2006), Rovai (2002a, b), and Rovai and Whiting (2005) reported classroom community to be essential for course designs in order to assist with attracting and retaining students. Similar findings, but with respect to the use of wikis, were reported by Coyle (2007) and Elgort, Smith, and Toland (2008), with their features considered as an appropriate choice for classroom community development (. Nevertheless, as noted by Ruth and Houghton (2009, p. 135), wikis remain somewhat of an enigma in community develop-

ment, as "much is written on the 'how' of using wikis and yet little on the 'why'".

Classroom Community

Within the context of online learning environments, the value of establishing community cannot be underestimated. Evidence for this is shown by a series of studies conducted by Rovai (2001a, b; 2002a, b; c) and Rovai and Whiting (2007) which focused on classroom community among undergraduate students, and which resulted in the development of the Classroom Community Scale. Results using this instrument indicated that a strong sense of classroom community benefits students by promoting retention and increased learning of course content (Drouin, 2008; Ouzts, 2003; 2006; Palloff & Pratt, 2007; Rovai & Whiting, 2007). According to Rovai (2002a, p. 4), classroom community is characterized by the "mutual interdependence among members, sense of belonging, connectedness, spirit, trust, interactivity, common expectations, shared values and goals, and overlapping histories among members".

Activity Systems

Given the importance of community and collaboration in the online learning environment, the concept of the activity system, which is a combination of interactions based on community, rules, outcomes, division of labor, context (Murphy & Rodriguez-Manzanares, 2008), presents a useful means by which to explore classroom community. With respect to this, by Engeström (1987; 1999), Barab, Evans, and Baek (2003), and Murphy and Rodriguez-Manzanares (2008) identified activity theory as an appropriate theoretical lens for investigating collaboration using wikis within the context of online learning courses. Drawing on research from Engstrom (1987), Murphy and Rodriguez-Manzanares (2008, pp. 443-446) depicted the five dimensions of an activity system, represented in Figure 1, as having the following characteristics:

  a. *community*: the organization or context in which the activity occurs;
  b. *rules*: the behavioral norms and conventions for the activity for the subjects;
  c. *outcomes*: the results of the activity, which may be intended or not;
  d. *division of labor*: the goal specific organizational processes used by the final dimension; and

  e. *context*: the contextual nature of the activity in relation to the rules and division of labor occurring in the activity.
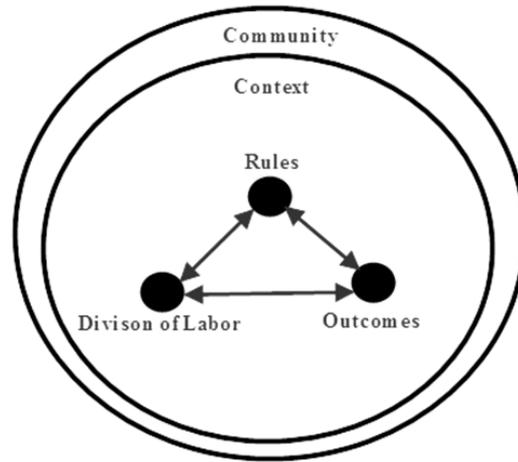

Figure 1: *Dimensions of an activity system (adapted from Murphy and Rodriguez-Manzanares,2008)*

Contradictions

Problems that arise in the use of technologies for learning are known as contradictions, and are caused by elements in an activity system that impedes the use of a technology for the desired ends (Barab, Evans, & Baek, 2003). As discussed by Murphy and Rodriguez-Manzanares (2008), these contradictions constitute "disturbances" which prevent efficient use of a technology in an instructional activity and are a key concern of an investigation of any activity system.

Wikis

Given the focus of activity systems and contradictions on the technology of online education, it therefore becomes important to examine how those technologies affect the systems in which they operate. One such learning technology is the wiki, a collaborative web-based authoring tool which enables rapid editing by multiple authors and the especially useful feature of version histories (Scardamalia & Bereiter, 2008). Elgort (2007) argued that, due to their inherent features, wikis have the potential to alter the very nature of community development in online learning environments because ownership of knowledge production and perceptions of interaction shift toward group rather than individual endeavors. Furthermore, Ruth and Houghton (2009) indicated that wikis challenge

traditional approaches to instructional design by centering designs on the process of constructing knowledge and by facilitating collaboration.

Wikis are considered a second generation or Web 2.0 technology, which enable affordances such as editing, contribution, versioning, and sharing. Dearstyne (2007) characterized Web 2.0 as any technology accessed via the Internet that embodies (a) new collaborative work styles leading to co-authored negotiated products of knowledge and understanding; (b) new applications supporting community interaction; and (c) new software connecting people and applications to capitalize on the benefits of distributed and collective intelligence (para. 3). And as a web-based technology, wikis facilitate rapid collaborative authoring and editing (Leuf & Cunningham, 2001) and therefore support social constructivist learning principles, which include "communication, collaboration, and knowledge building" (Robertson, 2008, p. 425).

While wikis have been shown to promote classroom community (Ruth & Houghton, 2009; Su & Beaumont, 2010), the use of wikis for collaboration in educational contexts has also revealed contradictions or tensions between learning and technology (Barab, Evans, & Baek, 2003; Murphy & Rodriguez-Manzanares, 2008). Considering that instructional design and the associated instructional strategies mediate these contradictions, it is paramount to understand the affordances of the wiki technology in terms of activity systems and contradictions on the context of collaborative learning designs.

Exploring the activity system of a technology to discover the nature of interaction and contradictions, or tensions, which arise with the technology, will expand understanding of the nature of collaboration in online learning. Given the evidence of the importance of classroom community for online learning and the associated impacts on activity systems and contradictions in those systems, the current study was established to investigate the influence of wiki technology in an online learning context on the development of classroom community. Consequently the research questions guiding this study were:

1. To what extent does classroom community develop in a learning environment in which a wiki is used as the method for participant collaboration?

2. When wikis act as a medium of student interaction in an online learning context, how does the activity system give rise to contradictions?

3. How does the instructional method used with a wiki activity influence the development of a sense of classroom community?

Method

Design and Instrumentation

This study employed an ex-post facto qualitative exploratory case study design, where data from student engagement with a wiki was analyzed using the Classroom Community Scale (CCS) developed by Rovai (2001a, b). The CCS consists of 20 questions scored by participants on a 5-point Likert-scale (Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree); ten of the questions measure the subscale *Sense of Connectedness* and the remaining 10 questions measure the subscale *Sense of Learning*. The questions for each subscale are shown in Table 1.

Completion of the Classroom Scale (CCS) generates possible scores between 80 (twenty *Strongly Agree* responses scored at four points each and zero (twenty *Strongly Disagree* responses scored at zero). The corresponding maximum and minimum scores for the two subscales are 40 and zero respectively. The closer a score is to the maximum, the closer that respondent is indicating they achieved a sense of connection or learning.

The *Sense of Connectedness* subscale represents participant's feelings about "cohesion, spirit, trust, and interdependence" with other participants in a course (Rovai, 2002b, p. 206). Rovai (2001b) explained that connectedness in a learning context is evidenced by a sense of benevolence and credibility toward peers. Rovai (2002a, p. 5) further explained credibility is an "expectation that the word of other students in the community can be relied on" and benevolence indicates the "extent to which students are genuinely interested in the welfare of other members of the community and are motivated to assist others in their learning". The *Sense of Learning* subscale represents participant's feelings about "interaction with each other as they pursue the construction of understanding and the degree to which members share values and beliefs concerning the extent to which their educational goals and expectations are being satisfied" (Rovai, 2002b, pp. 206-207).

Three open-ended questions were also included to elicit information to provide additional insights into classroom community

1. What problems do you recall experiencing with the wiki activity? For example, anything related to the activity that prevented you from performing the task you were required to complete. Please answer in as much detail as possible.
2. What else can you add about your use of the wiki and experience using the wiki in the cultural anthropology course?
3. Describe how the instructor's involvement in the wiki activity aided or prevented your successful use of the wiki for completing your task(s) with the wiki.

Other data used in the analysis included course journal responses completed by participants and post-survey follow-up interviews. In addition, direct observation and post-context analysis of the instructional context served as additional research data. This study represents the research component of a doctoral dissertation and IRB/Human Subjects approval was received for all students who were enrolled in the class at the time the data was collected. The lead author was the researcher and class instructor; the second author was advisor during the research process.

Participants

The case was represented by students enrolled in an online freshman social science course with little prior domain knowledge in the subject or experience with wikis. Six students agreed to participate in the Classroom Community Scale, and two of these participated in a telephone interview to clarify responses and explore definitions of classroom community. Of the six participants who were interviewed following participating in the wiki experience, each indicated they had not used a wiki previously. To assess the reliability of their recalled experiences, participants' confidence level in recalling course experiences using the wiki were also assessed, with four participants very confident and two somewhat confident of their recollections.

Data Collection

The wiki used for this study was the default wiki format for the Moodle v1.9 learning management system, also known as the Erfurt wiki (Moodle, 2011)., all 22 participants worked in small groups to develop weekly reading summaries in a wiki page preformatted by the instructor. The instructional strategy was aligned to meet the seven factors known to positively correlate with classroom community development (Rovai, 2002, p. 7) as represented in Table 2.

Table 1: *Classroom Community Scale: Subscale Questions*

Sense of Connectedness	Sense of Learning
I felt that students in the course cared about each other.	I felt that I was encouraged to ask questions.
I felt connected to others in this course.	I felt that it was hard to get help when I had a question.
I did not feel a spirit of community.	I felt that I received timely feedback.
I felt that the course was like a family.	I felt uneasy exposing gaps in my understanding.
I felt isolated in this course.	I felt reluctant to speak openly.
I trusted others in the course.	I felt that the course resulted in only modest learning.
I felt that I could rely on others in the course.	I felt that other students did not help me learn.
I felt that members of this course depended on me.	I felt that I was given ample opportunities to learn.
I felt uncertain about others in the course.	I felt that my educational needs were not being met.
I felt confident that others would support me.	I felt that the course did not promote a desire to learn.

Table 2: *Alignment of Community Factors with Instructional Strategy*

Community Factor	Instructional Strategy
Transactional Distance	Frequent communications within wiki pages and via email to groups to minimize distance
Social Presence	Instructor presence encouraging group interactions
Social Equality	Equality of group members with emergent leadership within groups; unassigned roles; wiki affordance for editing shared product of writing; encouragement by instructor toward consensus in responses; viewing of other groups' wiki responses
Small Group Activities	Consistent groups to answer weekly wiki questions with specific evaluation and collaboration instructions
Group Facilitation	Group assignments by instructor; preformatted wiki pages as group spaces
Teaching Style And Learning Stage	First year college learners; entry level course
Community Size	Class of 22 assigned to groups of 3-5 learners each

Small groups of three-to-five learners were given a weekly essay to write collaboratively that focused on a series of questions related to the course content. Since each learner could contribute multiple times and edit other learner's contributions, a degree of social equality was embedded within the instructional strategy design. The facilitation of the small group activity included use of the wiki technology to provide comments on page edits to guide groups toward quality in responses and consensus in their responses. Figure 2 provides an example of the main page of one weekly collaborative essay assignment demonstrating, in part, the organization of the group activity by the instructor.

Figure 2: *Wiki article page where groups would access the response pages*

Participants were also able to view the wiki question pages other groups', providing another dimension of interaction to the activity system that developed in the course through use of the wiki tool. Participants were able to recognize positive outcomes by other groups through instructor feedback throughout the week and apply those lessons to their group's response. Instructor comments encouraging the viewing of positive examples from each group promoted cross-group interaction. Therefore, employing the seven factors known to positively correlate with the development of classroom community (see Table 2), the teaching style in this case was seen to foster a sense of community among groups as well as within groups.

By way of clarification, the total number of students enrolled in the course was 22, and the data from their interactions in the wiki, resulting in the contributions and journal entries, were used to inform the analysis of the instructional strategies employed for the use of the wiki. The 'case', represented by the six participants, provided the data for the analysis of the CSS and the open-ended survey questions.

Course journal responses were completed at the time the course was active; participant responses about use of the wiki were coded for tensions and instructional factors that influenced classroom community development. Tensions were defined as factors that impede completion of an instructional activity, while instructional factors influencing the level of classroom community were identified based on the parameters proposed by Rovai (2002b).

Classroom Community and Wikis

Results

The first research question examined the extent to which classroom community develops in a learning environment in which a wiki is used as the method for participant collaboration. The raw scores for the Classroom Community Scale and the associated Sense of Connectedness and Sense of Learning subscales are presented in Table 3 and graphically represented in Figures 3, 4, and 5 following.

Table 3: *Overall and Subscale Raw Scores*

	CCS Score	Connectedness Score	Learning Score
Participant 1	61	33	28
Participant 2	75	38	37
Participant 3	35	11	24
Participant 4	42	16	26
Participant 5	58	30	28
Participant 6	64	34	30
Total (Mean/Possible)	**55.83/80**	**27.00/40**	**28.83/40**

Based on these results, a medium to high level of classroom community developed when a wiki was used for collaboration in an online learning context. The graphical representation shown in Figure 3 demonstrates that four of the six participants (P1, P2, P5, P6) indicated a strong sense of connectedness (scores of 30 and above) through the use of the wiki, while two (P3, P4) indicated a low sense of connectedness (scores of 16 or less). While this may not be causal in terms of wiki usage, the results point to classroom community developing in a learning environment in which a wiki is used as the method for participant collaboration.

Examples of participant responses illustrate the ways in which this connectedness was perceived: Participant 2 remarked, *"It was overwhelming at first and required an enormous amount of team effort. The team work, communication, sharing of ideas, and the process of learning was an amazing ride for me"* while Participant 6 commented "*It [the wiki activity] made the course interesting and fun. I can't remember the last time or a time I really enjoyed participating in a class".*
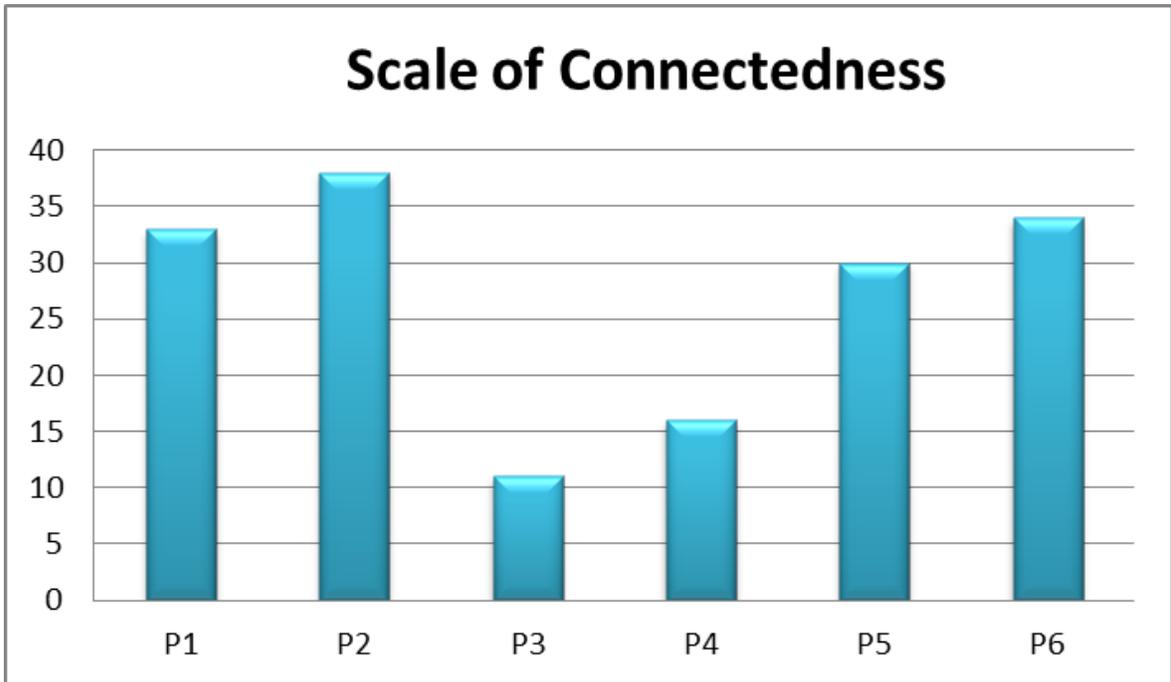
Figure 3: *Sense of Connectedness*

The connectedness data was complemented by that for the Sense of Learning sub-scale, represented in Figure 4, where all participants indicated at least a strong sense of learning, with all scores in excess of twenty. This again suggests that a wiki activity can influence the development of a sense achievement and learning within the class-room environment.
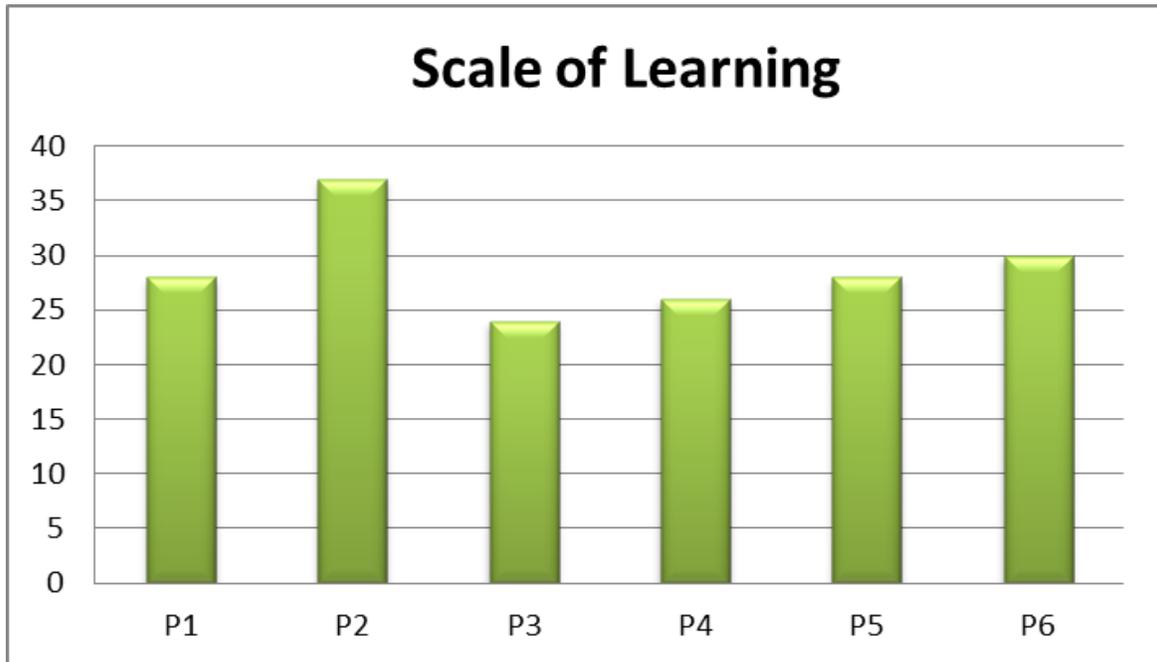

Figure 4: *Sense of Learning Subscale Scores*

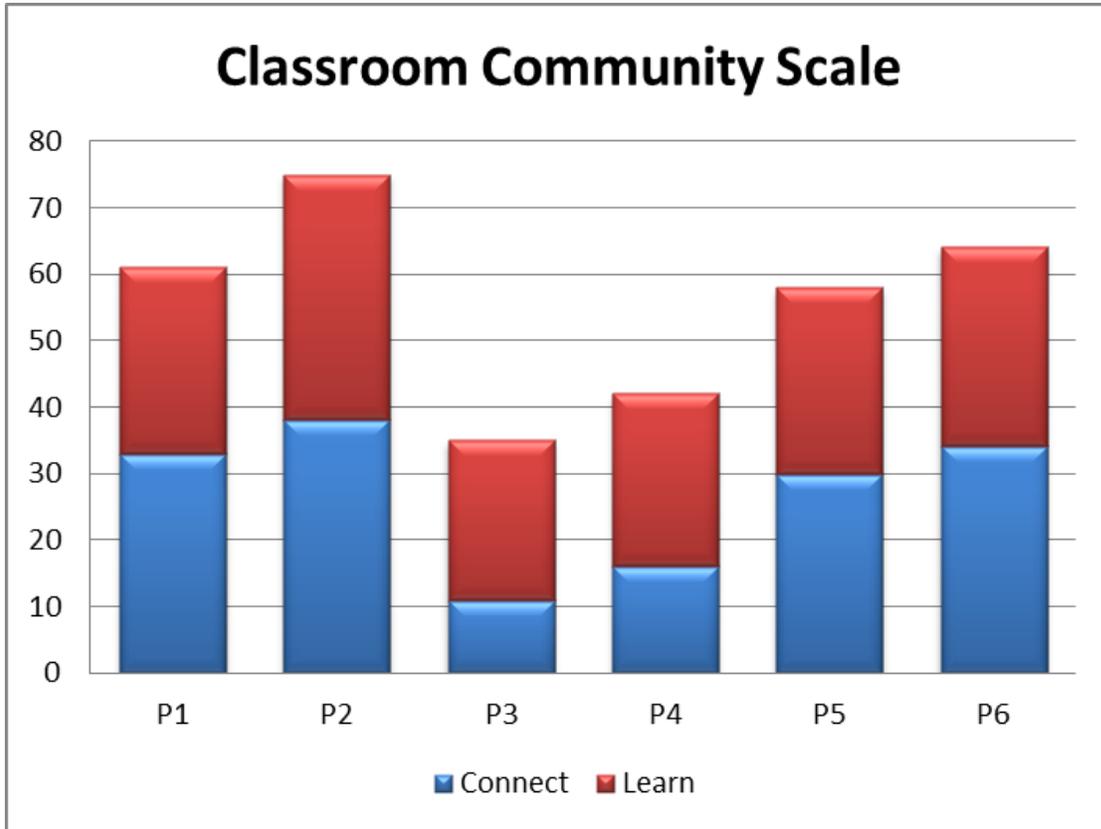Table 1. Design principles and guidelines for the VTS

Figure 5: *Classroom Community*

Together, as presented in Figure 5, the scores show that only one participant (P3) did not develop a strong sense of community (a combined score less than 40) as measured through the combined subscales of *connectedness* and *learning*. In combination therefore, these three sets of data provide supportive evidence for the first research question, al that classroom community can develop in a learning environment in which a wiki is used for participant collaboration.

Discussion

Given these results, further analysis of the data provides a context for their use within the online classroom. For example, embedded within the Sense of Learning subscale are participants' shared expectations and goals for learning. According to Rovai (2002a), shared expectations and learning goals signal that students have a "commitment to a common educational purpose and epitomizes student attitudes concerning the quality of learning" (p. 6). Furthermore, existing research addressing wikis in online learning indicated

that shared expectations and goals are a necessary characteristics for their successful classroom implementation (Elgort, Smith, et al., 2008; Johnson, Clarke, & Harrington, 2008; Peacock, Fellows, & Eustace, 2007).

Participants reported their commitment to the shared outcome of the weekly questions as a means for achieving the course outcomes, which suggested that, regardless of the technology used, the collaborative nature of the activity necessitated a common goal structure for group participants, which is reflected in the Sense of Learning sub-scale. Another element emerging from analysis of the CCS subscale scores is that the wiki activity collaboration experience developed a relatively consistent Sense of Learning among the participants while the Sense of Connectedness was more varied. What accounts for this difference may be the level of task-driven action by participants for completing the wiki activity: "task-driven interaction is directed toward the completion of assigned tasks while socio-emotionally-driven interaction is directed toward

relationships among students" (Rovai, 2002a, p. 5).

As interaction is characterized by task-driven and socio-emotional driven actions in a collaborative activity, the higher raw scores for the Sense of Learning subscale may be interpreted as having resulted from the task-driven actions of participants to completing the wiki activity. For example, as represented in Figures 3 and 4, Participant 4 indicated that success in achieving learning in the wiki activity resulted from the drive to complete the wiki tasks each week, even though they failed to achieve a Sense of Connectedness due to issues of cohesion and trust with group peers.

Activity Systems and Contradictions

Results

The second research question considered how an activity system might give rise to contradictions when wikis act as a medium of student interaction. To address this, the activity system that developed in the wiki-based collaborative learning instructional strategy was analyzed, using course journals and survey responses. The activity system that emerged from this study was characterized by small groups (*community, division of labor*) collaborating in a common wiki space to construct a substantial and coherent response to questions about course content (*outcomes, context*) following specific guidelines provided for interaction and criteria for evaluation of the collaboration (*rules*). Within this system, several contradictions were identified, which Murphy and Rodriguez-Manzanares (2008) stated arise when values about use of a technology are in conflict and may effect change in instructional practices. The contradictions emerging from the activity system associated with this study are detailed in the following exposition.

Contradiction: Familiarity

Based on participant responses, there were indications that a lack of familiarity with the wiki format caused contradictions in the use of the wiki technology, with some participants expressing concern that group members were able to replace their contributions to the wiki pages, even though the page history recorded every contribution, participants were concerned that the instructor would not be able to evaluate their work. This highlights the issues faced with using a technology – while the technology itself may have

apparent or assumed benefits, such as collaboration, the very act of collaboration can create contradictions. For example, Participant 1 reported that more time to learn the technology would have benefited the group's participation since some members experienced problems understanding how the wiki page revisions and histories were recorded.

Contradiction: Choice of Wiki

A contradiction that resulted from the activity system related to the wiki technology chosen for the activity. Based on participant feedback and analysis, the Erfurt wiki technology proved to be deficient in that it did not include talk or discussion pages, which can encourage discussion about page content. Consequently participants struggled with finding the best way to communicate with group members about page content and proposed revisions. Although the wiki pages often included comments from group members, this led to anxiety by the final editor who would have to comb the pages before the due date to remove comments.

Contradiction: Simultaneous Editing

With respect to the issues associated with simultaneous editing being unavailable, Participant 3 reported that, "*it was an inconvenience that the wiki was unavailable when other students were updating it*". While a page was open for editing, if another attempted to edit the page an error message would appear asking the individual to check back later because the page was open for editing. In course journal responses, participants remarked that peers would forget to close a page and it would delay editing. This delay in the ability to edit pages caused tensions among group members.

The contradiction caused by the inability to simultaneously edit pages may have reduced course learning because group members were unable to engage in collaboration when they so desired. Associated with this was the time period for participation, with allocation of one week per question. Consequently, if several group members attempted to contribute at the end of the week, there were delays and frustrations.

Contradiction: Cohesion and Trust

A final contradiction involved the level of cohesion and trust among group members. Anxiety about the unfamiliarity with the wiki technology and issues of

simultaneous editing and the division of labor in groups combined to cause a contradiction in the relationship between the participants (subjects) meeting their collaboration goals (object) and the use of the wiki (tool). Consequently, although the majority of participants felt the wiki activity was a success, a design using a wiki to develop strong classroom community would necessarily need to address these contradictions, which would involve revision of the instructional method and consideration of the limitations of the wiki technology selected for the collaborative learning activity.

Together these contradictions highlight the conundrum confronting designers of courses that integrate collaborative tools such as the wiki: how to generate benefit of the social aspects of learning when the technology to enable those social, collaborative interactions has inherent drawbacks (or contradictions). The following section considers this in terms of the design strategies that could be used to resolve these contradictions.

Classroom Community and Design Strategy
Design and Contradictions

The link between classroom community and design strategy was the focus of the third research question, which considered ways in which the instructional method used with a wiki activity influences the development of a sense of classroom community. This was assessed using responses to the Classroom Community Scale, the emergent contradictions from the activity system and responses to the survey.

For the contradiction "familiarity", an initial strategy, common with new technologies, is to give participants the opportunity to use a sandbox (or practice) area in order to become familiar with the technology prior to the formal learning activities. While this option was provided to participants, few took advantage of the opportunity. Reasons for this were not clear from the data, but based on other data related to the wiki activity itself; it was apparent participants felt rushed in the brief 10-week course time frame. To address this, an instructional design focused on lessening the influence of the contradiction might consider using scaffolding, whereby participants are provided specific activities to practice with the wiki prior to the collaborative activities commencing.

With respect to the "choice of wiki" contradiction, more informed consideration of the wiki chosen for collaborative learning will impact on the contradictions arising in the activity system. This is a poignant reminder for designers: that the technology selected for an instructional strategy must match that strategy! In this study, the features of the "default" wiki available through the learning management system resulted in contradictions within the activity system – with a subsequent effect on connectedness and learning for some participants. Because a technology, such as wiki, offers collaborative options does not mean those options will align with the collaborative strategies a designer may wish to deploy.

The third contradiction emerging related to "simultaneous editing", with participants frustrated at times because others were using the system at the same time. If the design is restricted by the technology available (in this study the Erfurt wiki) then designing for online collaborative learning requires consideration of the schedule of activities involving the wiki, the typical days of participation that will involve utilization of the wiki technology, and the editing capabilities of the chosen wiki technology. On reflection, the weekly timeline for question participation in the instructional method employed in this study proved a challenge for participants who were inclined toward participation on the weekend, or at the end of the weekly activity. To further facilitate the development of classroom community, a revision of the instructional method employed in this study would include weekday end dates for the collaborative activity and longer collaborative periods for questions. This aligns with Jeong and Frazier's (2008) assertion that the type of collaboration and cognitive engagement is dependent on the timing of interactions.

Considering the final contradiction, "cohesion and trust", and in association with the unfamiliarity with the technology, a strategy to use non-graded activities with a smaller group, dyad or triad would enable collaborators to develop a greater level of cohesion and trust before the larger group activity. Though Ouzts (2006) and Rovai (2002a) that small groups of five to seven members is effective, the unique nature of editing and revisions, essentially a rewriting of existing content, may mean fewer collaborators leads to greater sense of shared goals, learning, interaction, and connectedness. Applying accepted instructional methods

for collaborative online learning to wiki technology implementation may not be effective, reminding designers that the strategy must align with the outcome and technology, as emphasized by Sims (2008).

Further Design Reflections

Although participants were asked to consider developing group roles, such as editor, to facilitate a smoother cooperative endeavor to construct the weekly responses, few groups actually achieved this level of role-organization. Although groups were encouraged to divide questions into parts to manage the response workload, and to review responses from other groups for ideas and guidance, no groups were observed as having implemented these actions. A proposed revision of the instructional strategy to require role assignments and division of workload in the collaborative activity is recommended. That is, a suggestion of role assignments and division of workload for small group collaborative activities is not as effective as a requirement of these for the success of the instructional strategy in facilitating a sense of classroom community. These adjustments to the instructional method would place more constraints on participants, but may increase the cognitive engagement and shared responsibility among group members by providing the structure necessary to complete the collaborative activity.

The instructional method employed followed Chen (2007) and Zorko (2009) who both proposed that collaborative online learning designs include shared goals for collaboration and clear benchmarks of goal achievement. Based on the findings from this study, a revision of the instructional method to include more granular evaluation criteria is warranted. The wiki employed for this study enabled participants to co-author a single response to a group assigned question. Evaluation of the participation in groups focused on the number and frequency of contributions, but not specifically on the quality of the contributions beyond accuracy of information. Because participants reported anxiety about group peers editing and revising their contributions, a more transparent evaluation structure that informed participants of the instructor's use of the history tracking (page revision) for contributions is recommended for increasing the sense of shared goal and benchmarks of goal achievement.

Conclusion

Using collaborative activities to enable classroom community has been a key goal for designers of online learning, and this study investigated a course which deployed a wiki for collaborative learning. Data from the Classroom Community Scale, course journals and participant responses revealed that a medium to high level of classroom community developed; however the activity system that emerged gave rise to, largely related to the inherent features of the wiki technology itself.

While the higher education community continues to embrace online technology, and learning management systems integrate a wider range of collaborative tools, the risk is that designers and teachers will assume that those tools will, *de facto*, align with the chosen instructional strategies. Based on the findings from this study, the technology itself may compromise, through the emergence of contradictions, the very learning environment it is supposed to enhance. The challenge for the designer therefore is to anticipate such contradictions and to ensure the technology is aligned to instructional strategy; this will only be achieved through rigorous testing, observation, and motivation to achieve the best learning environments for both teacher and student.

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