AC 2011-2779: ASSESSING COLLABORATIVE UNDERGRADUATE STUDENT WIKIS AND SVN WITH TECHNOLOGY-BASED INSTRUMENTATION: RELATING PARTICIPATION PATTERNS TO LEARNING

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Assessing Collaborative Undergraduate Student Wikis and SVN with Technology-based Instrumentation: Relating Participation Patterns to Learning

1. Case Study Objective and Collaborative Context

Local industry representatives consistently point to the lack of large-project and team-based experience as a weakness in newly hired computer science graduates. To better prepare students for professional employment, two undergraduate computer science teachers at the University of Southern California combined a first and second year course so that students could work on projects whose scope was larger than the ones they normally worked on Wilczynski and Crowley (2009). Because second year students had already completed the first year course, they were able to mentor the first year students. This case study of that experiment, referred to as the Joint Coding Project (JCP), spans a seven-week period of collaboration among the two classes that took place during the spring semester of 2010.

The goal of this case study is two-fold: The first goal is to understand how these undergraduate students worked collaboratively from a pedagogical perspective. Though the software programs developed by the teams are larger and more complex than typical programs that are developed individually, it is the collaborative process of development that differs significantly. The second goal is to use the findings to determine how effective student knowledge and performance assessment tools can be developed to provide feedback to help instructors understand student strengths and need-to-improve areas. An Activity Theory framework is used to frame the analysis, to understand interactions between teams and tools, quantity and chronology of contributions, correlations between work and achievement. We found that increased collaboration and well-paced work patterns correlate with higher achievement.

2. Collaborative Learning and Collaborative Tools

Collaborative learning is associated with deeper conceptual understanding of the domain and increased interest, which can in turn facilitate transfer and enhance problem solving and motivation (Bruner 1986; Bransford et al., 2000, Boaler, 2002; Bruckman, 2000; Bruckman, Jensen, & DeBonte, 2002; Bunt et al., 2001; Shute & Glaser,1990; White et al., 1999).

Undergraduate engineering collaboration, as we will describe here, is complex process, involving the use of computer-based tools, including tools made available by the course instructor as well as tools that students use personally. In the course that is analyzed in this paper, students were asked to use Subversion, a freely available revision control system, and Brainkeeper, a commercial Wiki product. Students also used a number of secondary tools including email and web-based Google applications.

A version control system (VCS) is a software management tool. A VCS is used to track revisions that are made to files over time, usually by a group of authors. In a software development environment, the files commonly contain programming code and the authors are programmers on a software development team. In the paper's project context, teams of students used a VCS software called Subversion (SVN).

Wikis are editable web sites that support the creation of linked pages, the archiving of media, revision control, access control, searching, and a consistent look and feel. Wikis facilitate collaborative learning by allowing groups of laypersons to collaboratively create web content. Pedagogical uses include personal journaling, portfolio creation, collaborative under/graduate research, group editing, and coordination across disciplines and institutions (Higdon, 2007).

2.1 Related Work

Chen et al. (2005) studied the use of Wikis for portfolio building in a freshman design engineering course at Stanford and found a positive influence in "students' knowledge, awareness, and skills in design engineering". They found that the keys to maintaining student engagement included an expectation that the Wiki was a central part of the course, concrete assignments, regular feedback and software robustness. Grant (2006) used Wenger's Communities of Practice (CoP) theory (1998) as a framework to study Wikis in education; CoP describes how members of a group negotiate meaning and how knowledge is reified to become a coherent, understandable entity. She found that Wikis support collaborative knowledge building-networks and allow for a "personalized learning experience while also experiencing learning as part of a community through collaborating with others in shared activities."

Further case studies of educational Wikis, however, have resulted in conflicting outcomes. For example, Wang et al. (2005) found a significant inverse relationship between Wiki editing usage and academic performance. And in an extensive study of Wiki adoption, the results of years of studying the adoption of CoWeb at Geogia Technological University, Rick and Guzdial (2006) reported that CoWeb's use in STEM courses was "overwhelming disappointing" and STEM "students actively resisted collaboration" despite the fact that learning benefits were demonstrated in English composition and architecture classes. Obviously, further evaluation of Wiki use, especially in STEM areas, is needed.

3. Collaborative Tools as Data Sources

In this case study, students were provided two collaboration tools – Subversion (SVN), a freely available version control system (VCS), that can be used to keep track of the different versions of the code implemented during the course of the project and Brainkeeper, a commercial wiki product. Data were collected from these sources and additionally from the status reports sent by the team managers to the instructor.

4. Activity Theory Analysis Framework

Activity Theory (AT) provides a construct for representing relationships among the different aspects of the collaborative process, or the activity system. It facilitates the analysis of interactions among different parts of the activity system namely Subject, Mediating Tools, Object, Rules, Community and Division of labor. Figure 1 illustrates the activity system for the case study. This section describes the system in detail.

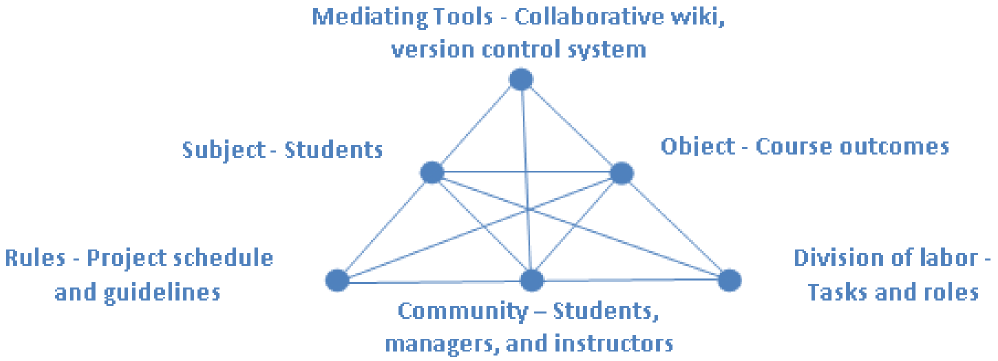
Mediating Tools - Collaborative wiki, version control system
Subject - Students
Object - Course outcomes
Rules - Project schedule and guidelines
Division of labor - Tasks and roles
Community – Students, managers, and instructors

FIGURE 1. Activity System view of the Joint Coding Project

4.1 Activity System Components

Subject- Two undergraduate computer science classes from two different courses participated: The first year course (CSCI105) emphasizes user-interfaces and the second year course focuses on architecture (CSCI201). A total of 102 students participated, 55 second-year students and 47 first-year students. There were 8 teams of students. The study was conducted on a joint-class coding project (JCP) activity between the two classes.

The main objective of the project is to provide students with experience of working in large teams, so that students use the software engineering principles learnt in the class. This project experience is also meant to develop the team co-ordination and project management skills of the students and equip them better to work in the industry. The project team had students from both classes there by allowing for implementation of larger projects whose scope is bigger than projects that can be implemented by a 3 or 4 member project group drawn from a single class. Each team also had a paid team manager who assessed the students based on their team co-ordination and leadership skills.

Object- The two main objectives of the activity from a student perspective were to complete their project on time and to achieve a high project grade. In this study, the overall JCP project grade and individual grades for the major release components (within the JCP) were used to quantify the level of achievement with respect to the objectives.

TABLE 1. Joint Coding Project (JCP) components and their contribution to the overall course grade.

JCP Timeline (Weeks)	JCP Contribution to Final Grade	JCP Major Components	Component Contribution to JCP Grade	Component Due Dates (Weeks)
Mar 22- May 09 (7 Weeks)	25%	Design	13%	Apr 4 (wks 1,2)
		Project Release	43%	Apr 18 (wks 3,4)
		Project Release	44%	May 9 (wks 5,6,7)

TABLE 2. Project team and grade information.

Team ID	#Total Students (#Y1, #Y2)	Design Grade	V1 Release Grade	V2 Release Grade	JCP Grade
Team 1	15 (7,8)	27	79	90	196
Team 2	14 (7,7)	28.5	98	100	226.5
Team 3	11 (6,5)	28.5	100	90	218.5
Team 4	11 (6,5)	28.5	81	80	189.5
Team 5	10 (5,5)	28.5	90	100	218.5
Team 6	11 (5,6)	28.5	100	95	223.5
Team 7	14 (9,5)	25.5	95	90	210.5
Team 8	16 (10,6)	25.5	85	100	210.5

Rules- Rules include the timeline, grade percentage and due dates, shown in Table 1.

Mediating Tools- Students in the project teams collaborated on various types of documents like technical design documents, meeting notes, availability and contact information, calendar of events, and task cards for assigning roles and sub-task. For project management, teams used a variety of applications, both internal and external to Brainkeeper, including Brainkeeper Calendar, Google Calendar, Google Groups, and WhenIsGood.net. Task Cards (Brainkeeper Wiki page for assigning Tasks and tracking status) were used for assigning roles and sub-tasks. Table 3 displays the types of documents generated by the teams during the collaborative process. All students used the Subversion (VCS) environments for coding collaboration and wiki for design documentation collaboration.

TABLE 3. The different types of documents created in Brainkeeper by teams.

Team Name	Types of Brainkeeper (Wiki) Documents Generated by Students					
	Meeting Notes	Availability Info	Contact List	Calendar	Task Cards (Team)	Task Cards (Individual)
Team 1	No	Yes	Yes	Yes	Yes	Yes

Team 2	Yes	No (Google Calendar)	No (Google Email Contact List)	No (Google Calendar)	Yes	Yes
Team 3	Yes	No (WhenIsGood.net)	Yes	Yes	Yes	Yes
Team 4	Yes	Yes (Task Card)	Yes (Task Card)	Yes	No	Yes
Team 5	No	No	Yes	No	Yes	Yes
Team 6	No	No	Yes	No	Yes	Yes
Team 7	No	Yes (Task card)	Yes (Task card)	Yes	Yes	Yes
Team 8	Yes	No	Yes	Yes	Yes	Yes

5. The influence of Wiki Participation on Performance (Student-Tools-Object)

With the exception of the design document, student use of the wiki was weak. Less than half the teams maintained availability lists, Contact lists and Calendar within the wiki workspace. Some students preferred to use external applications, or entirely skipped the creation of these types of documents. Of those that did, only two teams tracked meeting notes, meeting outcomes and messages within the wiki. The result of this inconsistency is that the instructors and team managers had difficulty fully assessing collaborative management processes.

According to student feedback, the wiki environment was “clunky”, and it was time consuming to create and update formal design documents in that environment, most of which were pseudo code and photos of white board-drawn flowcharts from team design meetings. On the other hand, one of the instructors commented that young students do not usually appreciate design and documentation aspects of code development until they enter industry; it is only then that he receives their appreciative comments. Additionally, the grading procedure did not emphasize the development of formal design documents – it was only 13% of the JCP grade - and coding, team-coordination and integration of code were the most important and time consuming components of the activity. Despite these issues, when we analyzed the number of design documents edited collaboratively by groups of students and correlated them with the first (V1) release grade, we found a slightly positive correlation between the number of documents and grades (Correlation of 0.40 with p-value .14 and 95% confidence interval between -0.24 and 1). This indicates that better collaboration on code design predicted better achievement on coding assignments, which, in theory, is what is supposed to occur. See Table 4 for details.

TABLE 4. Number of team-edited documents in the wiki space.

Team Name	#Students	#Team-Edited Documents	V1 Release Grade
Team 1	15	3	79
Team 2	14	3	98
Team 3	11	17	100
Team 4	11	4	81
Team 5	10	2	90
Team 6	11	11	100
Team 7	14	16	95
Team 8	16	1	85
Correlation to V1 Grade		0.40	

6. The influence of temporal code contributions on Performance (Student-Tools-Object)

In the JCP students used subversion, a version control system (VCS) to track versions of their individual code and the team-integrated code for the different releases. Code creation and update activity patterns in the version control system were analyzed to understand the teams' work schedules and their effect on team grades. In Figure 4, the pie-charts show the contrast in the distribution of work, as determined by the number of updates to the project code files in the VCS, at various time intervals. We compared the three low performing groups (Low#1 to Low #3) and the three high performing groups (High #1 to High #3), as determined by the V1 release grade. Work prior to April 13th (approximately one week into two-week V1 Release assignment) and then for every two days up until the V1 Release is shown.

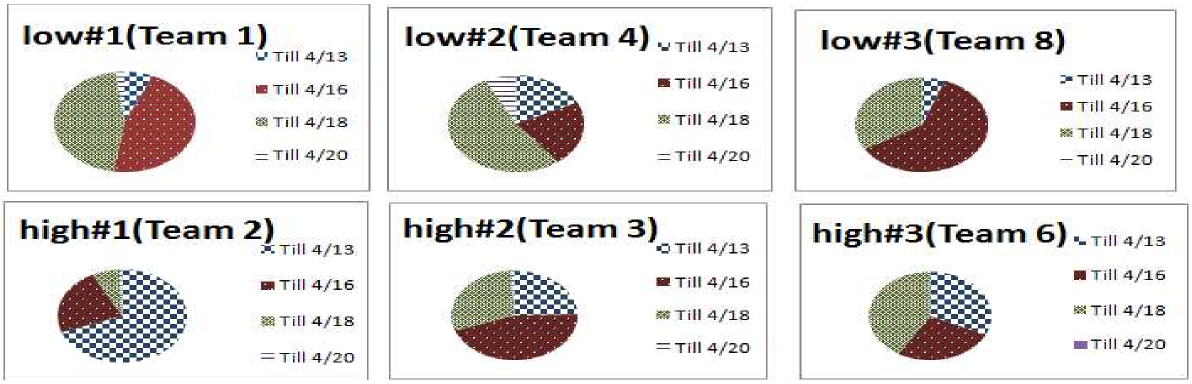

FIGURE 2. Contrasting distribution of work between top 3 (Hi-1 to Hi-3) and bottom 3 (Lo-1 to Lo-3) graded groups for V1 Release.

The top performing groups for the V1 assignment (High #1-#3) started early and completed a significant part of coding work the first week of the assignment, and submitted the V1 release on time. In contrast, the groups with lower grades for the assignment either did most of their work just before the due date (Low #1 and Low #3 completed over 90% of work during last 4 days), or did not complete the V1 release by the due date (Low #2 completed 7% of their work done after the due date). The highest performing group (High #1) had the most consistent schedule throughout the project (for both V1 and V2 assignments), and had the highest overall grade. These results show that activity levels in the VCS could be used as a metric to evaluate team progress during the course of the project, and that intervention may be justified when the results indicate lack of consistent progress.

7. The Role of Community on Team Performance (Community-Tools-Object)

The community in the activity system consisted of instructors, team managers, and the project teams. An analysis of the role of the community on performance, as measured by tool activity, is examined next.

7.1 Role of team managers on team performance

Team managers track team progress, resolve conflicts, provide a roadmap for task completion and advise students when team progress needs to improve. Team managers are paid students who have previously taken both courses. While going through the mangers' reports, we discovered two examples of manager influence on group performance. In the first example, the manager of Team 8 raised issues during the initial stage of the project. He pointed out that meeting attendance was very low, that students did not come prepared to meetings and work progress was very slow. The manager urged the students to work faster and reported that the team had a very low probability (15%) of submitting a completed quality deliverable for the V1 release. As shown in Table 2, Team 8 scored only 85% and had the 3rd lowest score for the V1release. Team 8 worked more consistently for the V2 release and achieved a high grade for V2. Thus based on the assessment, we find that manager could help students improve their work pattern. In the second example, the manager of Team 2 reported that his team was up to date in completing the tasks in the project roadmap. Figure 3 shows a project timeline contrasting the progress of Team 2 and Team 8. Team 2 started early and worked consistently throughout the project. They were the highest scoring group in the course.

These examples indicate that the team manager's analysis of team progress could be used as a metric to understand progress during the course of the project.

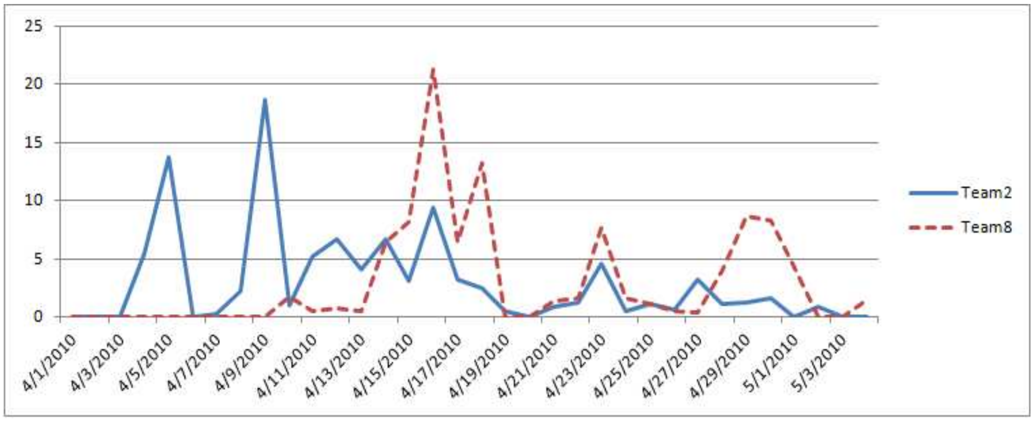

FIGURE 3. Number of updates to the version control system program files by Team2 and Team8 over time.

7.2 Role of late working students on team performance

In this section, the role of individual student performance on group performance is examined. Table 5 shows team performance and the numbers of students per team whose individual coding activity exceeded the class average activity during the last three days before the V1 release. Correlation between the number of late working students, as determined relative to the team average, to the number of points lost by a team for the V1 grade is 0.496 (p-value of 0.08 and 95% confidence interval values are between -0.12 to 1). The results show that it in a team's best interest to maintain student consistency.

TABLE 5. Correlation of the number of late working students to decrease in grade.

Team	Team Size	#Students in team working later than class average	V1 Release Grade (Team)	Difference of Maximum grade and actual grade
Team 1	15	11	79	21
Team 2	14	1	98	2
Team 3	11	4	100	0
Team 4	11	9	81	19
Team 5	10	10	90	10
Team 6	11	1	100	0
Team 7	14	9	95	5
Team 8	16	15	85	15

8. Summary and Conclusion

In summary, the usage of the wiki did not correlate to performance in the courses that we analyzed. Contributing factors include a lack of instructional emphasis on its use (in part because wiki usage was thought too complex for the instructional staff to assess) and student-reported difficulty using the tool for frequent updates and team-coordination activities. By looking at the use of tools and the influence of community, we discovered that metrics like VCS activity, team manager assessments, and team document generation might be used as measures to assess team progress. The results suggest that the collaboration might be helped by using a different wiki or project management system, and if the collaborative process is to be assessed, the tool must be enforced for good quantitative measurement results. Future work would involve analyzing the content of wiki and VCS systems using natural language processing and data mining to create qualitative metrics that can help better assessment of collaboration and learning.

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