Developing critical collaboration skills in project based courses

Pilar Pazos, Zikai Zhou and Nina Magpili
Old Dominion University

Abstract

In highly technical organizations, work is becoming increasingly distributed; requiring practicing engineers to master virtual collaboration skills while acquiring expertise in a range of collaboration technologies. Although there has been great emphasis on developing collaboration competencies in the engineering curriculum, empirical evidence of successful strategies for distributed team settings is scarce. As an attempt to fill this gap this study investigates the impact of a scalable intervention in developing virtual collaboration skills. The intervention, based on instructional scaffolds embedded with collaboration technologies, is aimed at supporting specific processes including planning, goal setting, clarifying goals and expectations, communication, coordination and progress monitoring. A quasi-experimental design was used to evaluate the impact of the intervention on student teamwork skills. Data from 278 graduate and undergraduate engineering students participating in virtual team projects was used in the analysis. Results from the analysis are presented suggesting a statistically significant impact of the intervention on self-management skills when comparing randomly assigned teams with and without the intervention. The intervention is designed to be scalable so that it can be embedded into existing project-based courses. Our findings have important implications for the development of teamwork skills in engineering courses and provide evidence of a successful strategy that can be integrated into the existing engineering curriculum.

Keywords

Virtual teams, team effectiveness, information and communication technologies, engineering education, collaborative learning

Introduction

The ability to work on multi-disciplinary teams constitutes a critical competency to succeed in an engineering career.[1,2] Many academic programs are invested on developing these skills through initiatives such as Columbia University's Gateway design course,[5] Massachusetts Institute of Technology's undergraduate design course and its "New Products Program"[6] and Rowan University's Engineering Clinics Program.[7] Although these efforts constitute very valuable initiatives for the development of teamwork skills, a recent review of research on engineering student teams suggests that our understanding of how best to cultivate and assess collaborative learning outcomes in engineering students is not well understood.[11]

Methodology

This paper describes a scalable intervention that combines the use of a web-based collaborative platform with embedded instructional scaffolds designed to support project-based teamwork. The

intervention was implemented in existing courses without changing the content. It was developed based on state-of-the-art knowledge on team effectiveness from the industrial, behavioral and cognitive psychology fields, as well as technology appropriation and acceptance theories from the field of Management Information Systems.[17-22,23] The approach was designed to support specific cognitive and behavioral team processes such goal setting, planning, strategy formulation, team monitoring and coordination.[7]

The collaboration tool was designed to provide easily accessible tools that best align with the specific activity or task that teams need to accomplish at different states of the project using the principles of task-technology fit. Figure 1 some key elements of the collaboration platform and the processes that the platform was designed to support. It includes tools that can be used to support communication, collaboration and progress monitoring such as an embedded videoconferencing tool, a file repository with version control and a task-tracking tool. Along with the tool, the intervention included critical activities that the teams were required to complete as part of the project to support collaborative work. Some of the activities included a team building exercise, development of a team charter and a project plan.

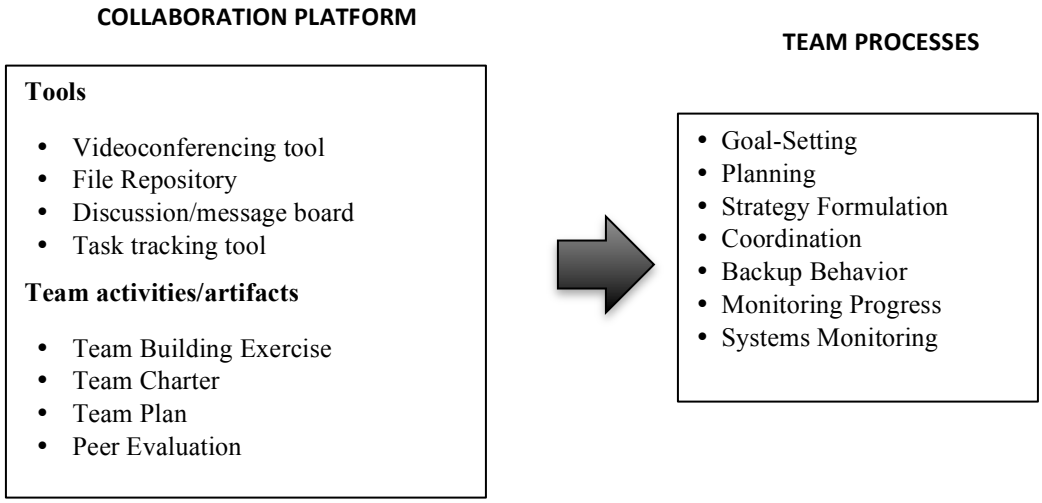

Figure 1: Elements of the collaboration platform and associated team processes

The video conferencing tool allows teams to communicate using high quality video and audio. The file repository relies on Google Drive and other Google Applications to allow for version control, document tracking and remote collaborative writing and editing. The repository has a prebuilt folder structure to organize the different types of project documents. Figure 2 includes a screen capture of a sample team home site that shows the team mascot, conference room access button (Hangout button) and team plan. The team mascot shown in the home page was an outcome of the team building exercise. The team developed the mascot during the first week of the project as one of the required activities and it represents the shared values of the team members with respect to the project.

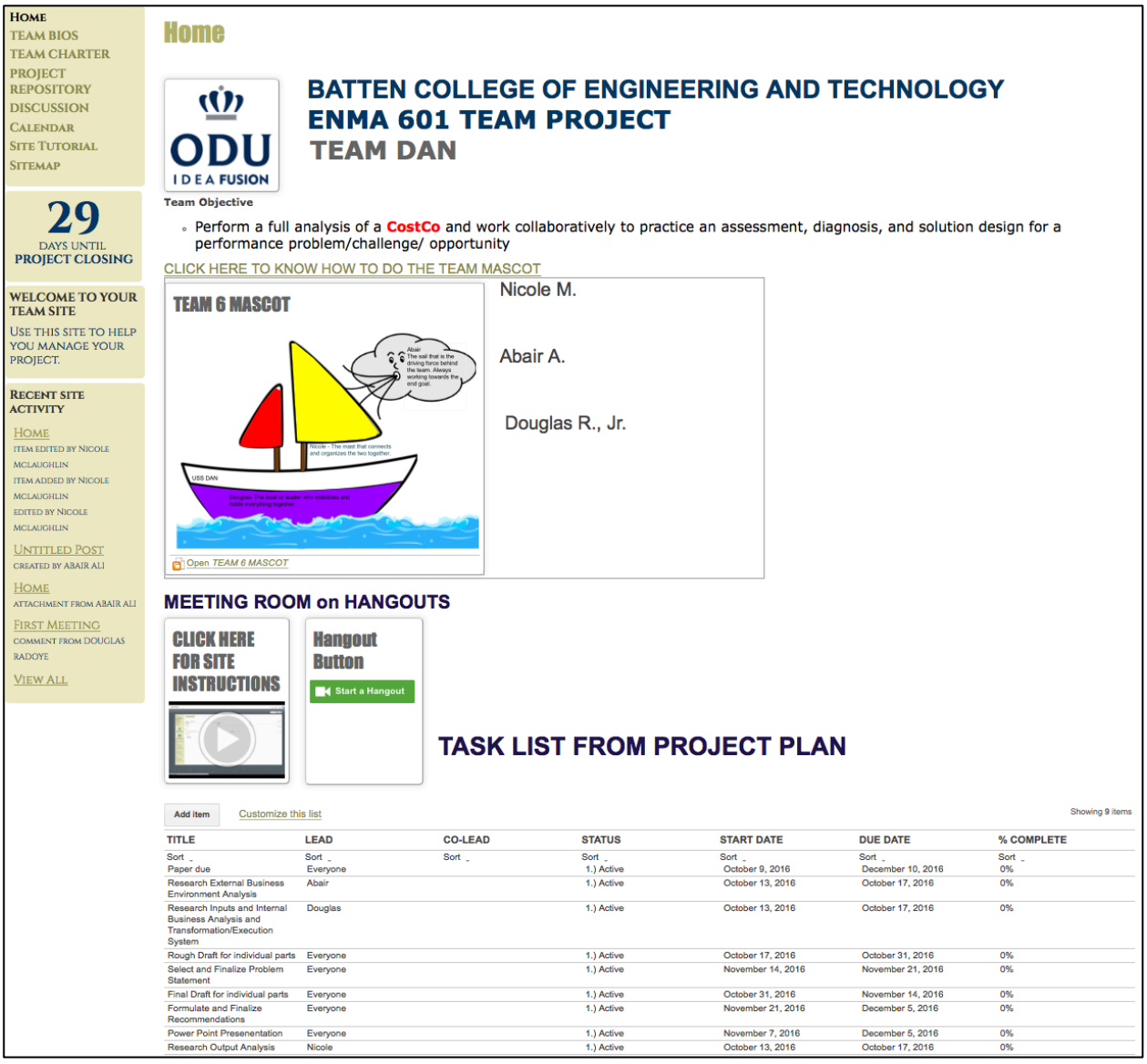

Figure 2. Screen shot of a sample team site

We evaluated the impact of the tool on teamwork activities using a quasi-experimental design. Results obtained to date have shown that the intervention has a significant impact on teamwork skill development. In particular, students that went through the intervention displayed a significantly higher ability to manage team projects than those in the control group. Teamwork skills were 7% higher in the teams that went through the intervention after controlling for incoming skills before the project (Pazos, Magpili & Zhou, 2016).

On a follow-up study (Magpili, Pazos & Ullal, 2016), we used qualitative inquiry to further explore what tools were more useful in supporting teamwork. Based on our findings, the tools, activities and artifacts provided to teams largely supported team processes as shown by the high percentage of teams which reported benefiting from the tools (90%). In general, the data

suggests that the majority of the teams found the scaffolds generally helpful in supporting the following processes:

- Team coordination. At least 81% of the teams reported benefiting from the collaborative platform to help them coordinate tasks in their project. The specific tools that they found most useful were the video conferencing toll and file repository.
  An illustrative quote on how some of the tools supported the teams is shown below:

  "Google hangout and the video chat capabilities … seemed to work really well. Regardless of really whether or not we had much to discuss, we always had a standing weekly meeting even if it was for a few minutes. If we were just working on just assigned tasking and we didn't have a decision point, we still discuss together … and just made sure everybody is on the same page".

- Progress monitoring. At least 80% of the teams reported that the collaborative platform helped them monitor individual and collective progress on the project. A quote to illustrate a specific instance is shown below:

  "Everybody set up their own little section, we each had whatever parts we had. It had our name and whoever co-help was and then our dates so I thought that was perfect. Go ahead, work at your own pace, set your own dates, just know that our final needs to be finished at this particular date. I did it that way. I was checking off my stuff, putting up progress like 60% done here. No one else really seem to so I had sent out weekly reminders saying hey guys where are at? What are you doing? Nobody really responded. . .but the tools that were provided, no one used them I was the only one, it was incredibly frustrating the entire semester."

The overall results of qualitative analysis showed that the intervention was very supportive of effective teamwork processes. The analysis also uncovered a wide variety in the way teams used the tools to support their collaborative work. Most teams used different combination of tools to support different processes based on their preferences.

The result from the qualitative analysis also helped identify the most common barriers preventing teams from using and benefiting from the tools, activities and artifacts to support team processes. These factors that were reported as barriers for successful teamwork include lack of initiative in team members, task orientation, team turnover, and perceived ease of use of the tool. Team turnover emerged as a driving factor affecting teamwork. Team turnover affected team processes by negatively influencing the morale and level of initiative of the team. Developing training that teaches students how to make their team adaptable to sudden changes in membership may help. Another option is to keep a stable team membership for student teams by increasing the initial team size to account for possible dropouts. A small number of teams focused excessively on the task while largely ignoring the interpersonal aspect of collaboration. They reported having a less successful experience than those that focused on both the task and the collaboration.

The combined results from the mixed (qualitative and quantitative) methods study provide evidence of a successful approach to improve collaborative work in the engineering classroom. By incorporating some or all of the previously described tools and activities in an existing project based course, has great potential in creating more successful team project. With respect to the experience for the faculty teaching the course. They reported having to invest less time and effort in managing teams and they perceived that quality of the projects was higher when using the intervention. Further analysis are being conducted to test whether their observations are statistically significant.

This study comes with some limitations. Data collected during the qualitative study relied on structured interviews with students. These data, as it is typically the case in similar studies, relied on what the interviewees remember. Students' description of past events might be limited by the individual ability to recollect facts and events. We used additional sources of data to triangulate the results from the interview analysis (collaboration platform activity log, progress reports and team reflection essays).

Acknowledgements

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