A Qualitative Inquiry into the Role of Web-based Collaboration Tools and Instructional Scaffolds in the Facilitation of Team Processes

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Globalization and advances in information technologies drive organizations to use virtual team structures to support work accomplishment. Information and communication technologies (ICT) are continuously evolving to support effective collaboration among remotely located individuals.[1]These technologies constitute the operational environment of any virtual team, making it critical to examine how they can be used and developed more effectively to support team processes.

Institutions of higher education have acknowledged the importance of preparing students to thrive in this global environment. Future engineers must develop critical professional skills such as the ability to work in teams. Leading engineering scholars and educators increasingly recognize teamwork and communication skills as critical competencies required for successful professional practice.[2,3] To fulfill this requirement, educators have developed team-oriented projects and activities in engineering courses that help enhance and cultivate these skills.

To work effectively in teams, students must master collaborative skills including efficient sharing and processing of information, collaborative problem solving, communication and conflict resolution among others. While some technologies have been found to support collaboration, they can also add a layer of complexity to the virtual team interaction. It has been suggested that most existing engineering programs don't fully incorporate the opportunity for students to master technology-supported teamwork as a core element of the curriculum.[4,5] In addition, courses that use team projects give little consideration to the cognitive and behavioral processes such as team building, clarifying goals and expectations, planning, communication, consensus building and conflict resolution; which hold the key to successful collaboration.[5,6] A recent review of research on engineering student teams suggests that our understanding of how best to cultivate collaboration amongst remote teams of students is largely underdeveloped[7]. Others have noted an opportunity to capitalize on much of the life-long learning that can occur through team dynamics and interaction.[6]

Web-based scaffolds that include technologies and team activities help enhance virtual team collaboration by providing support for online collaboration. A team scaffold is a stable structure that helps students to act like a team.[8] It enables specific collaborative behaviors to occur that would otherwise be difficult. Scaffolds themselves do not directly enhance students learning, but rather make it easier for students to learn on their own or with others by enabling access to resources and other team members who provide content and ideas that, in the end, become part of their individual cognition.[9,10] Therefore, new knowledge related to how students use web-based instructional supports will help to positively influence learning outcomes.[11-13]

Team processes are integral components of successful collaboration and learning that can be supported by scaffolds. Paucity of research exists that explores the use of scaffolds to facilitate effective virtual team processes. This paper explores the role of a collaboration platform with embedded instructional scaffolds on supporting team processes in engineering student virtual teams. This knowledge will have a positive impact on the quest to further enhance virtual team collaboration.

Foundational knowledge on team effectiveness from the industrial and organization psychology field and by social-constructivist learning theory informs the design of the platform. The collaboration platform incorporates tools, features and artifacts designed to support collaboration in the context of a group project in engineering courses. The collaboration platform includes elements such as team profile, team charter, Gantt chart, message board, automatic reminders, project repository, task progress tracking, etc.

Theoretical Foundation

The theoretical foundation of this research is built on social constructivist theories suggesting that collaborative learning can be facilitated by scaffolded instruction that allows collaboration and interaction in authentic environments using state of the art tools and processes.[6] Scaffolds are defined as instructional supports in the guise of tools, artifacts or guided instructional materials that facilitate task completion. Scaffolding offers a powerful approach to support learning in complex collaborative environments.[6,7] Through scaffolding, learners can accomplish complex tasks that they will have difficulty completing on their own.[9] The provision of expert support for learners surpasses unsupported instruction with regards to the effective transfer of knowledge.[6] Collaborative work largely reflects the actual environment in engineering-intensive organizations that use interdisciplinary teams to solve engineering problems. By carefully constructing guidance to support the team in the form of tools and guided activities, we can facilitate and evaluate interactions and then further determine design improvements to ensure that effective collaboration takes place. The structure and goals of the collaboration tool and instructional scaffolds aligns with evidence-based research and the foundational knowledge of team processes and team effectiveness.[14-16] The collaboration tool was built using Google Apps that are freely available through the university and customized using Google Script. The tool's features were incorporated to address the key barriers to remote collaboration and aligns with best practices in virtual teams.[17] Two prior empirical studies support the effectiveness of the intervention (scaffolds) by empirically showing that a combination of the collaboration tool and embedded scaffolds have significant impact on teamwork skill development for engineering students.[18] We extend this study by exploring qualitatively how the scaffolds supported collaborative work and what elements of the intervention made an impact to the different processes that teams go through when working in projects.

Figure 1: Example of a Team Site with Embedded Scaffolds

In the succeeding sections, we present the research questions and the qualitative methodology undertaken to answer the research questions. Lastly, we present and discuss the results as well as provide insights into their implications on research and practice. We also present recommendations for future research and practices.

Research Questions

The following questions guided the qualitative inquiry:
1. How do collaboration tools, team activities and artifacts (scaffolds) support virtual team processes?
2. What other factors affect the extent and manner in which these tools, activities and artifacts support virtual team processes?

Figure 2 below illustrates the conceptual relationship between specific features of the scaffolds and key processes in collaborative settings. As shown in the figure below, the key elements of the collaboration tool include an embedded videoconference tool, a file repository with the ability to maintain version control, a message board and a progress-tracking tool. The figure also shows the scaffolded activities and artifacts that teams used along with the collaborative tool.

The team processes are based on a widely accepted framework of team processes from the team literature.[19] Transition processes have been defined as activities in which the teams focus primarily on preparation and planning activities to guide the accomplishment of a team goal or objective.[19] It includes activities related to goal setting, planning and strategy formulation. Interpersonal processes represent interactions and activities related to managing interpersonal relationships.[19] It includes conflict management, motivation and confidence building and affect management. Action processes have been defined as activities during periods of time when teams engage in actions that contribute directly to accomplishing the goal of the team.[19] They classify action processes into monitoring progress towards goals, monitoring the overall system (resources and environmental conditions), backup behaviors and coordination.
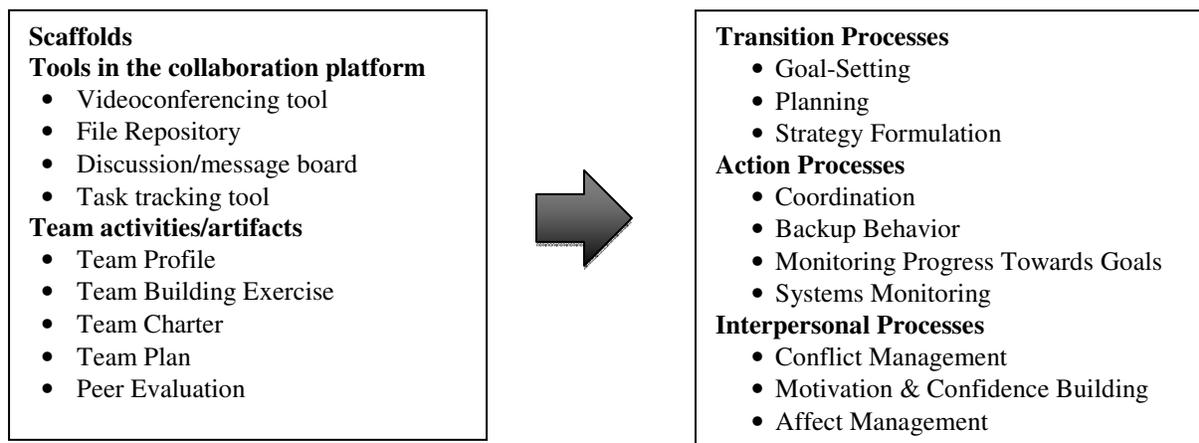

Scaffolds
Tools in the collaboration platform
  • Videoconferencing tool
  • File Repository
  • Discussion/message board
  • Task tracking tool
Team activities/artifacts
  • Team Profile
  • Team Building Exercise
  • Team Charter
  • Team Plan
  • Peer Evaluation
	Transition Processes
	  • Goal-Setting
	  • Planning
	  • Strategy Formulation
	Action Processes
	  • Coordination
	  • Backup Behavior
	  • Monitoring Progress Towards Goals
	  • Systems Monitoring
	Interpersonal Processes
	  • Conflict Management
	  • Motivation & Confidence Building
	  • Affect Management

Figure 2: Conceptual Relationship between Scaffolds and Team Processes

Method

We used an inductive inquiry approach to gain insight into how the tools supported team processes by using a loose type of qualitative research method following the guidelines set by Miles, Huberman & Saldaña to be able to extensively explore the rich context in which teams operate. [20] Qualitative studies aim to explore the rich dynamics of a phenomenon of interest by organizing the rich information into themes to explain the phenomenon under study leading to the emergence of relevant factors and outcomes.[21-24] whereas quantitative studies provide the researcher an empirically-based simplified version of the relatively more bounded phenomenon with pre-determined variables at the start. It is important to note that both studies are empirical in nature but they differ in their goals, approach and outcome. The qualitative approach is richer in detail and less bounded whereas the quantitative approach is very specific and bounded. A qualitative approach can provide an enhanced understanding of the complex dynamics of the team-technology interaction that cannot be attained through a quantitative approach.

There are two types of qualitative research method - loose and tight. A loose type of qualitative research allows emergent themes to emerge whereas a tight type of qualitative research aims to verify a pre-determined conceptual model. The loose approach is deemed appropriate for our study because the research questions have been largely unexplored in prior literature and not all the intervening factors are well understood.

The approach described in this work represents the second stage of a two-stage mixed methods study. The first stage of the study looked into the impact of the intervention from a hypothetical deductive perspective and showed evidence of the positive impact of the collaboration tool and embedded scaffolds.[18] The study reported here is the second stage qualitative analysis that explores how the intervention (collaboration tool and scaffolds) are used to support different team processes as well as factors that affect this.

To address the vast amount of information analyzed in a qualitative study, a rule is typically used to determine when sufficient data has been collected. The rule is that data collection can stop when further collection of data does not modify or change the constructed theory at hand. This stage is known as *theoretical saturation.*[25] This study provides an unusually large sample size when comparing it with what is typically found in qualitative research.[20]

Participants in this study were enrolled in a semester-long graduate-level engineering course (Fall 2014, Spring and Fall 2015) where they worked in a virtual team that was tasked to conduct a systems analysis of a large Fortune 100 company and provide problem statement and recommendations. The students went through 30-minute in-class training module to learn how to use the collaboration tool. They were also provided with a training video accessible directly from the collaboration tool. The professor highly recommended the use of tools but extended some flexibility to the students by allowing them to use substitute tools (Webex, Smartsheet, etc.) if they want to. Substitute tools that highly resemble our scaffolds were considered part of the intervention. The students also received extra points for using the scaffolds provided. Twenty-five one-on-one interviews with students serve as the major source of data. Participant's ages ranged from 22 to 50. The majority of students were not familiar with the tools used in the class. Each structured interview lasted approximately 30 minutes. After the interview, the audios were transcribed and coded. The research questions guided the inquiry by providing the basis for the constructs used to code interview data. The core constructs of this study relate to virtual team collaboration technologies, team activities, artifacts and team processes.

Even though qualitative studies do not emphasize analysis through numbers, patterns emerge when something happens consistently. To increase the validity of our conclusions, counting is essential to discover patterns in the relationships between variables. This method also protects researchers from bias especially since humans have the tendency to base conclusions on instances that they recall first or appear more salient in their memory.

Our coding of interview data allowed the comparison and contrast among teams. We observed which teams experienced a particular incident and which teams didn't. Then we examined the differences among the two groups by comparing them using other constructs. To move to a higher-level analysis, we subsumed particular categories into more general ones by combining incidents or relationships that go together. While doing that, we implemented enumerative induction where we collected instances that go in the same direction as well as eliminative induction where we tested existing relationship with counter-evidences. Through this, we discovered intervening variables and ruled out spurious relationships. Finally, we looked for theoretical constructs and explanations from literature that align with our resulting framework to achieve theoretical coherence. This process links our raw data with theory.

Results

This section describes the major findings regarding how specific tools, activities and artifacts supported particular team processes as well as other factors that affected the ability of the scaffolds to support the team processes.

A. Transition Processes

The majority of the respondents reported a number of tools, activities and artifacts that supported their transition processes. The most common tools and artifacts that supported transition processes were the team charter, project plan and the web-conferencing feature (Google Hangouts). The percentages of teams (shown in parentheses) who reported specific tools, activities and artifacts as being helpful in supporting each type of transition process are as follows: for goal-setting, the team charter was the most widely used (70%); for planning, the team charter (82%) and project plan (81%); and for strategy formulation, the project plan (38%). Furthermore, data suggested that planning had a direct effect on action processes as indicated by 75% of the teams. In particular, the planning process facilitated the subsequent coordination, monitoring towards goals and backup behaviors.

The teams used the team charter and project plan to set goals and plan for the project.

We spent a little time discussing the charter and project plan and said who would take on what sections. Setting up the goal, obviously we wanted an A on the report. And we wanted to learn more. And I think one of our goals was specifically to learn more about the topic we were writing about. We set those goals. And at that time, we hadn't done that kind of research. We've only just done the preliminary aspects of it so we kind of set out responsibilities and specific goals for each person. . .We'll have the portions of it done on these dates. So the charter and project plan helped with that. And we never needed to go back and adjust those goals with the exception of some minor adjustments. . (Team Member 4BF14)

The team charter helped in setting roles and responsibilities during planning. The teams' decision to assign roles determined how they were going to coordinate (action process).

The team charter in terms of rotating responsibility, we had 4 roles like an editor, a prime researcher and team lead who's supposed to be the one to interface with the instructor. And then the other one was the secretary, which was also kind of like the de-facto meeting coordinator. The person who was keeping a tabs on what do we need to accomplish this meeting and then that person was the one who updated the meeting minutes. That duty rotated as well. . .I think that was a good way to keep everybody involved and kind of on task. Cause hey this is my time to conduct the meeting. And it kinda of puts you in the spot little bit too. Because you got to make sure you are staying plugged in to what the task is. (Team Member 12AF14)

The teams implemented strategy formulation during their meetings in Google Hangouts by reassigning tasks and adjusting due dates in the project plan.

Every week in Google Hangouts when we meet, we see how much we have accomplished. Is it finished or incomplete? Are we having any difficulties in doing that? We helped out with each other and we assigned a new date when that can be finished. (Team Member 2AF15)

Some teams also implemented strategy formulation by reassigning tasks in the project plan after a team member drops from class.

We decided to adapt. We hadn't done too much other than assign who is going to do what or who is going to research what. We had already begun doing that so as soon as he dropped, we had to rearrange who is doing what so we just had to take on a little bit more than we thought we were going to have to do because we were splitting it 50-50. (Team Member 2CF14)

A few teams experienced some challenges in using the activities and artifacts to support planning. Only two teams (12%) reported that the team charter did not support them in assigning the right roles to the right members. They reported that the team charter did not help them assign roles effectively because they assigned the editor role to someone who lacked writing skills that they did not know about until they received the first draft of the paper.

The few teams that reported the project plan did not support planning also acknowledged in the interviews a lack of initiative (19%) as a barrier:

There was a lot of ambiguity about who's gonna take over the leadership role. I felt like some folks require, they wanted to have meetings every week when I didn't feel like it was necessary and I felt like the path has been clearly laid out. I guess just in general I would say it kind of reminded me of taking a step back from where I am in my career to being on that level where you are subject to everybody's wants and needs a lot more than I am now. To be honest with you I ended up. . .I just kind of got tired of the back and forth. I personally made the plan …, said alright what do you guys think about this, and everybody said all right it's good. So that was what ended up get put up in the Google drive or out in the Google team site." (Team Member 5CS15)

In summary, the scaffolds largely supported transition processes including planning, goal and role setting. A very small number of teams reported not benefiting from the tools to support transition process due to intervening factors such as lack of writing skills and lack of initiative from team members.

B. Interpersonal Processes

Our analysis suggests that a variety of tools, activities and artifacts supported interpersonal processes. The percentages of teams (shown in parentheses) that reported the tools, activities and artifacts for the specific type of interpersonal processes are as follows: for conflict management, team charter (70%), mascot team building (31%), project plan (25%) and Google Hangouts (19%); for motivation and confidence building, mascot team building (50%) and bios (31%); for affect management, mascot team building (19%). Conflict management involved setting expectations, establishing consequences for actions and managing process conflict. Motivation and confidence building comprise getting to know one another. Affect management constitute

experiencing fun while getting to know one another. Conflict management was also found to facilitate action processes (31%).

The quote below shows an example of how mascot team building helped with motivation and confidence building:

I think that just helped us to. . . we were still getting to know each other at that point in time. So it gave us a little bit of background information on each other. Where we work, what our experiences were. Yeah, that was good. (Team Member 12AS15)

The next quote shows an example of how teams used the team charter to set expectations.

We just said if any member doesn't pull their weight, we'll just going to tell the instructor to get him off the team. (Team Member 12AF14)

A few teams reported not gaining a benefit from specific activities and artifacts to support interpersonal processes. Three teams (19%) claimed that one specific activity, mascot team building, did not support interpersonal processes as a result of their task orientation. They claimed that the mascot team building did not help their team because they felt the activity was not part of the critical task.

"I think the mascot. . .I think there is a lot other things were going on and it is one other thing that is not really a part of the critical task. I understand the point of it is the team building exercise, but for me in my group, we just kind of had like an intuitive understanding that our time was limited so let's just get down to business and do this thing. Let's not wait around and develop mascot and stuff." (Team Member 12AF14)

A small number of teams reported not using the bios (19%) for motivation and confidence building or the charter (13%) for conflict management because of lack of initiative from team members in developing them.

"I didn't know that was there (bios). I guess we all missed that thing because there wasn't any discussion on the bios." (Team Member 7DS15) (This particular team had team members that lacked initiative which is the reason why they failed to use the bios.) *Nobody really responded, they were like oh yeah, I'll be done by the deadline, that was what I would really get. . .but the tools that were provided, no one used them, I was the only one, it was incredibly frustrating the entire semester." (Team Member 7DS15)*

In summary, the majority of the teams reported that the tools, activities and artifacts supported interpersonal processes. The few teams that reported not benefiting from some of the tools identified some intervening factors such as high task orientation (the team building activity was perceived as not adding value to task) and lack of initiative in other team members to complete the task.

C. Action Processes

Data indicates that most of the teams used several tools to support specific action processes. The following results outline how teams used the tools to support each type of action process. Figure 3a and 3b below show the combination of tools that each team used for monitoring progress towards goals and coordination respectively.
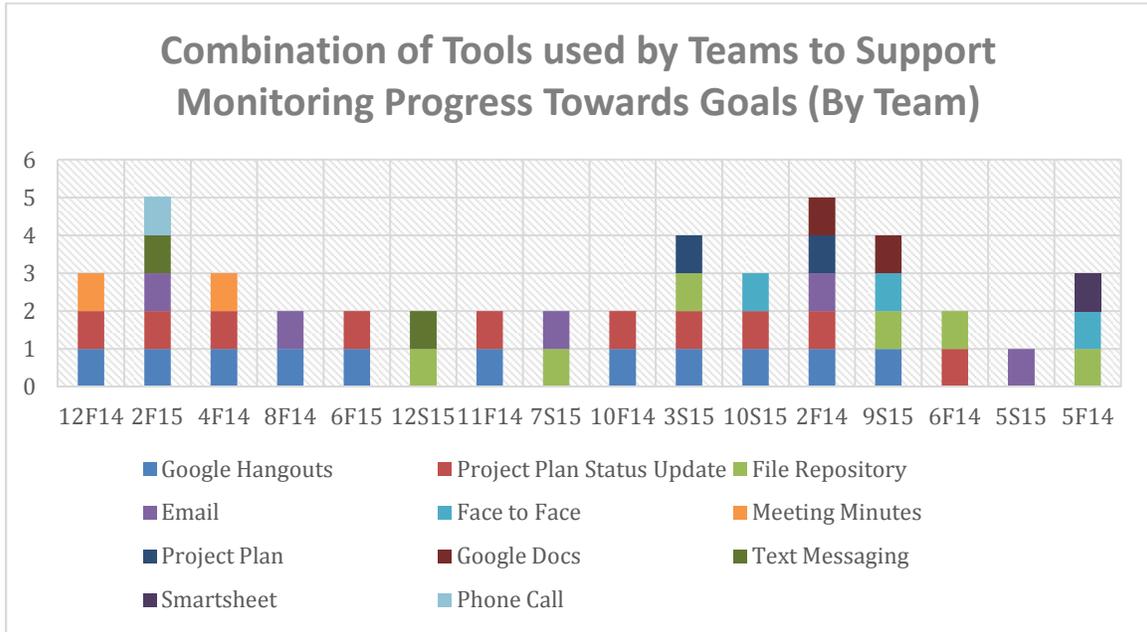

Figure 3a: Combination of Tools Used by Each Team to Support Monitoring Progress Toward Goals
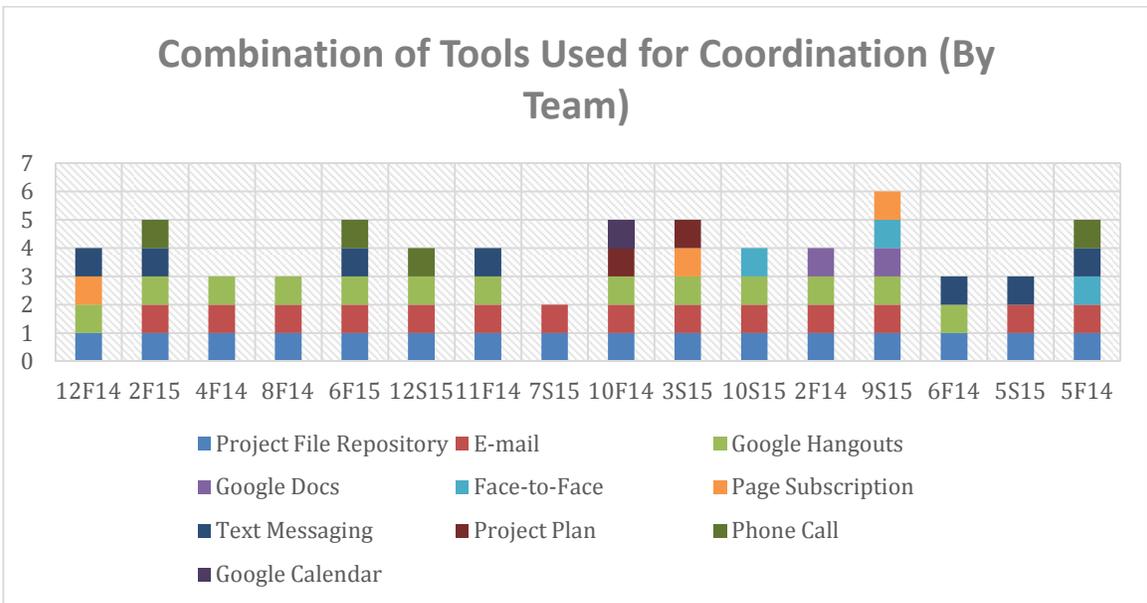

Figure 3b: Combination of Tools Used by Each Team to Support Coordination

As the graphs suggest, each team used a different mix of tools to support their action processes but most of the teams used at least one tool. This finding pertaining to the varied use of technology by teams has been supported by prior research. For instance, Bjørn and Ngwenyama have put forth the concept of open-endedness of technology based on the findings from their qualitative study where they observed teams that had the same available technology but developed distinct patterns of technology use.[26] The teams participating in our study had a similar experience. Although the teams widely used the available tools to support action processes, they varied in the manner in which they appropriated them.

1. Coordination

The majority of the teams reported using some of the tools to help them support coordination processes. The main tools used to support team coordination (percentages of teams shown in parentheses) were Google Hangouts (75%) and project file repository (70%).

Google Hangouts was reported being used primarily for meetings.

Google hangout and the video chat capabilities, that 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 like 5 minutes. If we were just working on just assigned tasking and we didn't have a decision point, we still discuss together even if it was for 5 minutes and just making sure everybody is on the same page. (Team Member 12AF14)

The project file repository was used to store drafts for others to see, review and edit.

I think for me there are a couple of things that worked really well. First of which was the project file repository. That seemed to work really well when we're all uploading different sections and … we get an alert when somebody post something or when something is updated. We used the project repository explicitly for transferring files and uploading. I was the one that was responsible for the final editing ... Once each individual section was edited and uploaded I took it all, coalesced it, edited it again and posted it. Now everybody had the opportunity to sanity check it. (Team Member 12AF14)

Four teams (25%), primarily low performing teams, reported some challenges that prevented them from using Google Hangouts to support coordination. Five teams (30%) reported challenges that prevented them from using the project file repository. However, the majority of the teams (81%) reported using at least one of them to support coordination. The few teams that did not benefit from a specific tool cited lack of initiative as the major factor.

"Yeah nobody had uploaded (in the file repository) until it was absolute final product of it. . . a member of our group did not hand in the project to me to combine it all until 11/15th, the night it was due." (Team Member 7DS15)

In summary, the majority of the teams reported that the tools and activities helped with the coordination. A small number of teams reported not using the tools to support coordination by indicating that they experienced challenges such as lack of initiative in the team.

2. Monitoring Progress Toward Goals

Monitoring progress towards goals is one of the main team processes that teams reported as being supported by the scaffolds. Monitoring progress is a major issue for virtual teams because the lack of visibility and direct access to team members prevent individuals from knowing immediately how their team members are progressing. The majority of the teams reported using the task tracking tool (70%). The quotes below show how some of the teams used this tool to track their progress.

We updated it pretty regularly. As a matter of fact, we made it a point to update it at the conclusion of every meeting. It only takes like 30 seconds. (Team Member 12AF14)

Every time we met we go back through that schedule that was on the website and we would update it on the website as needed so that everybody knew what was going on when it was going on. (Team Member 6CF15)

Thirty percent of the teams experienced challenges that prevented them from using the tool to monitor their progress towards goals. Two teams experienced problems in monitoring their team members because of lack of initiative to update the tracking tool.

"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." (Team Member 7DS15)

Three teams used substitute tools for progress tracking such as e-mail, text messaging, and Google Drive.

We track our team progress mostly through email. E-mail was my preferred method so if we have a deadline coming up in a couple days before I would just say, are you guys on track? (Team Member 5AS15)

In summary, the scaffold largely supported monitoring progress towards goals process except for a few instances when team members lacked initiative or used substitute tools.

3. Backup Behavior

Backup behaviors in the context of this study were exemplified by helping others through reviewing, revising and editing other's sections, sharing articles related to the project and

teaching others how to use a particular tool when others are not familiar with it. It also includes collaborative behaviors that lead to exchange of ideas and joint decision making. Teams reported (percentages of teams shown in parentheses) using mostly two tools to support backup behaviors including Google Hangouts (50%) and file repository (31%).

The quotes below show how Google Hangouts was used to support backup behaviors.

Yes, we shared our screen in Google Hangouts and also the view option that was available on hangouts so that we didn't have to download every document. We can just view it and work on it. As we were reviewing whatever someone posted, right after they posted it, review it and start discussing it. And also during every meeting we would share screens, whoever is doing the thing for the day or discussing something or sharing ideas with the team, we always share screen for that. (Team Member 3AS15)

The following quote illustrates how the project file repository was used to support backup behaviors.

We used the file repository on the team site. . .like Team Member 2B (F14) posted a SWOT analysis of our company on there and he was like hey take a look at this. I think I'm gonna include this in our paper and then whenever we were finished with a specific revision of our document, we uploaded it there so it was easy. . .we never had a problem accessing any work that we did.. (Team Member 2CF14)

Project file repository was reported not being used to support backup behaviors in 25% of the teams while Google Hangouts was reported as not being used to support backup behaviors in 19% of the teams. The incidents below show examples of these situations.

One individual's lack of access to Google Hangouts at work forced the team to do most of their collaboration through text messaging. A comprehensive look at this team's data suggested that this approach to collaboration negatively influenced backup behaviors by limiting the ability of the team to share meaningful feedback and integrate the content of the project.

"We did a lot of text messaging. But we didn't do it via hangouts (Google Hangouts), we actually did via our phones. Where I work I can't access Google Hangout. ...We would actually do our little group text meetings where we could just talk about something and break it up. We make decisions that way. . . I think we had somebody on our team who is a good engineer but not a very good writer and that was tough. I guess, we did help. . It was in really rough shape when we got the first draft of that section. And that was tough. . I could have gone back and just done all the research myself and did the whole section but I thought that was unfair and I really need to focus on the stuff that I was doing as a part of the paper. We really didn't synthesize information. Mainly, the writing and revising and editing part, we interacted. We did a lot of editing where we needed to do it. Like I said, not going back to actually redoing the research. (Team Member 6AF14)

Another team failed to use Google Hangouts and Google Drive for backup behavior due to team turnover and lack of initiative.

. . .the assigned tasks like he wasn't able to finish them according to the schedule. So two weeks before the end of the project, we decided to hand over the work that we did in the sections to one another. I did the four first sections and he did the last two sections. There wasn't very much that he did for the first sections and I didn't do much for the last except I gave him some ideas (Team Member 9CS15). . .My team experience was not very satisfactory. We lost a team member immediately so we were reduced to a team of two. I was thinking that would probably improve communication but, somehow it hindered it. It seemed like it kind of blew the morale of the team so we had a little rough start communicating and getting everything in line. We kind of ended up piling up a lot of the stuff towards the end of the project so it was pretty detrimental losing that person and then trying to recover from that in such a small team. . . .there was a little problem with the communication. We would schedule meetings and I would say 75% of the meetings would come through and about 25% would either get blown off, forgotten about or be just ineffective even if we had them. (Team Member 9AS15)

In summary, Google Hangouts and the project repository were the tools most frequently reported as being used to support backup behavior. Teams reported using it in helping others by reviewing each other's content, editing other's sections and sharing resources. There were a few instances when teams reported not using specific tools for backup behaviors. The most common factors preventing the teams from using the tool were lack of initiative, team turnover and lack of access to the tool.

Discussion

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. In general, the data suggests that the majority of the teams found the scaffolds generally helpful in supporting transition processes (goal setting, planning, strategy formulation) and action processes (coordination, backup behavior, monitoring progress and monitoring systems) and to a lesser extent interpersonal processes (conflict management, motivation, and affect management). There were a small percentage of teams that did not find the tools beneficial for specific processes. Those instances were reviewed in great detail with the goal of enhancing the design of the instructional scaffolds so that they potential impact can be further enhanced. 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.

This study also helped shed light into the barriers preventing teams from using and benefiting from the tools, activities and artifacts to support team processes. These intervening factors include lack of initiative, task orientation, lack of writing skills, lack of access to the tool, teamwork skills, team turnover, technology familiarity and perceived ease of use. These intervening factors are associated to individual and team aspects. These findings align with two existing theories, sociotechnical systems (STS) theory[27] and adaptive structuration theory (AST)[28] which claim that the effectiveness of tools are not solely determined by the technology itself. Instead, there is a two-way interactive relationship between the characteristics of the users and tools. However, these two theories do not explore the relationship between scaffolds (including technology, activities and artifacts) and team factors at different levels (individual and

team). Our study fills this gap by uncovering how scaffolds can be used to support collaborative process and by identifying the major enablers and barriers at the individual and team level that influence how scaffolds are used to collaborate.

These results provide several avenues for further improvement of collaborative work. A deep understanding of how students used the scaffolds along with the challenges they encountered can be used to improve the future of activities and structures to support collaborative work.[29] We found that the level of initiative or engagement of individual team members is a recurring factor across all types of team processes (100% of team processes) and across all teams (100%) that influenced the extent to which the scaffolds supported team processes. Those teams who had members with high initiative (enabler) did not experience any challenges (63%) in using the scaffolds while teams who had members who lacked initiative (barrier) experienced challenges (37%). The role of individual initiative as a key intervening factor in this study brings to the forefront the importance of individual characteristics in successful collaboration. Prior research has suggested that improving the design of the scaffolds can actually help enhance the level of initiative and motivation of individual team members. Belland, Kim and Hannafin have acknowledged that educational researchers and designers usually have the misconception that when students are presented with challenging and authentic projects, they will automatically be engaged.[30] However, their research found evidence to the contrary, specifically when student motivation was not considered in the design of the scaffolds. Lack of motivation not only affects team interaction, but also the student's ability to transfer what they learned in the team into their work life.[31] Belland and colleagues proposed ways to improve scaffolds that enhance motivation and engagement in students by using motivation theories.[30] To increase motivation, they suggested establishing task value, and promoting mastery of goals, belonging, emotion regulation, expectancy for success, and autonomy.

Other intervening factors were found such as team turnover, lack of access to tools, task orientation, lack of writing skills, teamwork skills, technology familiarity and perceived ease of use of technology. However, since these factors did not affect all the team processes (20 – 60% of team processes) and were only experienced by a few teams (6 – 25%) so they are not considered major factors. However, we still present some suggestions for future research and potential approaches to address some of these barriers.

Since technology familiarity emerged as a minor factor in technology use, educators should put effort into providing training for their students when they face new technologies. This research used in-class training and an instructional video to prepare students to use the technology. However, it was found that not all students were present in the training or did not watch the instructional video. Resistance may abound when students are not familiar with the new technology, thereby, negatively affecting their team processes as well as their team-based learning. The user-friendliness of the interface of technology is also critical as it determines the perception of ease of use of technology that drives technology use. A user-friendly interface greatly encourages teams in using new technologies. Although our intervention included training, an enhanced version of the training may be needed to ensure transferability and effective use of the technology by all students.

Team turnover emerged as another minor driving factor. 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.

Excessive task orientation (task-work) inhibited a small number of teams from working on the interpersonal side (teamwork) of collaboration. Teamwork is typically considered a critical element in effective teams. A possible way to address this issue would be to educate students about the importance of the interpersonal aspect of teamwork to help enhance collaboration in the virtual team. When it comes to effective planning, we have found that educators may need to encourage their teams to share their strengths and weaknesses (e.g. lack of writing skills) among each other so that they will be able to assign the right roles to the right person.

This study comes with some limitations. A major limitation of the qualitative study that used interview method is recollection of students of their team experience. The data gathered mainly depends on what the interviewees remember even though we have other supporting documents to verify their statements. Their recollection of past events may not be accurate. They may also interpret the questions differently from what it is intended. The interviewee's failure to recall an event does not mean that the event did not happen. There may be statistics presented above that did not account for events that the interviewees simply did not recall during the interview process. This is the reason why some of the percentages presented above do not add up to 100%. However, majority of the teams were still accounted for. Another limitation is the use of student teams who worked in a short and temporary academic project. Some students may not have the motivation to bring their best into the team because they do not foresee working with their teammates in the long run.

Validity, Trustworthiness, Replicability, and Generalizability

We have demonstrated that qualitative research is a fruitful endeavor to get a rich insight into exploring the role of scaffolds in facilitating team processes. In spite of the rich context, the method helped identify how the scaffolds supported team processes and the relevant factors that affected this link by providing sound principles to ensure validity and replicability.

We implemented several steps and strategies to ensure validity and trustworthiness of our findings based on the guidelines provided by Miles, Huberman & Saldaña.[20] First, we checked for representativeness by making sure that we have teams that represent all parts of the spectrum (e.g. high and low performing teams, high and low initiative teams). During the interview process, participants were blind to the objectives of the study so that they would not be tempted to craft their answers to the questions based on their self-interests. We instituted triangulation by verifying interview statements with other sources of data such as record of online team activities, team charter documents, project plan documents, individual reflection activities, class team update presentation and e-mail exchanges with the professor. There were few occasions when we found contradicting statements between interview statements and documents. For example, one team member said their team used the team charter to assign a lead and co-lead for tasks. However, when we checked the team charter, it was not there. Instead, we found it in the team plan. It is fairly easy to determine that the project plan document is a more reliable source

because it is the product of the team's interaction during the project whereas interview statements are a product of what the student recalls from the project experience. We also did triangulation by researcher. Another student researcher helped check coding and analysis. We also did triangulation by theory and found support for our findings based on existing theories.

We also analyzed counter-evidences and rival explanations. We handled counter-evidences and rival explanations by following this principle: If the proportion of negative to positive evidences is low, then we ignore the counter-evidences. If the proportion is high, then we investigate them further to be able to provide explanations for them that could possibly either strengthen the current framework or lead to the modification of the framework. We also sent follow-up e-mails to students to investigate incidents deeper. Miles, Huberman & Saldaña have emphasized that outliers are your friends because they actually help verify one's conclusion when what is present in them is absent in the mainstream data.[20] We adopted this principle in our qualitative analysis by comparing teams who had two different levels of a particular attribute (attribute A) and checking their link with another attribute (attribute B). If we find that several teams who had a high level of attribute A also had a high level of attribute B while teams with low level amount of attribute A also had low level amount of attribute B, then that confirms the conclusion that attribute A impacts attribute B because the presence of attribute A leads to the presence of attribute B while its absence leads to the absence of attribute B. Through this process, we eliminated many spurious relationships.

Through the process we have mentioned above, we believe that this study is replicable. When it comes to the transferability or generalizability of the results of this study, different scholars present different views. Grounded theorists claim that this method is able to generate high level abstractions that enable transferability to other populations or contexts.[32] Other scholars suggest that the transferability to other context is up to the reader, not the researcher.[33] Others say that it is the researcher's job to find universality in the case,[34,35] and yet others believe that the context-rich and case-specific data prevent generalizability.[36]

Conclusion

We started out with two simple research questions that sought to explore how scaffolds supported team processes and other factors that affected that link. In the end, the data collected provided a comprehensive picture of the phenomena that was facilitated by the research approach. The knowledge generated contributes to the understanding of how effective teamwork can be facilitated in online environments and lays the foundation for improving the design of scaffolds to support collaborative work. Our findings could help both researchers and educators identify strategies that enhance the collaboration and learning of remotely located students. Team scaffolds bridge the gap between what students can do on their own and what they can do with the help of others,[10,37] so that they can learn beyond lectures and homework assignments.[38] It is only paramount that we investigate what we can do to improve these web-based scaffolds so students would be able to maximize collective outcomes while promoting individual learning.

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