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A Pattern Approach to Understand Group Collaboration in Hands-on and Remote Laboratories

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ABSTRACT

We identify patterns of group collaboration within hands-on and remote laboratories. The pattern of group collaboration includes three elements: the collaboration mode, the communication medium and the collaboration structure. In addition, we examine how patterns of group collaboration evolved during different phases of the labs. Based upon our observation of 22 engineering students, we found two common patterns of the collaboration mode in both hands-on labs and remote labs: in one case, students seem to minimize cognitive effort, and in the other, they continue to do what they have been doing before. We also described the different types of communication media and collaboration structure in the two labs. Face-to-face meetings were found to be the dominant method of group communication in both labs, but students adopted a wider variety of communication methods when working with remote labs, and they interacted more with each other when they ran remote labs.

Keywords

Group collaboration, communication media, remote laboratory, education

INTRODUCTION

Information technology has changed the way educational laboratories are run. Unlike traditional laboratories, remote laboratories allow students to control apparatus at a remote site, whenever they want (Scanlon, Colwell, Cooper and Paolo, 2004). Thus, students' interactions with the laboratory apparatus are mediated by information technology. The use of new information technology has also transformed the social processes involved in laboratory activities. Changes in group collaboration may amplify the effects of information technology on the laboratory experience (Rohrig and Jochheim, 2001).

We did a series of study to evaluate and compare different formats of the laboratories and the learning mechanisms behind them (Ma, Nickerson, 2006). A model that explores the relationships of multiple factors for testing the relative effectiveness of different lab technologies was presented and pilot tested in 2004 (Nickerson, Corter, Esche, and Chassapis, in press). The results were replicated and further tested on a broader range of topics with more than 300 students (Corter, Nickerson, Esche, Chassapis, Im, and Ma, in press). We found three is a big group effect on students' learning performances, which

draws our attention to the role of collaboration, as student's collaboration processes may mix up with the lab technology to affect what they learn from different laboratory experiments. Previous research illustrates the impact of new information technology on group collaborations (Olson and Olson, 2003). However, we know relatively little about the way group collaborations evolve in virtual versus traditional learning contexts.

In this study, we want to use a pattern approach to outline group collaborations in traditional hands-on and remote labs. The remainder of the paper is organized as follows: We first review pertinent literature on group collaboration patterns. Next, we develop a model to describe group collaborations patterns in the labs, followed by a description of the research method. Finally, we discuss the implications of the work.

LITERATURE REVIEW

Group collaboration patterns have been discussed from different perspectives. In the following table (table 1), we reviewed five primary sample articles on patterns of group collaboration with respect to the theoretical perspectives developed, the defining characteristics of patterns and the patterns identified. Although these articles did focus on different contexts, for example, the first two articles studied group collaboration in a classroom context, the rest of the articles focused on virtual and remote communication; they also converged on some key aspects to capture the characteristics of group collaboration. For example, the first two articles focused on collaboration structure and collaboration mode (time and place of group collaboration) to define group collaborations, while the third and the fourth articles used intensity of group collaboration to distinguish group collaboration. Also, there is another research stream, like Millen, Muller, Geyer, Wilcox and Brownholtz. (2005), who used communication media as a way to identify different group collaborations patterns.

To summarize, we identify three key elements to outline group collaborations: collaboration mode (time and place of group collaboration), communication media (media used for group collaboration), and collaboration structure (organization and intensity of group collaboration). Using this as a foundation, we now provide a way of analyzing group collaborations with respect to educational laboratories.

Authors	Theoretical Perspective	Defining characteristics of patterns	Patterns identified
Hogan, Nastasi and Pressley (1999)	Cognitive and social culture	Individual involvement and information flow	Consensual, responsive and elaborative group interaction
Bowers and Nickerson (2001)	Social constructive	Structure of collective learning	Two cyclic patterns: ERE (elicitation-response-elaboration) and PD (proposition–discussion)
Hara, Solomon, Kim and Sonnenwald (2003)	Social constructive	Interdependence and intensity of the collaboration	From complementary to integration collaboration
Lahti, Seitamaa-Hakkarainen and Hakkarainen . (2004)	Social-technical (Information system design)	Degree of shared objects and intensity of joint activity	Coordination, cooperation, and collaboration
Millen et al. (2005)	Social-technical (information system desigy)	Media used	communicating, coordinating, and semi-archival filing

Table 1. Literature on Patterns of Group Collaboration

THEORETICAL FOUNDATION

Two types of patterns are generally discussed: activity and design patterns. Activity patterns focus on identifying the regularity of the behavior, while design patterns describe the problem, the context and the solution to that problem. We focus on activity patterns in this study. Building on Martin and Sommerville's (2004) work, we define the patterns of group collaboration in the labs as a mapping of linkages among different phases in a laboratory activity, and identifying the regularities in group organization of work, the interaction among participants, and the interaction of the participants with the laboratory apparatus. Specifically, we will examine group collaboration patterns from three levels. First, at a horizontal level, we will compare the group collaboration patterns in different lab modes: hands-on labs and remote labs. Second, at a vertical level, we will look three different phases for each lab, which we describe next. Third, as we summarized from the literature review, more specifically, we will discuss collaboration mode, communication media and collaboration structure for each phase.

Three phases of laboratory activities

Tuckman's (1965) seminal work on group development suggests that groups will experience four stages to finish a task: forming, storming and norming and performing. For lab groups, performing the lab is not the end of the activity. It is usually followed by a reflection phase during which the lab groups interpret the data from the lab and write the lab report. Built on Boud's idea (1973), we distinguish three development phases of a laboratory activity. The three phases are:

Planning phase: lab groups make preliminary plan to prepare for the labs such as discussing the instructions; Performing phase: various laboratory activities are carried out and the data is collected; Reflection phase (discussion & writing phases): the data is analyzed and interpreted; the findings and conclusions are presented verbally or by documentation.

In addition to examining patterns of group collaboration in different labs and over different labs phases, we also look at more details at each lab phase. We combine three major attributes to capture the essence of group collaboration at each lab phase. The three features are collaboration mode, communication medium and collaboration structure.

Collaboration mode

Collaboration mode describes the time and place for group collaboration. We distinguish between co-located vs. distributed and synchronous vs. asynchronous communication. For example, in hands-on and remote labs, a lab group may stay at the same place and communicate in real-time. They work remotely but continue to use real-time communication. Or, groups may be in different locations and use asynchronous communication to conduct the laboratory activities.

Communication media

The use of information technology has made variety forms of communication media available, by which media richness theory suggest that different media vary in their capability to transfer social and context cues (Mayer, 2001). In this study, we asked the students what media they choose in hands-on labs and remote labs to exchange ideas and information; it could be e-mail, telephone, on-line chat or face-to-face meetings.

Collaboration structure

Placing students in a team does not guarantee that they will work effectively and collaboratively. Group collaboration research (Jonhson, Johnson and Smith, 1991) demonstrates that group may have different collaboration teahouses, which involve the variations in organization of the group work, the frequency and the intensity of group interaction.

Summarizing the approach

We now summarize this approach using the following figure (figure 1): there is a sequence embedded in it, we first consider the lab context (hands-on or remote), then the lab phase (planning, performing and reflection), and finally the attributes of each phase (collaboration mode, communication medium, and collaboration structure). We show this overall view of the approach and the inter-relations in figure 1.

METHODOLOGY

Participants and context

Participants included twenty-two students in an introductory mechanical engineering course at an urban college of engineering during the summer of 2006. It was a core course on Dynamical Systems for all the undergraduates in mechanical engineering. Labs were used primarily to deepen the conceptual understanding and demonstrate the theory on principles and applications of dynamics. The students worked in self-formed pairs. There were 11 teams in total.

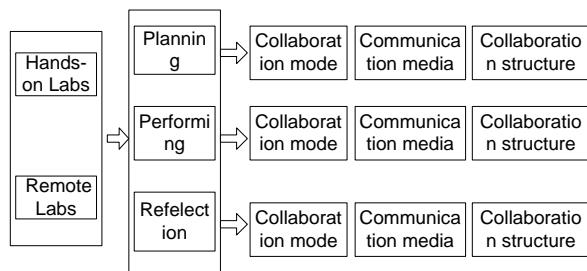


Figure 1. An overview of the Approach

Measures

In order to identify group collaboration patterns, data on collaboration mode, communication media and collaboration structure were collected. For each stage of a laboratory activity, we asked questions about when and where the group members interact with each other, what communication media they used, the frequency of their interaction, the way the group organized work, and individual contribution of each team member. A short questionnaire was designed to gather relevant information as well as other information such as group composition, group member relationship history, students' perception and satisfaction with different labs.

Procedure

There are two lab topics in this course: Gear labs and Vibration labs. Gear labs have five lab sections that were delivered by traditional hands-on context and vibration labs have three lab sections that were conducted remotely. Two versions of the questionnaire were designed to gather the information on the last hands-on and remote lab. The students were randomly assigned to one of the questionnaires. The questionnaires were distributed on the last day of the lab section, when the students had finished all the labs. As a result, 20 out of 22 students answered the questionnaire, 11 of them did the remote version and nine of them did the hands-on gear version.

Data analysis and results

First, we compared and contrasted the patterns of group collaboration in hands-on labs and remote labs. Second, we looked at three developing lab phases, *planning*, *performing*, *discussing and writing*. Third, we also looked at how the collaboration mode, communication media and collaboration structure evolved at each lab phase. Descriptive statistics were used as a primary way to examine the behavioral patterns in the labs. In addition, ANOVA was used to compare the communication media and collaboration structure used in hands-on labs and remote labs.

We observed two common patterns of collaboration mode and different patterns of communication media and collaboration structures in hands-on and remote labs.

Common patterns of collaboration mode

A) Least cognitive effort

In a laboratory activity, data collection and writing are required. Initial planning is also very important for the students to have a better understanding and make sense of the principals and the theories demonstrated by the labs. However, our study suggests that students try to limit their cognitive effort to finish the lab assignment. In hands-on labs, only three out of nine students reported that they did initial planning. Similarly, in remote labs, three students out of 11 had the experience of planning for the labs. It might be because the information given in remote labs are sometimes confusing and the teacher/TA is not available for immediate help, in these cases, discussion might be needed for clarification.

B) The effect of inertia

Although we expect to see different performing and writing patterns in hands-on and remote labs, the data presents different results. Most of the students developed the same collaboration patterns in both labs, there seems to be an effect of inertia. Student in remote labs established a meeting-dominant, collective-oriented collaboration pattern, which is still preserved in hands-on labs.

Specifically, in running the labs, 54.5% of the students in remote labs reported that “we ran the experiment together, working in the same location simultaneously” and 77.8% of the students in hands-on situation choose the same answer (see table 2). The case is similar for writing the labs; over half of the students in remote labs (54.5%) and hands-on labs (66.7%) said “we worked together at the same location at the same time.”

Hands-on Labs (N=9)				
Lab Phases		Planning	Performing	Reflection
Collaboration mode	Same place, same time	100%	100%	66.7%
	Different place, different time			33.3%
	Different place, same time			
	Others		11.1%	
Communication media	Meeting	33.3%	77.8%	100%
	Chat or E-mail			66.7%
	Phone			11.1%
Collaboration structure	Frequency	1, 33.3%	1, 55.6%	1, 66.7%
	Immediate communication	8.17	8.33	8.33
	Individual contribution	77.8%	88.9%	33.3%

Table 2. Group Collaboration Patterns in Hands-on Labs

2. Different patterns of communication media in hands-on labs and remote labs

2.1 Patterns of communication media in hands-on labs

A) Face-to-face meeting is the primary venue for group communication and interaction. For example, in planning and performing stages, group interaction completely relies on face-to-face communication (see table 2).

B) Over the course of the semester, more and more communication media were used as a reflection of increased requirement for information exchange. For example, students use both face-to-face meetings (100%) and remote communication media (email and online chat) (66.7%) to interact with each other and write the lab report.

2.2 Patterns of communication media in remote labs

A) Face-to-face meetings, rather than remote media, were used predominantly for group communications, but it is mixed and the distribution of the mix tends to more dispersed than in hands-on labs (see table 3).

B) The ANOVA analysis indicates that there was no significant difference for communication media used in hands-on labs and remote labs. Two reasons might explain this; first, the effect of inertia may make the

students keep face-to-face meetings as the primary means of communication in remote labs. Second, remote communication media, such as e-mail and online-chat have already become part of the everyday life. Students were already very familiar with them and use them in hands-on labs.

Remote Labs (N=11)				
Lab Phases		Planning	Performing	Reflection
Collaboration mode	Same place, same time	100%	54.5%	54.5%
	Different place, different time		18.2%	18.2%
	Different place, same time		27.3%	27.3%
	Others			
Communication media	Meeting	27.3%	54.6%	81.8%
	Chat or E-mail		9.1%	45.5%
	Phone		18.2%	9.1%
Collaboration structure	Frequency	1, 45.5%	1, 72.7%	1, 45.5%
	Immediate communication	7.09	6.64	8.27
	Individual contribution	100%	90.9%	45.5%

Table 3. Group Collaboration Patterns in Remote Labs

3. Different patterns of collaboration structure in hands-on labs and remote labs

3.1 Patterns of collaboration structure in hands-on labs

A) Students’ rating for their group members decreased with the progress of the lab work. They reported that everyone in the group did his job and contribute equally (over 70%) in planning and running stages, however, when it came to “real work time” (discussion and writing stages), the rating for individual contribution dramatically dropped; only a small number of the students (33.3%) thought everyone contribute to the group work equally.

3.2 Patterns of collaboration structure in remote labs

A) ANOVA analysis of collaboration structure in hands-on and remote labs revealed interesting patterns when the students were running the labs. Students in remote labs reported that in order to carry out the experiment they have to put more efforts and have more interactions than in hands-on labs ($F= 6.766$ $P=0.19$). However, their perceived frequent communication with their group members was significantly less than in hands-on labs ($F=4.856$, $P=.041$).

DISCUSSIONS AND IMPLICATIONS

Surprisingly, we found our expectations about group collaboration in remote labs are contradicted in many ways. We thought one of the advantages offered by

remote labs is to relieve the students from technical problems. However, some students found the technical system for control was hard to use. The result is interesting, because, paradoxically, such problems may be good. The problems may force students to talk with each other and interact, and may lead them to better learning results than if everything is clear and the experiments work flawlessly. We also expected the use of remote lab technology to lead to the use of mediated collaboration technology such as instant messaging or email. On the contrary, we found meeting in person is dominant in remote labs and remote communication media is also widely used in the later phases of hands-on labs. However, a greater variety of communication media was used by students working on remote labs.

LIMITATIONS

This study is a pilot study, and it has limitations. First the sample size is small, so the results might not be representative and need to be further validated. Second, there was a lack of geographical diversity, because students lived on campus. Groups with all members living close to each other may afford to meet in person to run the remote labs and establish “meeting-dominant” collaboration patterns. However, groups with more geographical diversity might use electronic communication more. In addition, the responses from the students are all self-reported and no pretest. In the fall semester 2006, we plan to conduct a large-scale study to investigate these issues more thoroughly.

CONCLUSION

Focusing on patterns of group collaboration in educational labs, this research studied the collaboration modes, communication media and collaboration structures across three stages of educational laboratory work. We observed two common patterns of collaboration that described student’s general attitude toward laboratory work. In general, students try to limit their effort as much as possible and there is inertia associated with the collaboration mode: once the mode has been established, it persists.

We also found different patterns of communication media and collaboration structure in the two different types of labs. Face-to-face meetings continue to be the primary venue for group communication, but students adopted more forms of media in communicating about remote labs and they interacted more with each other when they ran remote labs. As a function of time, the frequency of group interaction increased over different lab phases. It could be that problems with understanding the technology led them to reach out. It could also be that they had more time to inquire about what was happening, as they performed the labs at the time of their choosing for as long as they wanted.

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