**Collaboration Processes in Hands-on and Remote Labs**

Jing Ma  
PhD Candidate, Howe School of Management, Stevens Institute of Technology,  
Hoboken, NJ 07030  
jma1@stevens.edu

**Abstract** - Collaborative learning has been widely discussed as an effective way to promote cognitive learning. However, the speculations on how a collaboration process is related with meaningful learning in the laboratory context are insufficiently addressed. To understand these issues, this paper focuses on two collaboration processes in both the hands-on labs and the remote labs: students’ interactions with the laboratory apparatus and students’ interactions with their group members. Three collaboration designs are identified—integrated collaboration, responsive collaboration and isolated collaboration—which are defined in terms of where, when, and how team collaborates. The results suggest that many factors, such as the geographic distance, relationship histories among group members, which are less important in hands-on labs, may become critical factors in determining the way students communicate and collaborate in remote labs.

*Index Terms* – Hands-on labs, remote labs, collaboration, interaction

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**INTRODUCTION**

Educators are now experiencing great challenges when trying to integrate information technology into the laboratory education curriculum. On the one hand, the use of new information technology changed the way how the laboratory material can be delivered. The remote laboratories provide flexibility and accessibility to use laboratory apparatus at the students’ convenience and at their own pace. On the other hand, the use of new information technology also transformed the social processes involved in the laboratories [1]. For example, Will remote labs encourage or discourage group interaction? Will the group have more face-to-face communication or less? Will the group tend to have more independent work or more group work?

These questions will be addressed through the exploration of collaboration processes in hands-on and remote labs. In particular, my research questions are:

- **R1:** How students collaborate in hands-on labs?
- **R2:** How students collaborate in remote labs?
- **R3:** What are the similarities and differences in hands-on and remote labs?

**THEORETICAL FOUNDATION**

Based on sense-making theory, Roy Pea addressed that the key to distributed collaborative learning is transformative communication—construction of understanding and meaning of communicative message. He argued that the information “technologies per se are not the central issue for learning,” what really counts is the activities involved with the technology [2, p292]. In order to make transformative communication take place, highly interactive conversations and interactions are required and should be supported.

Sense-making theory provides us a different angle to view how the old learning paradigm in the laboratories might be shifted and shaped by the presence of new information technology. In
remote labs, cognitive learning is mediated by the computers and the communication is indirect, students may compensate these disadvantages by promoting learning conversations and interactions with the subjects as well as the objects in order to makes sense of the materials. The advocates of face-to-face communication often criticize remote communication for its incapability to deal with ambiguous and complicated issues. Nevertheless, the confusion or ambiguity carried by remote conditions may drive the students to interact more with their peers or look for more external help to interpret the material. Reference [3] also found that more efforts and social interactions are required when the students are encountered with more difficult and complex learning.

With these assumptions, in the following sections, I will first introduce the research methodology used in this study. Then, the data from nine in-depth interviews will be presented and analyzed. Followed by that, I build a three-dimension framework which involves time, place and collectivity to analyze students’ interaction with laboratory apparatus and students’ interaction with team members. Finally, I will discuss the implications of this study.

**Research Methodology**

As reference [4] noted, there is a paradigm shift “from units to contexts, from attributes to connections, from causes to events” (p. 93). Reference [5] also advocated that a process approach can be used to develop a deep understanding of how and why things change over time by tracing particular details. He made a successful case using a process approach to explain organizational behavior. In like fashion, the research [6] focused on the sense-making process. It was claimed that the central theme and primary task every organization confronts is to understand this process. Similarly, reference [7] investigated various organizational phenomena through the study of live scenarios, focusing on every specific event.
The process theory approach has also been applied in previous and present educational research [8, 9]. Reference [2] states that science learning depends on two conversational processes: peer collaboration as well as student-to-instructor discussion. It is clearly stated that the process approach should and has been widely adopted in studying different laboratory activities including Chemistry, Biology and Physics [10].

Fitting into this paper’s research purpose, I borrowed the process approach to “look into the process itself to see whether it occurs as alleged and look for implications of the phenomena rather than the outcome” [5].

**Preliminary Results**

An interview study was performed as the first step to investigate the collaboration processes in different laboratory contexts. Nine in-depth interviews were conducted in a mechanical engineering introductory course at an urban college of engineering during the summer 2004. In this course, the principles and the applications of dynamics was taught, labs were used primarily to deepen the conceptual understanding and demonstrate the theory taught in the lecture. There were three teams in the class and each team had three students. Ten questions were designed and developed, closely asking for group interactions in the two laboratory modes. Each student in a team was interviewed individually for about ten minutes.

Generally, the students questioned have a positive attitude towards laboratory activity. Most of these students think that learning in remote labs and hands-on labs is fairly similar for the assignments they have performed. In reference to the distinction in reference [6], it can be said with respect to the effect of technology on cognition, students intended to treat remote labs the same as hands-on labs. However, with respect to the effect of technology on action, students treated the remote labs differently. They demonstrated an obvious preference for remote labs.
They all agree that hands-on labs are good for learning, but generally preferred remote labs for their flexibility and convenience.

- Student Interactions with the Laboratory Apparatus

Prior research in distance education and computer-mediated communication has distinguished group communication from two perspectives, time and place [11]. Basically, two dimensions of time (synchronous and asynchronous) and two dimensions of place (co-located and distributed) are distinguished. Apparently, hands-on labs and remote labs differ in the way they present and deliver laboratory materials, which determines the way students can interact with the apparatus for the concern of time and place.

In hands-on labs, all the students get together in the laboratory during scheduled lab times, perform the lab and get the results right after the lab. During all the processes, students are physically present in the lab and are able to observe immediate responses in the lab. In this regard, the communication between the students and the lab is collocated and synchronous.

In remote labs, students do not have to get together in the classroom at a certain time and they can manipulate the lab equipment which might be far away from where they are located. However, the communication between the students and the lab equipment might not be as smooth as in hands-on labs. Due to the bandwidth speed, remote manipulation may experience a time delay in video transmission. Furthermore, the results of the remote labs are not available immediately after the labs. Several hours after the lab, an email with all the data will be sent out to the students. From this point of view, I observed that students have remote and asynchronous interactions with the remote labs (See table I).
Student Interactions with Other Students

Student interactions with lab equipment are much different from student interactions with their peers, which involve more elements and more complex processes. In order to capture the nature of group interactions in laboratories, another dimension was added to describe this relation: the collectivity of the group, that is, how the groups structure their work: individually or collectively. Groups may choose to do all the work together, or they may choose to split-up the tasks. Thus, there are three dimensions to characterize group interactions in different labs, two of them are within-group variables (time and place) and the third one is a between-group variable, working mechanism.

Rather than looking at the lab activity as a whole, I divided the laboratory process into four continuous stages: running the lab, planning the lab, discussing the lab and writing the lab. Specifically, each laboratory team was examined by the way they communicated with their team member and the way they structured their work at each stage.

Comparatively, three collaboration designs were adopted in the three teams: integrated collaboration, responsive collaboration and isolated collaboration, which were defined by the interaction intensity and the closeness between group members. Although the three teams tended to keep similar collaboration style across different labs, they experienced different adaptations in the presence of information technology.
Team I was in favor of physical interaction and group work. There was a large overlap in personal relationships and study relationships among the team members, therefore, they often hung out together and persisted with real-time, face-to-face meetings to organize their interactions and finish the assignment. The first team had a similar interaction style with respect to both real and remote labs; the collaboration design is indicated in Figure 1.

In the figure, shape difference, square and circle are used to represent co-located or distributed place. Line difference, solid line and dotted line are used to differentiate synchronous or asynchronous communication. I also use big shape and small shape to distinguish collective or individual work.

Team III also preserved a similar communication style in hands-on labs. In the hands-on lab, these students ran the lab in the classroom which provided face-to-face meeting time. This in turn facilitated the real-time, co-located interaction pattern in the following stages of the laboratory activity, such as planning stage after that. However, things were different in remote labs. The members of team III changed the way they contacted each other, used more remote communication and relied on email and online chat in remote labs. Therefore, they employed “warm collaboration design”, which indicated that the team members were not closely coupled as people in the first team (see Fig 2).
Team II consistently worked remotely, asynchronously and individually. In a hands-on lab setting the members of team II had no physical team interactions except for running the lab in the classroom and a face-to-face meeting to split up the work. In the remote lab, team II used e-mails to contact each other and to discuss issues only if necessary. The students in this team were only loosely connected and divided up the work on more of an individual basis than the people in other two teams (see Fig 3).

**Implications**

A recent survey paper addressed that an increasing emphasis of science-learning methods has been placed on “collaborative learning at all levels of education,” especially in technology-
mediated practice work [12]. Our efforts only provide one perspective to look at the collaboration processes in scientific laboratories, which is far from enough to unravel this issue. Thorough group collaboration process research in scientific laboratories has unearthed many interesting issues worth investigation. For example, environmental forces may guide team interaction. With respect to remote labs, team II was consistent across phases with their remote communication and individual working style, which included running the labs. A team member ran the lab by herself instead of arranging to run it together with her group. Also, the distance between team members may have a dramatic influence on determining the interaction style. Team members that live far from each other are reluctant to have face-to-face meetings. As a result, the working strategy adopted by team II might be preferred by people geographically distributed and not very familiar with each other.

Another element offered by remote labs that provides the opportunity to enhance learning is that students can concentrate and reflect on ideas, instead of being preoccupied with technical issues. It seems that in hands-on labs because of the preoccupation with technical activities students have limited or no time to interact about central ideas. This means students have no time to express their ideas, beliefs and interpretations about the meaning of their inquiry [13]. On the other hand, in remote-labs all these technical issues are nonexistent and students might have the time to engage in reflection, otherwise called meta-cognitive thinking. Moreover, it would be interesting to see further research qualitatively study the kind of the collaboration used in science learning. For example, it would be enlightening to see an investigation into whether there are any qualitative differences in the discussion content from real and remote labs.

The new informational technology holds great promise for the educational paradigm. Most researchers, however, address the capability of the new technology; the speculations on the
process and the way how people are involved in and adapt to the technology are relative unexplored [14], which is important not only for the development of the technology but also for the effective use of the technology in the future.

REFERENCES


