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Abstract

In 2006, The University of Texas established an inter-institutional Department of Biomedical Engineering encompassing three campuses: The University of Texas at Austin, The University of Texas Health Sciences Center at Houston and The University of Texas MD Anderson Cancer Center. Since the campuses of the participating institutions are in two cities separated by about 170 miles, distance learning technologies are key for the pedagogical component of the graduate program. As this program began, we conducted a series of surveys and focus groups to assess faculty and students’ perceptions of their distance learning needs and competencies. Our findings indicated that faculty were, for the most part, unaware of today’s instructional tools and their challenges. Students, on the other hand, were concerned about the professor’s abilities to support communications and interactions in a distance learning environment. Armed with these initial insights, we implemented our first round of distance learning (DL) courses for the inter-institutional department. The results of our first post-DL survey, coupled with student and faculty testimony, indicate that “we’ve only just begun” when it comes to realizing the potential of distance learning. We will share our lessons learned, student survey results, and our plans for improving distance learning offerings.

Introduction

Teaching to students who are not physically on site is not a new notion for correspondence classes began as far back as 1728 when students taking shorthand lessons could send in their lessons.\(^1\) Given today’s technologies, however, students can virtually attend classes and partake in labs. It is estimated that a third of all post-secondary schools offer distance learning (DL) options and that the number of enrollments will steadily increase.\(^2\) Simply put, distance education is defined as a formal education process in which the student and instructor are not in the same place with an estimated 12.2 million students enrolled in these classes.\(^3\)

Despite the availability of various instructional technologies and a better understanding of how people learn, “in distance education, the field is still wide open for creativity and innovation in the curriculum, instructional techniques, and use of delivery technology.”\(^4\) Like any discipline, engineering has unique demands and these typically require students to have physical knowledge that only lab activities and hands-on experiences can provide.\(^5\) Yet today’s instructional technology tools can help to promote interactions and hands-on learning and as a consequence, engineering education is being offered through DL. Yet adopting the methods of quality online learning has been slow to take hold in engineering education.\(^6\) Often the engineering courses that are offered through DL are at the graduate level. Speculation has been that the special needs (i.e. laboratory work and the operation of instruments) of undergraduates have slowed down the development of DL courses. These special needs still exist for engineering graduate students, but they may, for example, be able to work more independently and have access to facilities where they conduct research.
Finding out what impact distance education has on student learning is a topic for study. Research is moving beyond the days of simple comparison studies where student outcomes (often course grades) for a DL course are compared to those of a traditional course. This research known as the “no significant differences” phenomenon that concludes, “…there is nothing inherent in the technology that elicits improvements in learning.” Further studies continue to suggest that if the technology (such as videoconferencing) is used, it may sufficiently duplicate a face-to-face class and you will find no significant difference. The use of technologies, such as online delivery, can provide a new instructional model.

The research on DL in BME is still sparse. There are papers such as the one from ASEE’s 2008 Conference that describe a DL Master of Science program. Through the use of instructional technology they have made it possible for distance students to have the same experience as a local, campus-based student. Another paper by Lenart describes a computer supported distance learning courses (CSDL) that they found to overcome many of the problems of their conventional course: Unified Medical Sciences, a course team-taught by physicians and life scientists, allows self-paced study, exploration of unfamiliar areas, skipping unneeded reviews and assisting the students to dig deeper with guidance and possibly with editorial assistance from the developers of the course.

Our study looks at how interactions are impacted by distance instruction. If we go on the assumption that students at different campuses will not interact, then we are short sighted as to the benefits of DL. In today’s world, many interactions are virtual and we believe with today’s technology and well structured instruction, student-to-student and student-to-faculty interactions will not be limited by time and space. We realize that technology and its support are costly and can require a steep learning curve. Both faculty and students may be so familiar with a traditional approach to learning that they don’t “step out of the box” when it comes to DL approaches. Teaching at a distance, just as learning at a distance, requires adjustments. No technology can overcome poor teaching and poor teaching skills can be exacerbated in distance learning instruction.

Background
In the fall of 2006, an inter-institutional Department of Biomedical Engineering was created that includes The University of Texas at Austin, The University of Texas Health Sciences Center at Houston and The University of Texas MD Anderson Cancer Center. Given that these institutions are located in two cities, separated by a couple hundred miles, distance learning is utilized. Prior to the launching of this department, we surveyed both faculty and students to assess their needs and perceptions of DL. These surveys indicate that even though technology plays a supporting role, strong pedagogy is fundamental to its success. Both faculty and students recognize that instructional approaches need to be active, visual and interactive. Yet our professors who are, for the most part familiar with more rudimentary uses of instructional technologies, do not explore new capabilities. Students worry that a professor may lack the insight or ability to experiment with technologies and as a result, we realized that professional development and peer support are needed in order for faculty to enhance their teaching with current technologies.

Our initial study was to identify the functional skills that faculty need to possess in order to effectively teach at a distance and to identify student concerns and needs for DL prior to the
designing and delivery of courses. Now that we have offered courses at a distance, we are able to scrutinize and reflect on these courses.

**Purpose of the Study**

In our survey of faculty and students that was conducted before we began regularly offering distance learning courses\(^7\) we learned that students and faculty were most concerned about how interactions would be supported in distance learning courses. Traditional classroom interaction, the dialogue between teachers and students, is considered fundamental to the learning process and we were not surprised that our faculty and students had concerned about DL interactions. Therefore the focus of this study was on reported interactions among students and between students and faculty in the distance learning environment.

How to define interaction in DL is a topic of discussion. For some, “interaction” and “interactivity” are interchangeable. We, however, align with those who find that interaction focuses on people’s behaviors, while interactivity focuses on characteristics of the technology systems. We also found that we needed to clarify the players in any interactions.

Specifically, we define a “local learner” as a student who is typically in the same physical location as the instructor (Figure 1). Similarly, we define a “distance learner” as a student who is typically in a different physical location from the instructor. The purpose of this study was to compare the experiences of “local learners” and “distance learners” in the initial distance learning course offerings of UT BME.

![Figure 1. Students A and B are “local learners;” they are at the same physical location as the instructor. Students C and D are “distance learners;” they are not at the same physical location as the instructor. Consider student A; her “local peer” is student B, who is at the same physical location. For student A, her “distance peers” are students C and D, who are at a different physical location.](image)

Likewise, we define “local peers” as fellow students who are typically at the same physical location as the given student and we define “distance peers” as fellow students who are typically at a different physical location from the given student. In this analysis, we assessed student interactions with respect to their local and distance peers.

Secondary points of interest from our previous study\(^7\) were uncertainties about which characteristics of a course impact the effectiveness of it in a distance learning format and the enthusiasm of students for the idea of recorded lectures. Consequently, some aspects of the questionnaire followed up on these issues.

Thus, our research questions were:

- How are interactions between faculty and students the same/different for distance learners as compared to local learners? e.g., in terms of Figure 1, how is student C’s interaction with the instructor the same/different from student A’s interaction with the instructor?
• How are interactions between students and their “distance peers” same/different as compared to their interactions with their “local peers”? e.g., in terms of Figure 1, how do the interactions of students A and C compare to the interactions of students A and B?
• Are interactions among students affected based on their physical proximity to the instructor? e.g., in terms of Figure 1, how are the interactions of students C and D the same/different as interactions between A and B? In the interaction of A and C, do A and C perceive it the same way?
• Are recorded lectures helpful in practice? Do distance learners and local learners value them equally?
• What characteristics of a course impact its effectiveness in a distance learning format? Do distance learners and local learners perceive the same properties as being important?

Methodology and Data Collection
Nine courses with a distance learning option were offered by UT BME in fall 2007, spring 2008, and fall 2008. Some of these courses were cross-listed such that students from other programs could also participate. A total of 173 students were enrolled in these courses, including 10 non-BME students. The 163 UT BME students were surveyed, of which 24 (15%) chose to complete the survey. Given the small sample size, there are serious limitations to the strength of the conclusions that we can draw. Consequently, our preliminary analysis is intended to provide a list of more focused research questions based on our observations.

The survey was offered electronically; a copy of the survey questions is provided in Appendix A. The survey questions were organized into blocks pertaining to each course since students could enroll in more than one course. However, for the purposes of this analysis, responses from an individual student were combined for similar course experiences. Specifically, if a student was enrolled in more than one course as “local learner,” a composite was created by taking the median value for ordinal questions and a logical “or” of questions permitting multiple responses. Likewise, if a student was enrolled in more than one course as a “distance learner,” a composite was created. However, if a student was enrolled in one course as a “local learner” and in another course as a “distance learner,” his/her responses were treated as two separate observations.

<table>
<thead>
<tr>
<th></th>
<th>Local Learners</th>
<th>Distance Learners</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gender</strong></td>
<td>Male / Female</td>
<td>9 / 11</td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21-24 years</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>25-30 years</td>
<td>11</td>
<td>4</td>
</tr>
<tr>
<td>31-40 years</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td><strong>Enrolled Local &amp; DL</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 1. Descriptive statistics of the composite student survey responses.

Since the number of local learners and distance learners for each course was known from registration data, we were able to identify two students that apparently did not understand the questionnaire as they incorrectly identified themselves, e.g., reported that one was a local learner when one was a distance learner. The data for those students were correctly re-assigned for the analysis of faculty-student interactions. However, we assumed that those students may have also
been confused in the questions about local vs. distance peers; thus, their data were eliminated from the analysis of student-student interactions. In this manner, the survey responses of the 24 xxx BME students resulted in 20 observations of local learners and 7 observations of distance learners for the analysis of faculty-student interactions and 20 observations of local learners and 5 observations of distance learners for the analysis of student-student interactions. Descriptive statistics are provided in Table 1.

**Findings and Analysis**

How are interactions between faculty and students the same/different for distance learners as compared to local learners?

With respect to interactions with the instructors during class time, the distance learners in this small sample actually reported a lower level of comfort and effectiveness (median = 4.0 on a 5-point Likert scale) than did the 20 local learners (median = 4.5). This is likely an artifact of the small sample size, but may also reflect the distance learners’ low level of comfort comparing with the result for the outside of class time.

The 7 distance learners reported relatively high comfort and effectiveness in interacting with instructors outside of class time (median = 4.0). The 20 local learners reported a similar experience (median = 4.0).

How are interactions between students and their “distance peers” same/different as compared to their interactions with their “local peers”?

Students were asked to indicate the extent to which they interacted effectively and comfortably with local and distance peers both during and outside class time. Most students (73%) agreed or strongly agreed that their interaction with local peers was effective and comfortable during class time (median = 4.0). However, only 8 out of 23 students (35%) agreed that their interaction with distance peers was effective and comfortable during the class time (median = 3.0).

With respect to interactions outside of class time, the majority (87%) of students agreed or strongly agreed that their interaction with local peers was effective and comfortable outside class time (median = 4.0). However, only 4 students (17%) agreed that their interaction with distance peers was effective and comfortable outside the class time (median = 3.0).

Students’ comfort level of interaction with distance peers during and outside class time was similar each other. Most (65% and 83%) of the students reported that their interactions with distance peers were ineffective both during (median = 3.0) and outside of class time (median = 3.0).

Most students (73%) agreed or strongly agreed that their interaction with local peers was effective and comfortable during class time (median = 4.0). Moreover, the vast majority (87%) of students positively reported that their interaction with local peers was effective and comfortable outside class time (median = 4.0).
Thus, our students’ reported that they were equally comfortable and effective in interacting with their peers outside of class as during class time. However, this small sample indicates that interactions with distance peers were deemed less effective than those with local peers in either setting.

Are interactions among students affected by their physical proximity to the instructor?

Most local learners (75%) agreed or strongly agreed that their interaction with local peers was effective and comfortable during class time (median = 4.0). Distance learners (71%) also agreed or strongly agreed that their interaction with local peers was effective and comfortable during class time (median = 5.0). These preliminary results suggest that classroom interactions among students at the same physical site do not seem to be negatively impacted if the instructor is at a different site. Or put the other way, classroom interactions among students at the same physical site do not appear to be enhanced by the local presence of the instructor.

On the other hand, both local and distance learners reported that their interaction with distance peers was not effective or comfortable during class time. Only 5 out of 20 local learners (25%) agreed that their interaction with distance peers was effective and comfortable during class time (median = 3.0). Similarly, distance learners reported that their interaction with distance peers was not effective or comfortable during class time (median = 3.0). These preliminary results suggest that the difficulties students face in interacting with their distance peers during class time are not mitigated by being at the same physical site as the instructor.

The vast majority (85%) local learners agreed or strongly agreed that their interaction with local peers was effective and comfortable outside class time (median = 4.0). Distance learners reported a similar experience. Distance learners (86%) also agreed or strongly agreed that their interaction with local peers was effective and comfortable outside class time (median = 4.5). This small sample suggests that, as was the case with activities during class time, the effectiveness of interactions between students at the same physical site outside of class time is not impacted by whether or not the instructor is at the same physical site.

However, only 2 local learners agreed that their interaction with distance peers was effective and comfortable outside class time (median = 3.0). And 2 of the distance learners agreed that their interaction with distance peers was effective and comfortable outside class time (median = 3.0). These preliminary results suggest, as was the case for class time activities, the difficulties that students face in interacting with their distance peers outside of class time are not mitigated by being at the same physical site as the instructor.

In conclusion, in our sample, neither student interactions with their local peers nor their interactions with the distance peers were impacted by proximity to the instructor.

Are recorded lectures helpful? Do distance learners and local learners value them equally?

The majority (74%) of students agreed or strongly agreed that the recorded lectures aided their learning (median = 4.5). However, the answer was divided by local and distance learners. While
all local learners, excepting one neutral responder, agreed that the recorded lectures aided their learning (median = 5.0), only one of the seven distance learners agreed that the recorded lectures aided their learning (median = 3.0). This somewhat surprising difference may be an artifact of the small sample size but warrants further investigation. The overall positive response confirms the prediction from our earlier survey which suggested that students would find the recording of lectures to be a valuable side effect of the distance learning environment.

The use of tracking software, like Net Tracker, allow you to see how many times someone visits a link. Due to an upgrade to our software, we were not able to compile all of the numbers for the BME DL classes since 2007. We only results from two courses in the fall of 2008; one course had 225 hits and the second course 529. It is apparent that they do go to the class recordings, but we need to have more complete data to make any inferences.

<table>
<thead>
<tr>
<th>Interaction with</th>
<th>Instructor</th>
<th>Local Peers</th>
<th>DL Peers</th>
<th>Rec. Lecture</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>During</td>
<td>Outside</td>
<td>During</td>
<td>Outside</td>
</tr>
<tr>
<td>Distance Learners</td>
<td>Median (N)</td>
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<td>4.0 (7)</td>
<td>5.0 (7)</td>
</tr>
<tr>
<td>Local Learners</td>
<td>Median (N)</td>
<td>4.5(20)</td>
<td>4.0(20)</td>
<td>4.0(19)</td>
</tr>
<tr>
<td>Total</td>
<td>Median (N)</td>
<td>4.0(23)</td>
<td>4.0(23)</td>
<td>4.0(22)</td>
</tr>
</tbody>
</table>

Table 2. Medians of comfort levels of local and distant learners

What characteristics of a course impact its effectiveness in a distance learning format? Do distance learners and local learners perceive the same properties as being important?

Students were asked to indicate which characteristics of the course positively the success of the course as a DL course. Out of seven multiple choice items, most students (78%) indicated that the “lecture medium (e.g., whiteboard, PowerPoint, Doc Cam)” influenced positively the success of the course as a DL course. Likewise, the “level of course organization” was chosen by most students (63%) as important positive characteristic of a DL course.

Interestingly, the level of course organization was also reported to be one of the most influential (33%) negative characteristics of the course. By comparison, few students (11%) reported that the lecture medium negatively influenced the course as a DL course. These results suggest that in future work we need to further probe students’ to understand how these properties are perceived to affect the DL environment.

There were no big differences between local and distance learners with respect of the course characteristics that were considered to positively impact the course a DL course. 85% of local learners and 57% of distant learners indicated that “lecture medium” positively impacts DL courses. Also 70% of local learners and 43% of distant learners reported that “level of course organization” is a positive characteristic of a DL course.
However, the level of course organization was chosen as the most negative characteristic of a DL course by most local learners (40%), while only one of the seven distance learners (14%) answer so. Further study is needed to determine if this is simply a consequence of the small sample size and the mechanism by which course organization impacts its effectiveness for DL.

Three of the local learners expressed concerns about the class size for a DL course. Two of them added comments about the large class size. One said to reduce the size of the class and the other said that we “need to have a smaller class. There are many different students with many different backgrounds causing a lag in learning/teaching.”

Summary and Conclusions

Using our findings from our previous surveys of faculty and students, we created this study to look specifically at the nature of DL interactions. We realize that it is difficult to get students to respond to surveys and that despite our attempts to make the survey readily available (via online) and sending numerous requests for participation, our numbers are still low. In the future, we are considering focus groups with the students to not only probe deeper, but to also broaden those who respond. With these initial responses, we will continue to listen to our students and to study our DL offerings.

We found that the interactions with instructor and local peers were relatively high. However, the interaction with distant peers, who were at different physical locations, was low. Hence, we want to study more on how to facilitate interaction between local and distance learners or how the negative effect of low interaction between them can be minimized.

Using these results we are able to come up with follow up questions. Given that the DL students indicated they had a higher level of comfort interacting with their faculty outside of class, we want to get more specifics on these interactions and the types of technology that are facilitating them. We want to get at the “why” behind this. This survey suggests that interactions that occur with DL students (either inside or outside of class) are less effective than those with local peers. We need to look at the instructional strategies to see if interactions were encouraged and to what extent students were involved in collaborative work. Additionally we will see if the technology was able to assist or hamper interactions. Specifically we want to explore what value peer interactions bring to the DL paradigm and how we can best facilitate such interactions.

In our DL courses, lectures are recorded. In our survey the local students agreed that the recorded lectures aided their learning, but the DL students did not find this to be the case. Our DL students participate real-time and it seems that the viewing of recorded lectures would be as useful to them as the local students. We want to investigate this further.

In looking at which characteristics of their courses positively and negatively impact their DL learning, the students indicated that the “lecture medium” is a positive influence. The “lecture medium” plays a fundamental role in the success of DL courses and these results indicate that we need to look at how lectures are delivered to study the impact of these approaches. Are there specific needs that DL students seek when it comes to instructional delivery, for example?
Also, some local students indicated that some characteristics of their course(s), e.g. course organization and class size, negatively impact their learning. Further investigation is required on what the better or worse characteristics of DL course are comparing with traditional course and how we can improve them.

From this data we question how do different characteristics influence learning? We also need to scrutinize our findings by looking at the impact of prior experience with DL, age, and gender. Also in this study we combined our findings and did not analyze differences by different instructor.

Our university provides an end-of-course survey that goes out to all students. That survey does not directly address DL attributes and we plan on continuing to survey our students so that we can refine our courses and technology to better meet their instructional needs.

Appendix A

The purpose of this survey is to collect data to better understand how students perceive distance learning (DL) classes. Results from this survey will be used to help the BME department plan for more effective distance learning instruction and may be shared with colleagues at other institutions through engineering education conferences/journals. Basic background information about you will be collected for analysis purposes and at no time will your personal identification be recorded or disclosed. You may choose to not answer any questions. The data gathered in this study will be reviewed by Dr. XXX, Director of XXX. You will never be identified. Should you have concerns please contact the Office of Research Support and Compliance at XXX-XXXX. While answering the questions below, keep in mind this definition - “Instructional technology includes cameras, computers, CD players, presentation software, PDA's, audio (microphone and loudspeakers), and videoconferencing.”

What is your gender?
- [ ] male
- [ ] female

What is your age?
- [ ] 21-24
- [ ] 25-30
- [ ] 31-40
- [ ] 41-50
- [ ] over 50

Prior to enrolling in the XXX BME graduate program, had you ever taken a DL
course?

☐ Yes
☐ No

Since BME graduate students may have different experiences in different distance learning courses, this survey is structured with blocks of questions about each course separately. In answering the questions, please keep the following in mind: (1) In a DL course, you may usually be in the same facility as the instructor (you are a "local learner") or usually in a different facility than the instructor (you are a "distance learner"). (2) In DL courses, there may be other students at the same physical facility as you (your "local peers") and other students at a different physical facility (your "distance peers").

What kinds of actions is the BME department taking that help you feel like you belong in the department?

What kinds of things can the BME department do that would make you feel more "connected" than you do now?

Were you enrolled in BME XXX in fall 2007? (If no, please skip to the next block of questions).

☐ Yes
☐ No

In BME XXX,

☐ I was a local learner
☐ I was a distance learner

In BME XXX, I was able to effectively and comfortably interact with the instructor during class time.

☐ Strongly Agree
☐ Agree
☐ I don't know
☐ Disagree
☐ Strongly Disagree
In BME XXX, I was able to effectively and comfortably interact with the instructor outside of class time.
- Strongly Agree
- Agree
- I don't know
- Disagree
- Strongly Disagree

In BME XXX, I was able to effectively and comfortably interact with the local peers during class time.
- Strongly Agree
- Agree
- I don't know
- Disagree
- Strongly Disagree

In BME XXX, I was able to effectively and comfortably interact with the local peers outside of class.
- Strongly Agree
- Agree
- I don't know
- Disagree
- Strongly Disagree

In BME XXX, I was able to effectively and comfortably interact with my distance peers during class time.
- Strongly Agree
- Agree
- I don't know
- Disagree
- Strongly Disagree

In BME XXX, I was able to effectively and comfortably interact with distance peers outside of class.
- Strongly Agree
- Agree
In BME XXX, the recorded lectures aided my learning.
☐ Strongly Agree
☐ Agree
☐ I don't know
☐ Disagree
☐ Strongly Disagree

The fact that BME XXX was a DL course
☐ positively impacted my learning
☐ didn't impact my learning
☐ negatively impacted my learning

The following characteristics of BME XXX positively influenced the success of the course as a DL course (check all that apply)
☐ level of course organization
☐ lecture medium (e.g., whiteboard, PowerPoint, doc cam)
☐ frequency of class discussions
☐ class topic (e.g., amount of math content)
☐ course pacing (e.g., how quickly material is covered)
☐ time of day course was offered
☐ class size (number of students)

The following characteristics of BME XXX negatively influenced the success of the course as a DL course (check all that apply)
☐ level of course organization
☐ lecture medium (e.g., whiteboard, PowerPoint, doc cam)
☐ frequency of class discussion
☐ course topic (e.g., amount of math content)
☐ course pacing (e.g., how quickly material is covered)
☐ time of day course was offered
class size (number of students)

Improvements for DL experiences in BME XXX

References

9. The Office of Technology Assessment (1990), The Distance Education Network Report.