2006-1264: EVALUATION OF THE IMPACT OF INTERACTIVITY ON STUDENT PERFORMANCE

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Evaluation of the Impact of Interactivity On Student Performance

As dialogue continues regarding engineering education curriculum reform, supporters of innovative instructional methodology, such as active learning, are met with strong resistance by skeptics and proponents of traditional lecture methods. Though considerable evidence has been presented substantiating the benefits of active learning, the opposition to pedagogical change ensues as departmental resources diminish, and university reward structures fail to encourage such efforts. Furthermore, the overwhelming number of methods available to faculty can make the transition from a traditional lecture to active learning a daunting task.

At a large public research university, the first of three paired studies has been completed within a required senior level Manufacturing Processes and Systems course. Two equally sized sections were concurrently taught by the same instructor, exposing students to identical technical content, yet utilizing different instructional techniques. One section was taught using a high-level interactive instructional approach, and the other section was instructed employing mid-level interactive methods. This paper presents a new method for categorizing an active learning classroom environment by introducing the level of interactivity concept and explaining these levels of interactivity within the context of a unique experimental setup. Additionally, the preliminary results for instructional effectiveness, student conceptual knowledge gains and students' confidence in their technical knowledge will be compared for both course sections.

Introduction

Spectrum of Active Learning

Active learning has been broadly defined as "any instructional method that engages students in the learning process."[1] Bonwell and Eison define active learning strategies "as instructional activities involving students doing things and thinking about what they are doing." [2] In his review of current active learning literature, Prince discusses that "the core elements of active learning are student activity and engagement in the learning process." [1] These general definitions of active learning have inevitably led to a multitude of teaching techniques being grouped within the vast spectrum of active learning.

Furthermore, it has been acknowledged by several researchers[1, 3, 4] that active learning encompasses numerous strategies that facilitate student activity and engagement. These activities can include (but are not limited to): the pause technique,[5] class discussions,[6] informal small-group approaches,[7] formal small-group learning,[7] brainstorming, debates, role playing,[8] simulations, peer teaching and one-minute reflection papers.[9] Alternative active lecture formats include the feedback lecture and the guided lecture.[2] The most thoroughly discussed active learning methods include collaborative learning,[7, 10] cooperative learning,[3, 11] and problem-based learning.[12]

What is Interactivity?

To understand the multifaceted variable of interactivity, we can draw upon the research work done in distance education and educational interactive software. In an effort to minimize the misunderstandings that were occurring between educators in distance education, Moore[13] identified three types of interaction: learner-content, learner-teacher, and learner-learner. The *learner-content interaction* is defined by Moore as the "interaction between the learner and the content that is the subject of study." This is the process of the student interacting with the content intellectually, with the outcome being a change in the student's understanding or perspective. Self-study materials are one example of learner-content interaction. In the *learner-teacher interaction*, there is interaction between an expert of the technical material and the student. An illustration of this interaction is what we refer to as traditional classroom instruction. It is noted that this interaction is missing the learner to educator feedback and the resulting teaching procedures are not individualized. Therefore, motivation, successful application of content and misconception analysis is a product of student independence. By using *learner-learner interaction*, inter-student interaction is accomplished through group tasks. This interaction promotes teamwork proficiency while developing and testing the student's expertise.

Dempsey and Sales[14] discuss that interaction in classic instructional theory enables the student or learner to receive feedback. This feedback is considered an essential part of the learning process, and can make learning more individualized. However, conclusive evidence that higher interactivity results in more effective student learning has not been presented. Reviewing the interactive multimedia software research performed by Reamon,[15] interactivity is defined as "the role of the computer in the interaction between the computer and the user." Software characterized as having low-level interactivity (LLI) uses the computer as a presentation device and is considered appropriate for teaching a sequence or process. Reamon describes mid-level interactivity (MLI) software as an effective teaching technology for instructing relationships and reference applications, where high-level interactivity (HLI) software has the potential to teach problem solving and application of content.

This paper proposes using the concept of interaction to differentiate active learning, which can be done in a way that mirrors the identification of interaction in distance education and educational interactive software. If we consider that collaborative learning, cooperative learning and problem-based learning each include learner-teacher interaction, learner-content interaction and learner-learner interaction, then we can characterize these methods as *high-level interactivity*. Though one can argue that during demonstrations, product part examples and movie clips students are passively receiving information, we contend that these items are still "engaging students in the learning process." However, these activities typically promote learner-teacher interaction and learner-content interaction and should be characterized as *mid-level interactivity*. Lastly, the traditional engineering lecture, where a faculty member serves as the content expert bestowing knowledge to students through the chalk board or PowerPoint® presentations can be characterized as *low-level interactivity*.

Why Categorize Active Learning by Interactivity?

Though active learning has a very broad definition, collaborative learning, cooperative learning and problem-based learning have received the greatest amount of attention in engineering education literature. Yet these highly-interactive techniques may not be fitting for every faculty member. Those with reserved personalities or faculty who do not speak English as their first language may find highly interactive techniques difficult to adapt. Subsequently, these faculty members may dismiss the notion of utilizing active learning with the argument that "it does not work for me," if they maintain the misconception that active learning must be highly interactive. It is essential to provide faculty members with a characterized middle ground where they can slowly transition from traditional lecture to a more active environment. This has the potential to remove the dichotomy between active learning and traditional lecture proponents, encouraging more faculty members to make small changes which provide mid-level interactivity, thus moving engineering departments towards institutional change.

It is a broad statement to proclaim that you utilize active learning in your course. The immediate ensuing question pertains to what procedures and methods the instructor is using. Many of us do not see our instructional methods precisely fitting in the collaborative, cooperative or problem-based learning divisions - but instead draw on elements from one or several of these areas to satisfy the context of our curriculum or teaching style. This variation in instructional techniques, coupled with innovative instructional technologies (interactive software, classroom response systems), provides for a wide spectrum of components that satisfy the core elements of active learning: student activity and engagement.[1] Yet one can argue that there is a significant difference between a course utilizing brainstorming, in-class discussions and a classroom response system, and a course that only employs a one-minute reflection paper at the end of each class. The type of activity selected has been found to impact material retention and the students' level of understanding.[1, 16, 17] However, for interventions that do not conform to the core elements of collaborative, cooperative learning or problem-based learning, no classification system exists within active learning; therefore, many techniques or combination of methods remain under the sizeable umbrella of active learning.

Providing an interactive classification system enables faculty to identify with a genre. By separating active learning into high-level interactivity and mid-level interactivity categories, we can more precisely define the broad spectrum of active learning, and study the correlating student outcomes. Additionally, these classifications will provide a stepping stone where future faculty, current faculty intrigued with innovative instruction and skeptics can embrace gradual change within their classrooms.

Background

A considerable amount of support for active learning can be found in physics education and engineering education literature.[2, 5, 18-20] However**,** pragmatic objections are heard from faculty members who are pressured to balance their research and instructional endeavors. We acknowledge that at our university, highly-interactive methods do not fit every faculty member's personality or interests, and prove challenging for foreign speakers. Additionally, low teaching assistant (TA) resources do not always allow for TA's to serve as collaborative assistants in the classroom, which could alleviate faculty personality or language issues. Nevertheless, the authors fervently wanted to expose their colleagues to best practices in active learning that could transcend the curriculum. Our belief is that unique contextual research performed at our university would present persuasive evidence that would encourage broad implementation of active learning methods. In an attempt to answer valuable questions posed by faculty, the research team (the authors) decided to investigate the following:

- What level of instructional interactivity in the classroom most effectively promotes student learning: high-level interactivity, mid-level interactivity or low-level interactivity?
- Does instructional interactivity affect student confidence in knowledge?
- Does the level of interactivity affect class attendance?
- Do female students achieve significantly greater learning gains than their male counterparts with higher levels of interactivity?
- Do both active and passive learning styles achieve greater learning gains with higher levels of interactivity?
- What instructional methods do students find most effective?
- When designing and preparing a class curriculum, does the level of interactivity affect lecture preparation time?
- Is the level of visitation at the instructor’s office hours affected by interactivity?

Anticipating questions regarding variability, we decided to remove the bias of the instructor and minimize the student variability. By having a single instructor teach two course sections in parallel during a single term, comparisons could be made between sections and the variability relating to instructor personality, age, level of interest, personal troubles or illness during the term could be minimized. As for the student population, by randomly sampling one graduating class, we could minimize the variability related to previous instruction.

This paper addresses the first year (fall 2004), when the high-level interactivity class and the mid-level interactivity class were concurrently taught in a required senior level Manufacturing Processes and Systems course in mechanical engineering.

Course Structure and Organization

The Manufacturing Processes and Systems course is designed to expose mechanical engineering students to fundamental material processing and manufacturing concepts. The instructor for the course was a doctoral student (Graduate Part-Time Instructor) with industrial experience in manufacturing, research in polymer processing, and collegiate teaching experience at another large public research university. When this instructor inherited the course, students overwhelmingly disliked the class.

Course Sections

The two sections were taught in the same classroom on Tuesdays and Thursdays for 15 weeks. The high-level interactivity class (section 1) was taught from 9:30 to 10:45 a.m. and the mid-level interactivity class (section 2) was held from 12:30 to 1:45 p.m. In an effort to create two balanced sections, each section was capped at a maximum of 80 students. Once the semester commenced, the HLI class consisted of 57 students, 6 female and 51 male. The MLI class totaled 86 students with 11 female students and 75 male students.

A specific set of techniques was used in each section (Table 1), with the HLI class including daily activities that promoted learner-teacher interaction, learner-content interaction and learner-learner interaction. The techniques utilized in the MLI course only provided for learner-teacher interaction and learner-content interaction. The methods chosen for the HLI section were determined by the instructor as components making up her ideal learning experience. The techniques chosen for the MLI class were considered by the research team to be interventions that most faculty would be willing to support in their classroom.

Section 1 **High-Level Interactivity (HLI)**	**Section 2** **Mid-level Interactivity (MLI)**
In-Class Techniques	***In-Class Techniques***
Lecture In-Class Movies and Animations In-Class Demonstrations In-Class Product Part Examples In-Class Group Activities (Group Work) Debate Brainstorming Classroom Response System (Clicker Questions) Quizzes One-minute reflection papers	Lecture In-Class Movies and Animations In-Class Demonstrations In-Class Product Part Examples Quizzes One-minute reflection papers
Out-Of-Class Techniques	***Out-Of-Class Techniques***
Group and Individual Homework Exams Case Studies Plant Tours	Group and Individual Homework Exams Case Studies Plant Tours

Table 1: In-class and out-of-class techniques utilized in each section of manufacturing processes and systems.

Several studies cited by Wankat[21] advocate that a students' attention span during a traditional lecture is approximately fifteen minutes. The instructor used this evidence to support her philosophy that the same sequence of activities should not be used every day. By changing the order of activities, students would enter class with a sense of anticipation. The instructor was deeply concerned that by engaging students in a repetitive pattern of daily activities, the interventions could become monotonous tasks for students. Therefore, in an attempt to maintain the students' attention span, the order and type of activity employed were rotated for each class meeting. No activity lasted more than twenty minutes in either class. Table 2 illustrates the second, third and fourth day of class in the high-level interactivity class, demonstrating how the order of the activities and the types of activities can be rotated.

Class Meeting 2	***Class Meeting 3***	***Class Meeting 4***
Announcements	Announcements	Announcements
Brainstorming	10 minute content lecture	10-15 minute content lecture
10 – 15 minute content lecture	Group Problem Solving (Case Study Investigation)	Reading Quiz
Group Problem Solving (Open-Ended Question)	Groups reporting out to class	Discussion Question
Groups reporting out to class	Movie Clip	Classroom Response System
One-minute reflection paper	10 minute lecture	

Table 2: Example of how activities and the types of activities can be rotated in the high-level interactivity (HLI) class.

<u>Part 1 – Casting Products</u> (3 minutes to complete this portion)
List five products that are made using casting processes.

<u>Part 2 – Chvorinov's Rule</u> (10 minutes to complete this portion)

1. What is Chvorinov's rule?
2. Use Chvorinov's rule to determine the <u>relative</u> solidification times for castings of the following geometries which each have the same volume.

   a) a sphere
   b) a cylinder with height equal to diameter
   c) a cube

   Note: Volume of a sphere = $4/3\ \pi r^3$
   Surface area of a sphere = $4\ \pi r^2$

<u>Part 3 – Chocolate Mold Defects</u> (5 minutes to complete this portion)
Examine each piece of chocolate that your group has been given (each group member can examine their own chocolate). The cast chocolate has defects that are similar to the defects found in cast metals. Identify at least 4 defects found in your cast chocolate.

Figure 1: Example of group problem solving activity (open-ended questions) used in high-level interactivity (HLI) class and photos used to discuss Part 3 – Chocolate Mold Defects.

Both the HLI and MLI sections started with daily announcements. A normal in-class group activity in HLI had several parts with associated time allocations for each part. Figure 1 shows a typical in-class group activity handout exhibiting quantitative and qualitative questions covering a specific content area (metal casting fundamentals). The photos presented were used for a in-class discussion of Part 3 of the exercise.

In the MLI class, the daily lecture was interrupted every 15-20 minutes and students were re-engaged though the use of short movie clips, demonstrations, or product part examples passed around the class. After the intervention was completed, an explicit connection was made to the concept that was the immediate focus of the lecture. There were some classes where the movie or demonstration prefaced the lecture. It should be noted that in each section the instructor learned the names of the students and randomly called on them by name to answer questions throughout the lecture.

The homework assignments distributed to the HLI and MLI sections were identical. Moreover, matching evening exams were given twice during the semester.

Course Expectations

The expectation for the classroom was based upon the philosophy stated by Smith and Waller,[3] a paradigm in which students and instructors are collaborators in the classroom, in which students view school as a place where they can learn and grow, and in which power is shared between faculty and students. Therefore, to minimize distractions and facilitate this environment, it was requested that students arrive to class on time, turn off their cell phones, put away newspapers and magazines and refrain from having discussions during class in loud voices when others were speaking. Additionally, it was anticipated that each student came to class prepared with their textbook, calculator, having read the assigned text and touting a good attitude.

Students grouped themselves into four-person teams. It was mandatory that each team be formed by the end of the first week and have only one “expert” who received a letter grade of ‘A’ in both Materials Science and Component Design (the course prerequisites). The class required that a portion of the homework and the semester case study be completed with the selected team. For students in the high-level interactivity class, these teams were used for in-class group activities (group work). It should be mentioned that students were occasionally assigned individual homework to encourage accountability. If teams were experiencing difficulties with group members, the instructor encouraged student teams to confront, discuss and resolve the problem. However, if problems persisted, it was requested that the instructor be informed as soon as possible, so she could try to help the team work through the problem. If all else failed, students who refused to participate with their group could be fired by unanimous consent of the rest of the team.

Preliminary Results

On the first day of Manufacturing Processes and Systems, a pre-survey, a pre-content test and Learning Styles Inventory were administered to each student. On the final day of class, a post-survey, post-content test and university Faculty Course Questionnaire (FCQ) was distributed to each of the class participants. Throughout the semester, the instructor maintained a journal to record class attendance, hours required for class preparation and time spent in office hours.

Journal Results

At the end of the semester the instructor tabulated entries from the daily journal to analyze the average daily attendance, the number of hours students visited office hours and the time required to plan both sections of the course.

Throughout the semester, the teaching assistant counted the number of students present. Table 3 shows that the average percent daily attendance for the two sections was comparable. From these numbers it is difficult to conclude that the level of interactivity affects class attendance.

	Average % Daily Class Attendance	**Total Time Dedicated to Office Hours**
Section 1 High-Level Interactivity (HLI)	92.9%	10.5 hours
Section 2 Mid-Level Interactivity (MLI)	91.8%	46.5 hours

Table 3: Fall 2004 average daily attendance and the total time dedicated to office hours during the semester.

The instructor held office hours on Tuesdays and Thursdays for 90 minutes. She also had an open door policy, encouraging students to stop by with questions at their convenience. Each time a student, or group of students stopped by for either formal or impromptu office hours, the instructor recorded the visitation duration and the students' associated class section. It should be addressed that the recorded office hours were not dominated by any individual students in either section. Several different students from each section populated office hours during the 15 week course. The resulting distribution of office hours (Table 3) shows a substantial amount of time being spent with the students participating in the mid-level interactivity class. Given that section 1 had 57 students and section 2 was comprised of 75 students, the enrollment deviation was accounted for during analysis by calculating the average office hour dedicated per a student. The MLI students required assistance 3 times more often than HLI students throughout the semester. This suggests that the level of visitation at an instructor's office hours is affected by interactivity.

Since the course curriculum was totally developed during the fall 2004 semester, the instructor was able to track the number of hours dedicated to planning the course. Several hours each week were devoted to creating PowerPoint® presentations, homework, exams, quizzes, content handouts, the course website, procuring product part examples and scheduling plant tours. These elements were used in both sections of the course and considered shared hours. The additional hours seen in Table 4 were utilized to develop and prepare in-class group activities and discussions.

	Shared Hours	Additional Hours
Section 1 **High-Level Interactivity (HLI)**	21.75 hours	4.0 hours
Section 2 **Mid-level Interactivity (MLI)**		0.0 hours

Table 4: Fall 2004 average hours tabulated for weekly planning.

Survey Results

A post self-assessment survey was completed by 44 students in section 1, and 80 students in section 2 on the topic of instructional effectiveness. Students were asked to rate the effectiveness of lecture, in-class movies and animations, in-class demonstrations, in-class product part examples, homework, exam and case studies (Figure 2) for learning course content. These elements were rated by student survey participants on a 1-5 scale, with 5 = very effective and 1 = not effective. Section 1 was also asked to rate the effectiveness of in-class activities and clicker

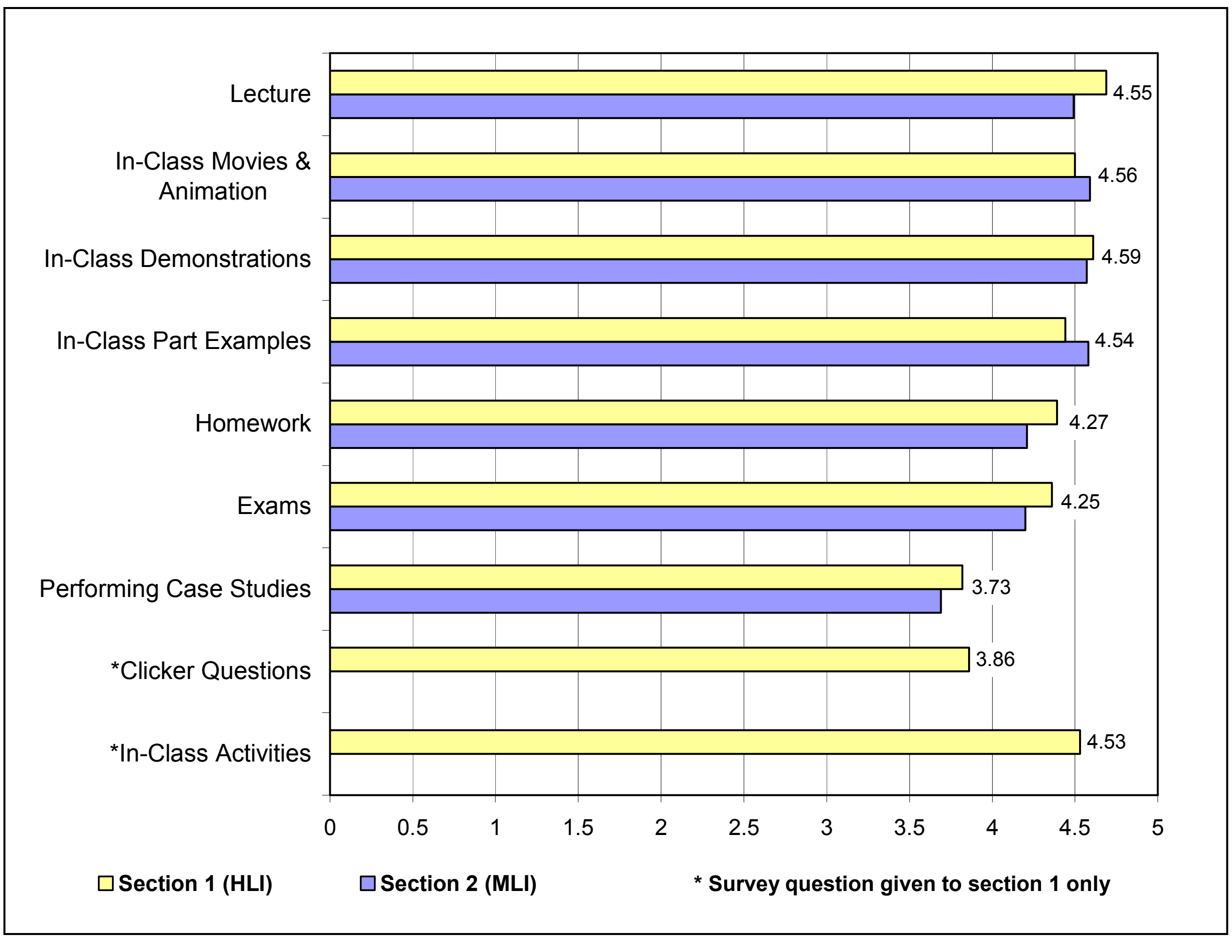

Figure 2: Mean effectiveness of instructional methods for section 1 and section 2. Values to the right of bar graphs display combined means for section 1 and section 2.

questions. A paired value t-test was used to test for significant differences between the sections. Since there was not a statistical difference between the HLI and MLI sections, the results are reported as the combined means for both sections, seen to the right of the bar graphs in Figure 2. The results show that students found lecture, in-class movies and animations, in-class demonstrations, in-class product part examples and in-class group activities the most effective for learning course content. They also rated the clicker questions and case studies as the least effective components of the course.

Students in both sections also completed pre- and post-course self-assessment surveys regarding confidence in technical knowledge. For section 1, 44 of 57 students participated in both the pre- and post-survey. In section 2, 80 out of 86 students submitted pre- and post-course self-assessment surveys relating to confidence. Students rated their confidence on a 1-5 scale, with 5 = highly confident and 1 = not confident.

Student confidence results are presented in Table 5. A paired value t-test was used to test for significant differences between the pre- and post-test assessments. Results indicate that students in both sections reported significant gains in confidence for each concept area. The strongest results were for casting and statistical process control (SPC) knowledge, with students reporting a gain as high as 275% in confidence.

	Average Percent Increase in Confidence	
	Section 1 HLI	**Section 2 MLI**
Knowledge of Material Properties.	43%	31%
Knowledge of Equilibrium Phase Diagrams.	51%	43%
Knowledge of Polymer Technology.	114%	88%
Knowledge of Measuring Instrumentations used in Quality Control.	141%	65%
Knowledge of Expendable Mold Casting.	237%	207%
Knowledge of Multiple-Use Mold Casting.	275%	221%
Knowledge of SPC.	250%	224%
Knowledge of Hot Working Forming Processes.	128%	129%
Knowledge of Cold Working Forming Processes.	135%	131%
Knowledge of Turning and Milling processes.	103%	88%
Knowledge of cutting tools for machining.	70%	66%

Statistically significant difference between Section 1 and Section 2, p < .05

Table 5: Percentage gains in student technical knowledge confidence.

A repeated measures ANOVA statistical procedure was employed to test for significant differences between sections. Results indicate that there is a significant difference in confidence gains between section 1 and section 2 for two concept areas: *Knowledge of Measuring Instrumentations used in Quality Control* and *Knowledge of Multiple-Use Mold Casting*. The preliminary data do not show a significant difference in confidence gains between section 1 and section 2 for the remaining content areas. However, the ANOVA test shows a pattern of section 1 gaining at a steeper rate than section 2, which is interesting but not statistically significant. More testing is needed to conclude if there is a difference between the confidence gains of the two sections.

Concept Test Results

Students were also assessed on course content knowledge by completing a 24-question multiple-choice, pre- and post-test on the topics of material properties, quality control, expendable mold casting, multiple-use mold casting, hot working processes, cold working processes, material removal processes and polymer processing. The test was completed individually, with books, notes and calculators prohibited. Unfortunately, a concept inventory or similar validated assessment metric does not exist for manufacturing. Therefore, the instructor developed a concept exam with 3 questions dedicated to each topic area. The authors recognize that the internal reliability of this assessment metric may affect the results and the subsequent conclusion validity. However, the extensive development process that is required to create a valid and reliable instrument was beyond the scope of this research project. Development of a manufacturing concept inventory is currently being discussed.

	Sample Size	**Pre-Content Test Mean**	**Post-Content Test Mean**	**% Change**
Section 1 **High-Level Interactivity (HLI)**	43	9.4	16.0	70.2%
Section 2 **Mid-level Interactivity (MLI)**	71	8.2	16.4	100.0%

Table 6: Percentage gains in student technical knowledge confidence.
Statistically significant, $p < .05$

A paired value t-test was used to analyze if a significant difference exists between the pre- and post-content assessment scores for each section. Both the HLI section and the MLI section proved to experience significant gains in content knowledge. Section 1 reported a 70.2% gain and section 2 yielded a 100% gain.

A repeated measures ANOVA statistical procedure was then utilized to examine if the section 1 and section 2 test scores were significantly different. The calculated results indicate that there was a significant interaction effect between the HLI class and the MLI class content assessment scores. To determine if a statistical difference exists between sections at both the pre-test and post-test, an additional t-test was performed. The results show that there was a significant difference between sections at the pre-content test, yet there is not a significant difference between sections at the post-content test. The MLI section started with a lower pre-content test mean and out gained the HLI section, resulting in the MLI section achieving a higher post-content test mean. These results are supported by the fact that the course class averages at the end of semester were equivalent for sections.

Student Evaluation of the Course

The instructor was highly regarded by the students, as evidenced by numerous teaching awards she received during the 2004 - 2005 academic year: Graduate Part-Time Instructor Teaching Award, Residence Hall Teaching Award, the Leads Faculty Appreciation Award, the Multicultural Engineering Program Faculty Appreciation Award, the university chapter American Society of Mechanical Engineers Best Lecturer Award and the Sullivan-Carlson Innovation in Teaching Award.

Faculty Course Questionnaires are part of the University course evaluation program. The aim of the evaluation is to help individual faculty improve their courses and teaching, to aid administration with course assignments and promotions, and to assist students with course selection. The FCQ ratings for both sections of the course were excellent. Students in section 1 (HLI) gave the course an A- rating and the instructor an A rating. Section 2 (MLI) appraised both the course and the instructor at an A. The year prior to the instructor taking over the class, Manufacturing Processes and Systems received a C course rating and an instructor rating of a B-.

Students also provided comments on the FCQ survey regarding the most effective aspects of the course. In the HLI section students remarked:

"This is the first class I have taken since Kindergarten where I had perfect attendance!"
"Instructor is one of the few professors that really seems to enjoy teaching the material."
"Hands-on activities and demos most effective."
"Fun classroom experience, great teacher"
"Excellent hands-on demos and in-class activities"
"Active lectures"
"Hands on learning"

However, the high-level interactivity section also commented on the least effective aspects of the course:

"Quizzes and class participation"
"Clickers!"
"Too much group work"
"Amount of group work"

In the MLI section students stated the following concerning the most effective aspects of the class:

"The lectures were interesting and involved students; we were well-prepared for exams."

"Lectures were very informative, fun to attend. Demos and animations helped a lot. Homework and exams made me study important ideas, many situational problems."

"The examples shown in class, being able to physically see the object that was manufactured by certain processes was most effective."

"Having a teacher come from industry has been the most beneficial part of this class. She keeps the attention of the class better than any I have taken in the last 4 years, while also teaching material that is relevant to things needed in the future."

The mid-level interactivity students did not provide suggestions for changing any of the interventions used in that section.

Conclusions and Future Work

After evaluating the preliminary results, we have reached a consensus that additional data are needed before firm conclusions can be drawn. Though there are some promising initial results, there are several unanswered questions that need additional investigation. For instance, will the results change during the second year – once the instructor has more experience with facilitation of in-class activities? Did technology problems influence student self-survey results?

Based on the current data, the following speculations can be made:

- The equivalency of the average percent student attendance suggests that interactivity does not influence student attendance.
- When developing a new curriculum, a high-level interactivity course only takes four additional planning hours per week over a mid-level interactivity course.
- The fact that the MLI students required assistance 3 times more often than HLI students during the semester may indicate that the level of visitation at the instructor's office hours is affected by interactivity. This could be beneficial for faculty who are concerned that adapting high-level interactivity techniques will be time consuming. If creating a course, time dedicated to developing in-class activities could be offset by a reduction in office hours.
- From the student perspective, the most effective way to learn course content is through lecture, in-class movies, in-class demonstrations, in-class product part examples and in-class group activities.
- In the self-evaluation, students reported significant gains in confidence for material properties, quality control, expendable mold casting, multiple-use mold casting, hot working processes, cold working processes, material removal and polymer processing. However, it is unclear if instructional interactivity affects student confidence in knowledge. There is evidence that HLI students do attain a higher confidence in their technical knowledge.
- Both the HLI and MLI classes gained significant technical content knowledge. At this time it appears that high-level interactivity is no more effective for student learning than mid-level interactivity.
- Teaching awards, FCQ ratings and student comments indicate that students were extremely satisfied with both the high-level interactivity and mid-level interactivity class.

- Not all students favored the highly-interactive class, which was demonstrated by student comments and FCQ ratings. This may be contributed to the fact that students had never been exposed to in-class group activities before this course.

Future work for this research project includes analyzing if gender and learning styles are affected by interactivity, performing a statistical analysis by content area on the multiple-choice content test and investigating the correlation between student grades and attendance. Additionally, the parallel section experimental design was re-implemented in Manufacturing Processes and Systems during the fall of 2005, and is scheduled for adaptation during the fall 2006 semester. The research team determined that a substantial portion of the first experimental cycle was dedicated to course development, and a learning curve was associated with effective facilitation of in-class group activities. Therefore, the high-level interactivity and mid-level interactivity concurrent section design was re-introduced during the fall of 2005. Assessment data similar to what has been discussed in this paper was collected, and will be analyzed during the coming months. The current proposal is to teach a mid-level interactivity and low-level interactivity course during the fall of 2006, providing a baseline for the research. It is the intention of the research team to implement the lowest level of interactivity (LLI), which is still commonplace among engineering departments, and compare the effectiveness of MLI to LLI.

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