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Observations on Benefits/Limitations of an Audience Response System

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Abstract

Providing stimulating lectures to large groups of students has been one of the most challenging aspects of a first-year engineering course sequence. Prior efforts at improving the lecture environment included use of an audience response system (ARS). While the ARS was a positive influence, two limitations were identified: (i) it did not provide for one-on-one interaction with students, and (ii) overuse led to student discontent. Experiments are underway to combine the ARS with use of a Tablet PC, allowing the lecturer to wirelessly project the Tablet PC screen while moving around the lecture hall. The lecturer can run software from any point in the hall, annotate / save slides in real time, or project student annotations and problem solutions to the class. This has allowed the lecturer to: (i) interact directly with individual students, (ii) encourage a participatory learning environment, and (iii) maintain higher levels of attendance at lectures. While a number of positive impacts on the learning environment have been observed, it is noted that the students do not generally recognize the novelty of the new technology. Thus, motivation for use of the technology should be based on improvement of the learning environment rather than on the novelty of the technology.

Introduction

The College of Engineering at the University of Notre Dame has developed a two semester course sequence for all first-year students interested in the possibility of pursuing engineering as a major. Brockman et al.[1] discuss the original motivation for the course, as well as the original format utilized. The format has since been modified to include two 50 minute lectures per week presented to the entire student body (classes number between 360 and 390 in the fall and between 260 and 300 in the spring) plus a 75 minute "learning center" session involving hands-on activities taught to groups of students not exceeding 30 in number. Lectures and learning-center periods equip students with the theory and applications required to complete four, one-half semester projects. Three of the projects are performed in groups and one is completed individually. The course has been assessed from a number of viewpoints. McWilliams et al.[2] and Pieronek et al. [3] present recent observations involving course modifications based on assessment and demographic comparison of student satisfaction with the course and student retention through the two-semester sequence.

A number of significant challenges have been encountered with this course. Among these has been creating a stimulating learning environment during lectures to large groups of students. Course assessment has consistently shown that students consider the lectures to be a weak

component of the course. Dissatisfaction with the lectures is related to three issues: (i) the inability of the individual student to feel an active connection with the lecture, (ii) the limited ability to allow student feedback during lectures, and (iii) student perception that lecture material is only peripherally related to the four projects that the students are required to complete during the course.

In response to the first two issues, an Audience Response System (ARS) was introduced to the lecture portion of the course. Discussed in Silliman and McWilliams[4], the ARS provided a means of stimulating students during lectures through introduction of regular student feedback in the form of response to multiple-choice questions. It also provided regular opportunities to tie the lecture material directly to the analyses required in the projects. Overall response to the ARS has been positive. However, two limitations were observed. First, the ARS did not necessarily assist in making a connection between individual students and the lecturer. Second, student opinion of repetitive use of the ARS was mixed. Whereas some students enjoyed the ARS (to the point where one student stated that it was the sole reason to get up "early" for a 12:50 class!), other students commented that the ARS was distracting in terms of the flow of lectures.

As a result of these observations, a means was sought to achieve greater interaction between the lecturer and the student. As part of a Notre Dame project on application of Tablet PCs (TPC) in the classroom (see www.nd.edu/~learning/tabletpc), the College of Engineering tested application of a TPC in the first-year course. Significant utility of the TPC was realized only after introduction of software that allowed its use while moving around the classroom. Applications that have been pursued range from those possible with wireless laptops (e.g., running PowerPoint® and other applications while roaming the lecture hall) to those facilitated by the Tablet PC platform (including annotation of slides and active student contributions to the lecture slides).

The Importance of an Interactive Learning Environment

It has been recognized that an interactive environment including student-student and student-faculty interaction is crucial to keeping students engaged in learning. A number of authors[4-11] have presented studies of the utility of various interactive techniques. Silliman and McWilliams[4], Zurita et al.[7], Campbell and Floersheim[8], and Burtner and Moody[9] have discussed the utility of information technologies in the classroom. Among the methods utilized have been hand-held student-response systems[3], handheld computers[7], and networked computers[8,9]. Reported advantages include enhanced student interaction during classes, more active student engagement in learning, and enhanced retention[4,7,8,9].

The TPC has also found a number of applications in the classroom. Mock[10] has discussed applications of the TPC as a replacement for the blackboard and in conjunction with PowerPoint® presentations. A number of additional applications are discussed at the Microsoft® website for TPCs (www.microsoft.com/windowsxp/tabletpc/). Additional links to use of TabletPCs at other universities may be found at www.nd.edu/~learning/tabletpc. Among the advantages discussed among these various applications are: portability, use of "electronic ink", saving / archiving live lecture notes, and the ability to interact with students in real time.

The Technology Used In This Study

The work discussed is based on two information technologies. The first is a radio-frequency based ARS[4]. As applied in the course, this ARS system allowed integration of multiple-choice questions into PowerPoint® with real-time summary of student response projected to the

students. Limitations on the number of response units available required that the units be used by groups of 3-4 students. These groups were not pre-assigned and varied from one lecture to the next. The responses were used primarily to: (i) provide feedback on student understanding of course material, (ii) increase student involvement / interaction during lectures, and (iii) provide reinforcement of course material and the link between lectures and the student projects. A number of variations on this approach have been assessed, and a number of benefits have been identified, including improved student response to lectures and improved retention[4].

Assessment, both formal and informal, has shown significant dichotomy of student opinion regarding this application of the ARS. One group of students felt that the ARS had little net value to learning. In contrast, another group indicated that the regular use of the ARS had a positive impact on the course (to the point that one student indicated that use of the ARS was a primary motivation to "get up early to attend" this class which meets from 12:50 – 1:40 !). Overall, use of the ARS, in the absence of other new technologies, has had a positive effect on the learning environment[4].

The second technology utilized is a Tablet PC (TPC), combined with NetSupport Manager® software, that can wirelessly project its screen to the class. All operations performed on the TPC can be viewed by the students, thus allowing the lecturer to utilize such software as PowerPoint® or MATLAB® while remaining mobile in the classroom.

The TPC gains advantage over a wireless laptop through the pen interface which allows annotation of PowerPoint® slides, creation of ink drawings, and derivation of (hand-written) lecture notes, all in real time. These capabilities have been applied in multiple ways, including:

- adding details to PowerPoint® slides during lectures
- presenting "live" derivations of equations
- creating lists of student responses to questions asked during lectures
- providing students with the opportunity to contribute to derivations and discussions through passing the TPC among the students during lecture

The ARS and TPC are applied in combination. For example, when working with multiple choice questions, the TPC can be used to add possible answers. The ARS system can then be used to seek student response to the question. Following display of results, the TPC is once again used to develop arguments for or against each possible answer. This approach has allowed both detailed discussion of the various answers, and justification / explanation of the approach required to achieve a single "best" answer (or a subset of equally probable answers).

Assessment of Impact

As the TPC / ARS combination has only recently been introduced to the first-year course, formal assessment has been somewhat limited and is based primarily on soft data (longitudinal surveys on long-term impact are not yet available). Assessment tools applied to date include:

- Discussion with individual students and faculty.
- Observation of changes in student behavior during lectures.
- Course evaluations, including student satisfaction with the lectures.

Assessment is made more difficult by the structure of the course. Specifically, each semester involves two student projects, each with its own 7-week series of lectures. Each set of lectures is typically presented by a different faculty member with a different interest in information technologies. Hence, there is not a uniform level of information technology used throughout any given semester. Further, each student is exposed to a different faculty member (typically not the faculty member giving the lectures) in the learning center portion of each project. Finally, course

assessments / surveys are currently administered only at the end of a semester, such that student responses are integrated over an entire semester's experience. The following represents initial analysis of the impact of the combined TPC/ARS on the learning environment.

Discussion with Students and Faculty

In assessing the TPC/ARS system, we spoke with one group of faculty and two groups of students. Each semester 5-6 faculty have responsibility for directing the learning center periods. Many attend the lectures and all have regular contact with students completing the course. Over the past year, formal and informal discussions have been completed with 8 faculty. In general, these faculty were satisfied with the use of the TPC/ARS combination, but did not note a significant change in student understanding. They did, however, note greater student interaction during lectures.

Fourteen undergraduate engineering majors are employed each semester as peer mentors for the course. These students completed the course sequence in prior years and interact regularly with the first-year students. Many also attend the lectures. The reaction among these peer mentors to the use of the TPC/ARS was positive. Feedback indicated that the ability of the faculty member to be mobile, to interact with individual students, to annotate lectures, and to challenge students via the ARS had positive impact on the learning environment.

The second student group consisted of those currently enrolled in the course. Results have been collected through questions regarding the use of technology on formal end-of-the semester surveys (average response rate of ~85%), comments added to course evaluations (approximately 10 out of 300 evaluations received had comments added regarding the use of technology), and informal questioning of a number of students (approximately 40 students out of a class of 360 were questioned on their response to the TPC/ARS). A wide diversity of reaction has been recorded. For example, one student wrote on a course evaluation that the lecturer "needs to stop circling everything on the slides . . . someone needs to take his stylus away from him." Although not stated as succinctly, the impression was garnered from other students that they had a similar reaction to the use of the TPC technology. Other students expressed significant satisfaction with the use of the TPC/ARS, with benefits ranging from keeping them engaged in lectures, to electronic archives aiding in review of lecture notes. One consistent result was that these students did not view the combined use of the TPC/ARS systems as new or unique. Rather, they appear to accept it as a standard part of teaching technology. This is consistent with the students, on the formal survey, marking the use of technology (particularly the ARS) as neutral with respect to their learning experience.

Our informal discussions with the students in the class also showed rising expectations with respect to use of information technology. This introduces two challenges. First, using advanced technologies in the first year raises the level of expectation for incorporation of technologies in later courses. Hence, there is an opportunity for a technology gap between the first-year courses and more advanced courses. Second, experimenting with new technologies in front of first-year students carries risk of technological glitches while eliciting few kudos from these students. Caution must be exercised to ensure that the technology is effective and the learning experience is superior to that which would have been realized using established technologies.

Observations of Student Behavior During Lectures

Three significant changes in student behavior during lectures were noted after introduction of the TPC/ARS. First, the students and lecturer were more personally engaged in the fall of 2004.

By roaming the lecture hall, the lecturer encouraged input from individual students. The students appeared less hesitant to respond to questions. There was also a noticeable decline in the "back-pack stuffing" (the tendency of the students to prepare to leave the lecture hall prior to the end of the lecture) that had become a hallmark of lectures in prior semesters.

Second, the students enrolled in the fall of 2004 were far more active in challenging the lecture material. In the fall of 2004, students regularly asked streams of pertinent questions and challenged the relevance of the lecture material. It is believed that this increased engagement is a direct result of the lecturer communicating his expectation of engagement via roaming the lecture hall, sitting with students during lectures, and noting student questions as annotations on the lecture slides.

Third, student attendance has increased (attendance at lectures is encouraged but not required). Although formal attendance is not recorded, head counts are performed on a regular basis by faculty residing in the back of the lecture hall. While these counts have an associated error of approximately 10-15 students, or approximately 5%, and vary from one lecture to the next (dependent on day of the week and lecture topic), we are confident in stating that the attendance has increased substantially over the past 3 fall semesters. Further, the decline observed during the semester in the fall semester of 2002 was not observed (i.e., attendance was approximately constant throughout the semester) in 2003 and 2004.

Student Course Evaluations

Course evaluations also provided insight into the use of the TPC/ARS. Table 1 shows the questions associated with student assessment of lectures. The evaluations were distributed to all students attending the course in the final week and over 300 responses were received. The students were given a four point scale for the first seven questions, including: "1 = no improvement is needed", "2 = a little improvement is needed", "3 = a fair amount of improvement is needed", "4 = major improvements are called for", as well as the option "not applicable". The students are given a five point scale for the question regarding the overall quality of the lecture: "1 = Excellent", "2 = Good", "3 = Satisfactory", "4 = Poor", and "5 = Very Poor". The average values and standard deviation of these values, for each question, are shown in Table 1.

Based on these results, there appears to be a difference between student assessment of faculty effort and assessment of the overall quality of the lectures. Mean student responses to the first seven questions were in the realm of "no improvement" or "little improvement", thus (based on our history of evaluating the same questions for all university courses) indicating satisfaction with the efforts of the lecturers. In contrast, the average response with respect to the overall quality of the course is between "satisfactory" and "good", a relatively low mark compared to the equivalent question evaluated over all university courses. This latter result is thus interpreted as indicating lower overall student satisfaction with the lecture portion of the course. Further, the students appear to be most comfortable with the level of preparation, enthusiasm, and instructor's care for student learning (lowest mean value of response). They appear somewhat less comfortable with the presentation and stimulation of the material. Finally, when correlations among these responses are determined, the student response regarding overall quality of the lectures is most strongly correlated with the student response to the questions on stimulation, quality of presentation, and degree to which the instructor is helpful and patient.

We interpret the combination of these observations as being consistent with an overall view, by the students, that the faculty are "putting in the effort", but that the large lecture environment

is simply not very conducive to stimulation or integration of theory with the specifics of their projects. This result reinforces the desire to identify appropriate learning technologies for application in the lecture portion of the course.

Analysis of patterns within the data (performed graphically by separating survey responses according to responses to question 8 versus the mean response to questions 1-7) indicates that there are 3 subsets of students with differing responses to this evaluation. The first group of students provided both consistent and favorable results among the first 7 questions ("little improvement" to "no improvement"), the assessment of overall quality of the course ("Good" or "Excellent"), and a separate question regarding the quality of the content of the course. This result is interpreted as these students being generally satisfied with the content and style of the course. Approximately 40% of the student responses fell within this group.

Table 1: Summary statistics of student response to lectures in first semester course.

Statement	***Mean Response***	***Stand. Dev. of Response***
The instructor is well prepared for lectures	1.43	0.67
The material was clearly presented	2.09	0.81
The instructor stimulates creative or analytical thinking	2.19	0.86
In dealing with students, the instructor is helpful and patient	1.62	0.69
When asked questions, the instructor satisfies the students	1.80	0.76
The instructor appears enthusiastic about the subject matter	1.32	0.54
The instructor shows care for the students' learning	1.53	0.70
Please evaluate the overall quality of the lectures	2.41	0.92

The second group of students indicated more satisfaction with the lecturer than with the overall quality of the lecture (mean response to questions 1-7 are low while mean response to question 8 is relatively high). In many of these cases, the student indicated lower levels of satisfaction with the overall content of the course. This response appears consistent with the material presented in the course being different than anticipated by the student such that dissatisfaction will be noted with respect to the overall quality of the lecture regardless of the techniques used by the lecturer. Nearly 45% of the students fell within this category.

The final group indicated that they intend to pursue a major outside of engineering and consistently mark either extremely high or extremely low responses to all questions. This response appears consistent with students who did not find an intended major within their first-semester experience. They therefore view the course either as an opportunity to investigate new

possibilities or as a waste of their time as the engineering curriculum did not fulfill their needs or interests. Approximately 15% of the students fell in this category.

Among these three groups, it is argued that the first group will enjoy a more active learning environment, but will generally not receive a substantially different learning experience by improvement in the information technology used in the lectures because their interpretation of the quality of the course is uniform over all aspects of the course. Hence, improvement in one aspect is less likely to dramatically change the overall student experience.

The second group of students would also be unlikely to receive a substantially different learning experience solely by improvement in the quality of the lecture style (e.g., the use of new information technologies or other methods to increase student stimulation during lectures). The reason is quite different in this case as the students in this group appear to be dissatisfied with the overall content of the course. Hence, it is argued that improvement in the level of stimulation or more advanced use of information technologies will not fundamentally change the reception of the course material by these students.

The most illusive group of students involves those that have decided within the first semester of this course sequence that they will change majors prior to their sophomore year. It remains unclear whether improved methods to stimulate these students, or different presentation of the course material, will substantially change the learning experience for these students.

The results from the evaluations indicate that the lecture portion of this course continues to be somewhat problematic in terms of student engagement and student satisfaction. Initial indications are that the students may be divided into multiple groups with differing sensitivity to the use of information technologies during lectures. Such diversity in response to use of information technologies is consistent with earlier studies of the application of these technologies in undergraduate curricula[12]. It is concluded that, for the majority of these students, improvements in use of the TPC / ARS can lead to improved reception of the lectures, but may be unlikely to dramatically change the overall learning experience of the students without a concurrent change in course content.

Conclusions

A combination of a wireless Tablet PC with NetSupport Manager® software and an Audience Response System was employed in a first-year engineering course. Assessment of the impact of this system included discussions with various groups involved in the course, observation of student behavior in the lectures, and analysis of course evaluations. Observations from these data include:

- The students enrolled in the course sequence had mixed reactions to use of this technology,
- These students generally did not recognize that this technology was either new or innovative.
- Peer mentors, who had prior experiences in this course sequence, generally indicated that the technology improved the quality of the learning environment.

- Faculty generally did not find fault with the technology, but neither did they indicate that it substantially improved the course, other than in terms of student behavior during lectures.
- Observations of student behavior indicate improved attendance, increased engagement, and increased willingness to take an active role in the lectures.
- Despite difficulties in interpreting formal course evaluations, overall results suggest students respect the lecturer's effort and enthusiasm, but are neutral regarding the overall impact of the lectures on the learning experience.
- There were 3 different groups of students identified in from the course evaluations, each responding differently to the course sequence. These groups are likely to respond in different ways to the use of TPC/ARS. Identifying these groups may provide guidance for new assessment tools, as well as modifications that would result in more beneficial use of the technology.

Application of the combined TPC/ARS systems has contributed to the continuing improvement of lectures in the first-year course sequence. However, faculty and students do not perceive that incorporation of these technologies has had a dramatic, short-term effect on the learning environment. Substantial care must be taken in first-year courses where students may not appreciate the uncertainties associated with educational experiments and may become disillusioned when technology use is not carried over into future years.

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