# ON PEDAGOGICAL CONCERNS OF ENGINEERING COURSES IN DISTANCE LEARNING ENVIRONMENTS

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**Abstract** — *The distance education and learning have emerged as a popular method of instructional delivery in engineering and technology-related fields. In this article, we discuss pedagogical concerns in distance learning environments including some background and lessons learned from our experience with online instructions in engineering and technology. We discuss students' performance using some accurate but crude data. The article's discussion encompasses faculty pedagogical concerns of security, interactivity, equity, hands-on demonstration of concept, team-workability assessment, and ethics, all related to online courses in engineering and technology. Some conclusions are also established intuitively through our informal discussions with the colleagues having similar experiences. One major conclusion is that in "open and honest" online learning environments such as those in most institutions of higher education in the United States, the most important focus should be on the "ethics" education of the students in mostly a minimal-proctored learning environment.*

*Index Terms — distance learning; pedagogy; engineering; faculty; performance*

## INTRODUCTION

Prior to the availability of computer and software technology used routinely in education today, "distance learning" was referred to as an individualized mode of learning only available through correspondence. Today, "distance learning" and interchangeably used "distance education," "E-learning," and "online education," are commonly referred to as education methodologies and delivery systems that provide the learners to remotely access courses via advanced technologies. Such methods are widespread across the world and here in the United States, i.e., at the University of Central Florida and the Texas A&M University. Present technology and the accessibility of the internet have made distance learning much more viable, and it has evolved from traditional ways to robust, more efficient, and more convenient for both the students and the instructors. Online teaching and learning is progressively regarded as a means of increasing flexibility and robustness of delivery to provide for greater student access to, and control over, their learning whether they are studying on-campus or in distance mode, or offshore[1, 2, 3].

Current technologies allow instructors and students to communicate asynchronously, at times and locations of their own choosing, by exchanging printed and or electronic information. New technology, such as Backboard™, provides a more efficient and robust management system for remote classrooms. Needless to mention that there are many economical advantages to distance learning that has been addressed previously in the literature (Mehrabian, et al., 2008). With this new trend in distance learning and education, in recent years distance education and learning have emerged as a popular method of instructional delivery in engineering and technology-related fields. Inevitably, many faculties of engineering and technology may find themselves teaching online courses or planning on teaching one. In this process, there are some pedagogical issues and concerns in curriculum development, much of them revolve around the educational quality and effectiveness. This process can be quite challenging at times, particularly for the faculty that do not have any prior experience with teaching online courses. Psychological setbacks and barriers among undergraduate engineering students also add another concern for the faculty teaching in a distance education environment, i.e., students may have fears of losing partial credit in an online multiple-choice exam. The asynchronous and economical advantages of distance education and learning that make offering and taking them very popular force the profession to re-examine, re-organize, and re-engineer some of the exam-related issues that otherwise don't exist.

For example, application of, "honest, open book, open mind" approach is being recognized in the literature as a potential method of examination for distance courses in the faculties of engineering, science, and technology[1,3]. In adapting to this method, faculty may have to develop new methodologies, and structure or restructure their course differently to accommodate and facilitate the effectiveness of online examination methods. Some very recent studies documented the practicality and effectiveness of distance learning methodologies[3]. Results from an early study of the desirability and feasibility of using distance learning indicated that this teaching and methodology has a useful role in distance learning[4]. The case for employing project-based learning methods as opposed to more traditional teaching methods, where the learning path follows a carefully predetermined structure, has been argued elsewhere[3].

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In this paper, the authors discuss their enduring practice and efforts with providing online instructions and education for the distance learning courses in engineering and technology. We touch on pedagogical issues of assessment, security, inclusion, etc. We use some accurate but crude empirical data and evaluation methodologies to draw our conclusions. The data used are collected by the authors from more recent sample courses that have been taught by the authors over the last five years. This facilitates the evaluation of the latest data, challenges, development of new methodologies, and monitoring the current trends. For inclusive reasons, we use the words "learner" and "student" interchangeably in this article.

## PEDAGOGICAL CONCERNS

In this section, we present and discuss some of the pedagogical issues and concerns in distance learning education. For clarity of presentation, each discussion is presented under appropriate sub-heading below.

Learning is seen as essentially a social process, requiring communication among learner, instructors, and others. It is believed that this process will increase the effectiveness of learning. This social process cannot effectively be replaced by technology, although technology may facilitate it[5]. While faculties are concerned with students' learning, course outcome, and effective assessment, based on our personal experience, we observe that students are often concerned with their grades and prompt feedback on their grades. Rightly so, but in some instances, students may take this too far and transform the objectives of a course from a learning-centered course to a grading-centered focus. This can adversely affect the course outcome and reduce the course effectiveness. Recognizing that grades are a valuable assessment tool in many courses, it is essential to ensure the impartiality of the examinations and thus increasing the effectiveness of this essential assessment tool. This is particularly applicable in an online environment where granting partial credit is neither practical nor effectively manageable using the available technology. How can a faculty ensure that a student's knowledge about the subject matter is measured by an online examination if the entire knowledge of the student about the subject matter cannot be measured? Most online examinations consist of either multiple choice, true/false, or short answer type of questions. In some online examinations, the combinations of the questions and their different types are used. In each case, there are variations in the responses. However, the inability of granting partial credit in an online examination environment may indicate false assessment measures of the students' progress in the course. Nevertheless, we find that the following concerns challenge the faculty on numerous occasions, and they are more common in distance learning for the engineering and technology-related courses:

***1. Examination Security:*** In an online "open book, open mind" examination environment where there is no live proctor or visual examination monitoring, the exams shall be crafted accordingly to prevent any kind of plagiarism or illegal use of the available materials. Several such cases are reported by Colwell and Jenks in 2005[6]. Due to the difficulty of controlling the online examination environment against plagiarism, we found that the students should be tested more on the concepts rather than the material that can be easily plagiarized. This may work well for some courses. However, this is not an easy task for courses that involve engineering design that heavily relied on calculations. To reduce the likelihood of plagiarism, we suggest and used a contract similar of that presented in Colwell and Jenks [6]. Depending on the course under consideration, we also use random question/problem generators in WebCT™ and Blackboard™. Basically, there is no easy way around this issue. We feel that this is one of the trade/offs of distance learning. However, like any other examination environment, there should be no concern about the exam security if the students are honest about their learning. "I feel I learn more in an open-book, open notes" examination" three students mentioned in an engineering course evaluation sheets. Others mentioned, "I feel less pressured in an online examination environment," "I like the fact that the professor trusted me with an online exam," and "I feel I am tested for the real knowledge that I gained in this course." In Summary, the authors feel that honesty is the best policy to enforce during an examination that fairly eliminates this issue.

***2. Interactivity:*** Some faculty feels that they should be available during the examination period. Some student suggests to us informally that they feel that they perform better if taking "live" exams as opposed to "online" exams. If that is the case, the availability of the faculty is essential in case students have any questions regarding the exam content and material. The faculty may desire to let the students know in advance about the exam availability period and his/her availability. Faculty can remotely contacted by the students via emails, messengers, and telephones throughout the course and while taking the examination.

***3. Equity:*** Some faculty is concerned with the level of difficulty of examination questions for different students. They believe that all students taking the same course at the same time shall receive exams of the same level of difficulty. Faculty may feel that this is just and equitable. In an online examination environment, we propose "guided grouping of the questions" in which we divide the questions according to their level of difficulty. We then use questions at random for the same examination for the same course. This is applicable to cases in which we use random question generation functions in the online course management systems. Faculty may have to go through a period of "trial and error" before they can master this method. It also requires more time and dedication in crafting online exams for the courses with less available resources for the faculty.

***4. "Hands-on" Demonstration of Concept:*** In some online laboratory environments, some faculty would like to see

their students demonstrate their understanding of the concept. This is not an easy task for online students that take the course remotely. We recommend utilizing screen-capturing software in which every movement of the cursor on the computer screen can be captured and traced back effectively. Our experience with experimenting with screen-capturing software at this stage is a work in progress. We should be able to provide more information of our experimental approach in the near future.

***5. Team-workability Assessment:*** Group performance and team-workability skills are important tasks for the engineering and technology students to learn while they are still at school. In an online course environment, there should be methods of assessment for students' workability and performance in teams. We assess students' performance in teams by methods used by Mehrabian et al[3,7] where they described their experiences for a senior design project course. In this case, students worked remotely in teams. In some case the students (team members) lived as far as 200 miles apart from each other.

***6. Ethics:*** The Engineering Criteria 2000 of the Accreditation Board for Engineering and Technology (ABET) pledge to significantly and rigorously improve the landscape of engineering education in the United States. One outcome of Criteria 2000 is increased attention in the curriculum to the ethical responsibilities of engineers. This is certainly a concern among many faculties including those teaching courses in online learning environments. The focus is to achieve meaningful ethics education for all engineering students, with particular emphasis on competing curriculum models.

Our enduring practice was a student-centered approach in the past. By using a "student-centered" approach, we imply relying on students themselves to be as truthful and self-disciplined as possible when taking courses in an online learning environment. We recently focused more on providing the learners with some documents serving as ethical guidelines for taking online courses. This is due to our astonished finding that some learners are truthful, but they simply don't have any frame of reference to ethical behavior when taking courses in an online learning environment. The learners must read the ethical guidelines document and agree to it before they can take the course. In "open" and "honest" online learning and teaching environments they also sign statements confirming that they conform to these guidelines before, during, and after an examination. In the near future, we plan to supply the learners with an online video clip, discussing course ethics and citing specific cases of online course ethical violations.

## PERFORMANCE EVALUATION

Online learning systems allow faculty to design exams with different types of questions including but not limited to multiple choice, true/false, matching, short question, paragraph, and calculations. Another mechanism that is helpful to the faculty is the ability to set up the online learning system to select randomly sets of questions for the same online examination for the students. To use this mechanism, the faculty should have more than the minimum number of examination questions in the question's database. The system can be set up to allow students to take the examination during a given time window and a specific exam period. We experiment with different exam periods, from 2 hours up to 48 hours, to accommodate many students that are also full-time working adults. This is particularly applicable in engineering technology courses. Another good feature is the ability to set the system as such to allow students to take the same exam multiple number of times, or only one time. If the faculty desires to test students on the understanding of the concepts, less accessibility of the students to notes and books is perhaps desirable. To be able to ensure the integrity of online exams, one issue of concern to faculty is the ability to adjust exam time in such a way that students won't be able to use their class notes, text book, etc. to answer the online exam questions.

In engineering and technology, many of the examinations include graphic-based questions. The learning systems mentioned above may not be capable yet of allowing faculty to fully design and implement that type of examination questions using available resources. To compensate for this present shortcoming feature, we think graphic-based exam questions can be designed in such a way that students can work on in groups using, for example, the capability of Autodesk® AutoCAD of allowing collaborative design. The contribution and input of every member in a group can be assessed and graded as all activities of given group of students at time stamped. In a course taught by the authors, student groups working different term assignments were assigned discussion boards only accessible by the group members. No one else has access to that discussion environment, but the instructor. Browsing individual groups' discussion boards can give faculty some indication of the assessment of the performance and contributions of group members. We believe these discussion boards can help providing faculty with some guidelines for preparing online exams. One may argue that such a method is casual and less formal than traditional methods of assessment and evaluation.

## CASE STUDY AND DISCUSSION

Examinations are viewed by many as measures of learners' learning success and teaching effectiveness in both live and distance learning courses. In engineering and technology related courses, examinations are routinely used for assessments of the course objectives. Depending on the nature of the course, other methods are also used in many institutions of higher educations.

At our institution some courses are offered using live and distance modes, simultaneously. This is to include both live and distance students in the same course, thus providing more educational opportunities while increasing the efficiency of course delivery system. Among many other

advantages, this would also reduce and sustain human and material resources. It is intuitive to mention that due to their choice of instructional and delivery mode, distance learners don't usually attend the live lectures. However, live students are not limited to live discussions only, and they do have access to the course material available to them online through the course website. We note that when a course is offered in two different modes of "live" and "distance" simultaneously in the same semester, the "live" students, taking the class synchronously, tend to also access much of the course materials available online. This data provided here is presented for the two sections taught by the same professor. We may interpret from this data that "live" students seem to have out-performed their counterparts who have taken the course at a "distance" only. One may conclude from this data that students who have access to multiple methods of learning are more likely to succeed. This is a work in progress and more information will become available as we complete our assessment of students progress and success in online versus live courses.

The authors offered some same undergraduate courses in different semesters using different modes of instructions of synchronous and asynchronous. Some data presented here are for comparison and assessment of the results. We present the data that are more directly related to the six issues raised in Faculty Concerns section of this paper, so we can draw some meaningful conclusions. Some of the results presented here are also intuitively confirmed through our informal discussions with the colleagues having similar experiences.

The data shown in Table 1 is a comparison between the percentage of live and distant students passed the same course taught by the authors offered using distance and live modes of instructions in 2005, 2006, 2007, and 2008. These courses had almost the same number of students registered for the course. We found that there is no significant difference between the level of competency of the students taken different sections of the same course observed by the faculty, and almost all other parameters influencing the students' performance are identical. In eight cases out of the nine cases evaluated here, the percentage of the students passed the distance section of the same course is higher by 5 percent or more than the percentage of the students taking the live section of the course. This may or may not attribute to the level of the examination security, and it doesn't provide any proof or disproof of plagiarism. Indeed, to reduce the likelihood of plagiarism, we did use a contract similar of that presented in Colwell and Jenks[6] for distant examinations, something that we did not apply to live examinations. For the same course number and corresponding term, the exams are identical, and the time to complete the exams is also the same for both live and distance section. In fact, examinations taken by live students were more interactive than the examinations taken by distance students. We found no correlations between examinations interactivity and the percentage of students passed the course. There is also no indication on the class size and the percentage of the students passed the courses here in our study.

| Course No./Semester | Percentage of Students Passed the Course | |
|---|---|---|
| | Live section | Distance Section |
| 1/ Spring 2005 | 90 | 100 |
| 1/ Spring 2006 | 85 | 95 |
| 2/ Fall 2005 | 90 | 100 |
| 2/ Fall 2006 | 90 | 95 |
| 2/ Fall 2007 | 100 | 100 |
| 3/ Fall 2005 | 95 | 100 |
| 3/ Fall 2006 | 95 | 100 |
| 3/ Fall 2007 | 80 | 100 |
| 3/ Fall 2008 | 95 | 100 |

Table 1: Passing Percentage of Live and Distant Students

Table 2 shows the result of the same exam (exam I – Fall 2008) taken by the same group of students, live and online. The live examination was taken a week later after the students have taken the online examination. The two examinations have the same set of questions in three sections: definitions of key terms, short questions, and matching. The live section statistics are as follows: max grade = 97%, min grade = 38%, average = 86.18% and standard deviation = 12.69. The online section statistics are as follows: max grade = 100%, min grade = 53%, average = 82.52% and standard deviation = 11.60.

| Student | Live | Online | Student | Live | Online |
|---|---|---|---|---|---|
| x1 | 93 | 53 | x18 | 87 | 77 |
| x2 | 92 | 77 | x19 | 71 | 70 |
| x3 | 93 | 77 | x20 | 95 | 93 |
| x4 | 86 | 90 | x21 | 90 | 87 |
| x5 | 90 | 90 | x22 | 72 | 77 |
| x6 | 92 | 100 | x23 | 93 | 67 |
| x7 | 97 | 72 | x24 | 93 | 90 |
| x8 | 97 | 82 | x25 | 93 | 77 |
| x9 | 87 | 98 | x26 | 38 | 88 |
| x10 | 86 | 98 | x27 | 90 | 88 |
| x11 | 91 | 95 | x28 | 77 | 77 |
| x12 | 97 | 78 | x29 | 93 | 62 |
| x13 | 71 | 92 | x30 | 96 | 92 |
| x14 | 87 | 83 | x31 | 94 | 92 |
| x15 | 62 | 58 | x32 | 93 | 93 |
| x16 | 90 | 85 | x33 | 92 | 80 |
| x17 | 66 | 85 | | | |

Table 2: Statistics of Exam I, Fall 2008

By comparing the performance of this group of students, it appears that the students did better overall in the online examinations although it was taken a week before the live one. Again, this may or may not attribute to the level of the examination security as we have no proof or disproof of plagiarism. Indeed, to reduce the likelihood of plagiarism, we rely on a contract discussed previously, something that we did not apply to live examinations.

| Student | COMP | MCH | Student | COMP | MCH |
|---|---|---|---|---|---|
| x1 | 90 | 88 | x18 | 96 | 53 |
| x2 | 77 | 77 | x19 | 83 | 82 |
| x3 | 93 | 62 | x20 | 84 | 80 |
| x4 | 96 | 92 | x21 | 68 | 97 |
| x5 | 94 | 92 | x22 | 87 | 97 |
| x6 | 93 | 93 | x23 | 59 | 83 |
| x7 | 92 | 80 | x24 | 87 | 60 |
| x8 | 92 | 80 | x25 | 95 | 83 |
| x9 | 88 | 77 | x26 | 66 | 72 |
| x10 | 87 | 70 | x27 | 67 | 75 |
| x11 | 97 | 87 | x28 | 84 | 88 |
| x12 | 90 | 93 | x29 | 97 | 65 |
| x13 | 93 | 90 | x30 | 98 | 70 |
| x14 | 94 | 98 | x31 | 86 | 62 |
| x15 | 94 | 97 | x32 | 66 | 57 |
| x16 | 94 | 88 | x33 | 75 | 85 |
| x17 | 97 | 83 | | | |

Table 3: Statistics of Exam II, Fall 2008

Table 3 illustrates the result of online examination covering the same topics (exam II – Fall 2008) taken by the same group of students, two times: first time the exam was a combination of definition of key terms, short questions, and matching (COMP), and the second time it was all multiple choice exam (MCH). The COMP examination was taken on a Wednesday afternoon and the MCH was taken "a few days later" on Saturday evening. The COMP examination statistics are as follows: max grade = 98%, min grade = 59%, average = 86.63%, and standard deviation = 10.62. The MCH examination statistics are as follows: max grade = 98%, min grade = 53%, average = 80.48%, and standard deviation = 12.36. By comparing the performance of this group of students on these examinations covering the same topics offered in two formats, it seems the students generally did equally in the two examinations. However, when the individual performance of the students is compared, it seems many students perform better on the COMP examination. This does not seem to relate to the examination security. We believe this has a lot to do with personal preference and comfort.

## SUMMARY AND CONCLUSION

Many faculties of engineering and technology may found themselves teaching online classes or planning on teaching one. In this process, students' performance is a crucial issue. Psychological setbacks and barriers among engineering students also add another concern for the faculty teaching in a distance education environment, i.e., students may have fears of losing partial credit in an online multiple-choice examination. The asynchronous and economical advantages of distance education and learning that make offering and taking them very popular, considering some pedagogical issues.

This article encompasses six faculty pedagogical concerns of security, interactivity, equity, hands-on demonstration of concept, team-workability assessment, and ethics in engineering and technology. We use some accurate but crude empirical data and evaluation methodologies to draw our conclusions. The data used are collected from more recent sample courses offered by the authors over the last five years. Some of the results presented here are also confirmed intuitively through our informal discussions with the colleagues having similar experiences. A major conclusion drawn from our experiences is that in "open and honest" distance learning environments such as those in most institutions of higher education in the United States, the most important focus should be on the "ethics" education of the students.

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