A Comparison of a Hybrid Undergraduate Engineering Economics Course

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Abstract—**This paper examines the mixture of distance education students and face-to-face students in a single undergraduate class of engineering economics. The class was offered to distance education students with live recordings of the face-to-face lecture, and all students were capable of viewing the lecture recording afterwards. The results indicate that students achieved the course learning outcomes regardless of their course delivery.**

Index Terms—**Distance Learning, Engineering Economics, Hybrid Learning, Outcomes Assessment.**

I. INTRODUCTION

Distance education is becoming more prevalent as it provides more access and greater flexibility to the diverse student body [1]. Lecture-based courses are capable of being deployed via distance education with the combined use of internet systems, course management software, and video technology [2]. Furthermore, hybrid courses, flipped-classrooms, and interactive learning environments are enhanced by the use of distance education technologies [3]. Online engineering education has shown to be effective at meeting assessment targets [4].

This paper discusses a learning environment where distance education students and face-to-face students were combined into the same course section for an undergraduate engineering economics course. The course was available to distance education students via a live recording of the face-to-face class. All students were capable of watching the lecture recording afterwards via the course management website.

This paper provides a literature review of online engineering education and engineering economics, an overview of the course including its structure, objectives, and outcomes, results, and concluding remarks.

II. LITERATURE REVIEW

There exist a number of articles centered on online engineering education and the different subjects that are being taught online. These subjects include engineering economics [5], engineering graphics [6], power systems [7], introduction to engineering [8], and thermodynamics [9]. Reference [10] studied multiple modes of delivery (e.g., totally online via asynchronous learning networks, traditional face-to-face courses, and sections using a mix of traditional and online activities) of courses in an information systems curriculum and found that there were no significant differences in perceived learning by students associated with mode of delivery.

Reference [11] studied the effectiveness of delivery modes by conducting a survey of students and faculty. The survey sample included 1206 students and 160 faculty members. The results indicated that classroom (face-to-face) delivery was more effective than distance education delivery; with online being preferred to video conference. The results were the same for both students and faculty members.

Additional factors were studied in other articles. The use of internet discussion boards was studied in graduate courses to determine whether perceived learning was impacted by active and passive learning styles of students [12]. The study found that the number of messages posted by a student (i.e., active learning) was a significant predictor of perceived learning; whereas, passive learning styles (e.g., accessing discussion boards but not commenting) was not significant.

There are a number of recent and ongoing studies of engineering economics education within the published literature. A futuristic look at engineering economics education was completed in 2002 by Eschenbach [13]. He makes a number of observations about the future of the course given past trends. He also provides insight into topical coverage of the traditional versus modern textbooks. In 1999, there were two papers with suggestions and comments for undergraduate engineering economics education [14, 15] and a follow-up discussion in 2005 [16]. These papers discuss the, perhaps unintentional, move towards financial mathematics from decision making analysis, and also discuss spreadsheets and online educational tools (e.g., CD and online material in addition to the textbook material).

Many recent (since 2000) articles have been published that provide either structure or experiences in teaching engineering economics at both the undergraduate and graduate levels [2, 5, 17-20], and the inclusion of risk and uncertainty in engineering economics [21, 22].

III. COURSE OVERVIEW

The undergraduate engineering economics course studied for this paper was a three credit hour, semester-based, course open to any junior or senior engineering student. All of the students in the course were usually campus-based students; however, the distance education section of the course was established for students who were completing internships or were otherwise off-campus for that particular semester. The course met four days per week for six weeks for 90 minutes each day. The course provided an introduction to engineering economy and its application in engineering practice. Topics included the time value of money, discounted cash flow techniques, decisions among engineering alternatives involving design options, equipment selection, breakeven points, cost estimation, consideration of taxes and inflation, analyzing uncertainty in economic estimates, and an introduction to techonomics [23]. Reference [24] was used as the course textbook, and supplemental lecture

notes were provided by the instructor via the course management website.

The course learning outcomes are, upon successful completion of the course, the student should be able to:

1. Evaluate discounted cash flow (e.g., equivalence, PW, equivalent annual FW, rate of return) problems
2. Evaluate cost (e.g., incremental, average, sunk, estimating) problems
3. Evaluate types and breakdown of costs (e.g., fixed, variable, direct and indirect labor, material, capitalized) problems
4. Complete analyses (e.g., breakeven, benefit-cost)
5. Evaluate alternatives involving uncertainty (e.g., expected value and risk)
6. Complete basic accounting (e.g., financial statements and overhead cost allocation) problems
7. Develop cost estimates
8. Evaluate alternatives using depreciation and taxes
9. Complete capital budgeting problems

IV. RESULTS

The course learning outcomes were assessed using both direct and indirect measures. The course learning objectives were assessed for each student using assignments (e.g., homework and examinations); thus, the performances on these assignments were used as direct measures for the course learning outcomes. Surveys distributed to students at the end of the course were used as an indirect assessment of the course learning outcomes, as well as additional questions regarding other issues (e.g., instructor effectiveness, textbook effectiveness).

Table I shows the results of the direct assessment for the distance education students; whereas, Table II shows the direct assessment for the face-to-face students. The target for each item was a 70% mean for a specific assignment problem. This was a standard set by the department's curriculum committee and was standard throughout the department for assessment purposes. Based on results, the course learning outcomes were achieved at or exceeding the target level.

The indirect assessment completed by the students is not aggregated between distance education and face-to-face students. Thus, Table III shows the results of survey for all students participating in the course. The scale for the survey was 1 to 5, with 5 being "Strongly Agree," 4 being "Agree," 3 being "Neutral," 2 being "Disagree," and 1 being "Strongly Disagree." The results indicate that the students felt that they met the course learning outcomes.

TABLE I.
DIRECT ASSESSMENT OF COURSE LEARNING OUTCOMES FOR DISTANCE EDUCATION STUDENTS

Assignment	Maximum	Mean	Median	Minimum	Target Met	Course Learning Outcome								
						1	2	3	4	5	6	7	8	9
A1, Q1	100.0%	70.6%	68.0%	36.0%	Yes						X			
A1, Q2	100.0%	98.5%	100.0%	84.0%	Yes		X							
A1, Q3	100.0%	93.5%	76.0%	76.0%	Yes			X						
A1, Q4	100.0%	74.5%	60.0%	20.0%	Yes			X						
A1, Q5	100.0%	73.2%	76.0%	52.0%	Yes						X			
A1, Q6	100.0%	90.5%	100.0%	52.0%	Yes		X							
A2, Q1	100.0%	93.8%	100.0%	76.0%	Yes	X								
A2, Q2	100.0%	81.2%	76.0%	20.0%	Yes	X								
A2, Q3	100.0%	80.6%	100.0%	37.5%	Yes	X								
A3, Q1	100.0%	78.6%	100.0%	0.0%	Yes	X								
A3, Q2	100.0%	75.4%	100.0%	37.5%	Yes				X					
A3, Q3	100.0%	70.2%	75.0%	37.5%	Yes				X					
A3, Q7	100.0%	80.6%	100.0%	50.0%	Yes					X				
A3, Q8	100.0%	83.1%	100.0%	50.0%	Yes					X				
A4, Q1	100.0%	81.9%	100.0%	0.0%	Yes							X		
A4, Q2	100.0%	85.7%	100.0%	16.7%	Yes							X		
A5, Q3	100.0%	74.2%	66.7%	0.0%	Yes								X	
A5, Q4	100.0%	90.9%	100.0%	66.7%	Yes									X
A6, Q2	100.0%	75.0%	66.7%	50.0%	Yes									X
A6, Q3	100.0%	81.2%	91.7%	0.0%	Yes								X	
Course Learning Outcome Acheivement (Y/N)?						Y	Y	Y	Y	Y	Y	Y	Y	Y

TABLE II.
DIRECT ASSESSMENT OF COURSE LEARNING OUTCOMES FOR FACE-TO-FACE STUDENTS

Assignment	Maximum	Mean	Median	Minimum	Target Met	Course Learning Outcome								
						1	2	3	4	5	6	7	8	9
A1, Q1	100.0%	71.9%	67.7%	36.1%	Yes						X			
A1, Q2	100.0%	96.5%	98.5%	83.0%	Yes		X							
A1, Q3	100.0%	93.1%	74.8%	76.6%	Yes			X						
A1, Q4	100.0%	76.4%	61.7%	15.0%	Yes			X						
A1, Q5	100.0%	74.7%	75.4%	50.0%	Yes						X			
A1, Q6	100.0%	88.6%	100.0%	60.0%	Yes		X							
A2, Q1	100.0%	92.8%	100.0%	80.0%	Yes	X								
A2, Q2	100.0%	82.4%	76.6%	20.0%	Yes	X								
A2, Q3	100.0%	79.0%	98.1%	37.5%	Yes	X								
A3, Q1	100.0%	77.9%	98.8%	0.0%	Yes	X								
A3, Q2	100.0%	76.9%	98.1%	50.0%	Yes				X					
A3, Q3	100.0%	68.6%	75.5%	0.0%	Yes				X					
A3, Q7	100.0%	81.5%	100.0%	50.0%	Yes					X				
A3, Q8	100.0%	81.7%	98.7%	50.0%	Yes					X				
A4, Q1	100.0%	82.1%	100.0%	0.0%	Yes							X		
A4, Q2	100.0%	86.7%	100.0%	16.7%	Yes							X		
A5, Q3	100.0%	73.9%	66.7%	0.0%	Yes								X	
A5, Q4	100.0%	90.5%	98.4%	66.7%	Yes									X
A6, Q2	100.0%	76.0%	66.6%	50.0%	Yes									X
A6, Q3	100.0%	82.9%	91.7%	0.0%	Yes								X	
Course Learning Outcome Acheivement (Y/N)?						Y	Y	Y	Y	Y	Y	Y	Y	Y

TABLE III.
INDIRECT ASSESSMENT OF COURSE LEARNING OUTCOMES

Question	Mean	Median
I am able to evaluate discounted cash flow problems.	3.96/5.00	4.0/5.0
I am able to evaluate cost problems.	4.15/5.00	4.0/5.0
I am able to evaluate types and breakdown of costs problems.	4.08/5.00	4.0/5.0
I am able to complete breakeven and benefit-cost analyses.	4.14/5.00	4.0/5.0
I am able to evaluate alternatives involving uncertainty.	4.17/5.00	4.0/5.0
I am able to complete basic accounting problems.	4.20/5.00	4.0/5.0
I am able to develop cost estimates.	4.04/5.00	4.0/5.0
I am able to evaluate alternatives using depreciation and taxes.	3.75/5.00	4.0/5.0
I am able to complete capital budgeting problems.	4.11/5.00	4.0/5.0

V. DISCUSSION AND CONCLUSIONS

The results from Table I and Table II show that both distance education students and face-to-face students achieved the course learning outcomes for the undergraduate engineering economics course. The difference between the two groups of students was

minimal (insignificant) on a question-by-question basis; which indicates that both types of students achieved the outcomes at the same level of aspiration. The results from Table III show that the students felt that they learned the material and achieved the outcomes.

The results and achievement of the course learning outcomes is consistent with prior published results [1-5, 10]. The unique feature of this study was that both distance education students and face-to-face students were grouped together into one section of an undergraduate course. Further research and studies would need to be completed to distinguish engineering laboratory courses versus engineering lecture courses. The course studied in this paper was a lecture course, which is perhaps easier to adjust to satisfy the needs of distance education students. In addition, all of the students in the studied course were upperclassmen (i.e., juniors and seniors); thus, they already had a good idea of time management and individual accountability that is required to excel with a distance education course.

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