Comparison of On-Campus and Distance Learning Preferences in a Junior-level Materials Science Course

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Abstract

Students taking courses in face-to-face and asynchronous formats face potentially different barriers to learning in engineering courses. Students enrolled in a junior-level materials science course were surveyed regarding which teaching methods they found the most beneficial to their learning experience and how confident they were in their mastery of the course material. Over 90% of the students responded to the survey. Approximately 20% of the respondents were distance students. Both groups reported the largest positive effect on their learning from viewing lectures compared to participating in class discussions or in-class group activities. The difference in average response between on-campus and distance learners was also largest for questions related to the benefits of the lectures. When asked about their confidence in discussing course material with the instructor, distance students tended to respond with higher confidence, while the face-to-face students tended to report being more confident than distance students in discussing course concepts with their peers. Analysis of data from a subsequent survey of distance students administered during the following semester provides insights into the motivations and backgrounds of distance students in the program. Implications of the findings for distance engineering course design are discussed.

Introduction

The University of North Dakota (UND) offers ABET-accredited undergraduate distance engineering programs in chemical, civil, electrical, geological, and mechanical engineering. The programs began with industrial collaboration in the early 1990s and have grown to comprise approximately 1/3 of the total enrollment in the UND College of Engineering and Mines. They enroll students from across the country and around the world. While originally developed for working professionals with technical experience looking to finish a degree, increasing numbers of students are enrolling in the Distance Engineering Degree Program without a prior engineering background. The growth in the distance program, along with the changing demographics, presents a challenge to ensure that the same quality of student learning can be achieved. Two primary purposes for this study are 1) to compare the preference for various teaching methods between on-campus and distance learners and 2) to better understand the background and motivations for distance learners in the mechanical engineering department.

Ibrahim and Morsi[1] performed an early survey of distance engineering programs, focusing primarily on Electrical and Computer Engineering. At the time, they found that most distance engineering/technology courses were offered at the associate degree level with the fewest offerings at the baccalaureate level. Goodson *et al*.[2] demonstrated that there can be different learning outcomes (or areas of learning strength) between on-campus and distance students in the same course. These can depend on the class structure as well as the content. Houdeshell *et al*.[3] reported significant differences in student perceptions regarding the face-to-face and distance learning but the primary respondents were students from traditional face-to-face courses.

Murray *et al.*[4] describe the challenges of the hybrid classroom in which some students are learning face-to-face and others are at-a-distance. They make the case for modifying pedagogical methods to best achieve student learning. Enriquez[5] describes additional flexibility in learning materials to help distance students succeed in a hybrid course structure. Considine[6] stressed the importance of focusing on active learning techniques even in distance education.

Kinney *et al.*[7] surveyed students to better understand their perceptions of online engineering education in general as well as the perceived effectiveness of various teaching pedagogies and tools. Both students and faculty reported strong confidence that technical courses could be effectively taught online. Traditional teaching tools like recorded lectures were cited at the preferred format. Mackey and Freyberg[8] reported that student preconceptions about student/instructor interactions could have a significant effect on perceptions of the effectiveness of distance learning and preferred course design. This can make it difficult to optimize a single course for all students and reinforces the importance of understanding the background and motivations of one's students.

Method

During the Fall 2011 semester, ME 301 – Materials Science was taught in three sections. Two were on-campus sections and one was an asynchronous distance section. Sessions of the first on-campus section of the day were recorded and posted for the distance students to view. On-campus students also had access to the recorded lectures. At the end of the fall semester, an electronic survey was distributed to all ME 301 students. The purpose of the survey was to better understand which teaching methods employed in the class were the most helpful and if there was a difference in the perceived efficacy of different teaching methods for on-campus and distance students. All on-campus students (66 students) and 15 distance students (out of 20) responded, response rates of 100% and 75%, respectively.

The first segment of the initial survey asked students to identify any teaching methods that they found helpful during the course of the semester. Options given were lectures, class discussions, synthesis exercises (essentially group problem sessions with more open-ended, practical problems), exams (overall), or synthesis questions included on the exams. They were also given the chance to specify other items not in the list. Next, the students were asked to rate the efficacy of lectures, discussions, and synthesis exercises on preparing them for exams, helping them to understand the material, improving their confidence in discussing the material with their peers, and improving their confidence in discussing the material with their instructor. The survey then asked the students to assess their overall understanding and comfort with various topics in the course. Finally, the survey asked the students to report their overall confidence in their engineering abilities and their ability to succeed as engineers.

During the Spring 2012 semester, a second electronic survey was distributed to all distance students in the Mechanical Engineering Department (not just those who had taken ME 301 during the previous semester). The purpose of the survey was to better understand the motivations of those students pursuing an engineering degree at a distance. Thirty-one responses were received out of 174 distance students enrolled that term (a response rate of 17.8%).

Results

Comparison of On-campus and Distance Students in ME 301

Table 1 shows the teaching methods identified by students as the most helpful to their learning. The percentages indicate the fraction of each cohort that identified that teaching method as being helpful. Within the 'Other' category, the method reported most often amongst both groups was homework assignments.

Table 1: Student-reported most helpful teaching methods

Cohort	Lecture	Discussion	Synthesis	Exams	Synthesis Qs on Exams	Other
Distance	86.7%	46.7%	53.3%	40.0%	33.3%	20.0%
On-Campus	81.8%	72.7%	63.6%	42.4%	30.3%	6.1%

ME 301 is taught in three sections, Mechanical Properties (Mech), Electrical/Optical/Magnetic Properties (E/O/M), and Thermal Behavior (Therm). Table 2 shows the reported efficacy of lectures, class discussions, and synthesis exercises on preparing students for the exams in each of the three course segments. Students responded from 'Extremely Well' to 'Not Very Well At All' with regards to the efficacy of each method. Answers were converted to numerical scores with 'Extremely Well' = 5 and 'Not Very Well at All' = 1. Scores shown in Table 2 are average values for the cohort.

Because the expected value for several of the questions, particularly for the distance students, fell below 5, a chi-squared statistical analysis is not applicable for evaluating statistical significance of differences in the responses of the two groups[9,10]. Instead, the Fischer exact test was used (F.E. in the tables)[11]. Essentially, the Fischer exact test evaluates the probability that a more diverse set of responses exists compared to the actual data. The lower the value of the F.E. parameter, the less chance that a more diverse set exists or, conversely, the higher the probability that the difference in the responses is statistically significant. To ensure each "bin" was properly populated for the statistical analysis, responses were grouped as (1 or 2), 3, and (4 or 5), resulting in a degree of freedom of two for the analysis.

Table 2: Student-reported efficacy of lectures, class discussions and synthesis exercises for exam prep

	Lecture			Discussion			Synthesis		
Cohort	Mech	E/O/M	Therm	Mech	E/O/M	Therm	Mech	E/O/M	Therm
DEDP	3.53	3.40	3.20	3.07	3.13	3.00	3.20	3.07	2.87
On-Campus	3.60	3.54	3.38	3.18	3.14	3.09	3.03	3.06	2.97
F.E.	1.00	0.70	0.83	0.02	0.34	0.67	0.72	0.25	0.72

Students were asked to report the effect of lectures, discussions, and synthesis exercises on their perceived understanding of the material in each section of the course. Results are shown in Table 3. A score of five indicates the students are extremely confident in their understanding. A score of one indicates the students have very little confidence in their understanding.

Table 3: Student-reported efficacy of lectures, class discussions and synthesis exercises for understanding of each course section

	Lecture			Discussion			Synthesis		
Cohort	Mech	E/O/M	Therm	Mech	E/O/M	Therm	Mech	E/O/M	Therm
DEDP	3.60	3.47	3.27	3.07	3.13	3.07	3.00	2.93	2.80
On-Campus	3.31	3.26	3.11	3.25	3.18	3.06	3.09	3.09	2.92
F.E.	0.20	0.62	0.74	0.12	0.80	0.86	0.58	0.46	0.93

Tables 4 and 5 contain data related to student confidence with regards to discussing various course topics with their peers or their instructor. Students were asked to quantify the effect of the lectures, discussions, and synthesis exercises on their confidence in discussing each topic with their peers (Table 4) or the instructor (Table 5). A score of five indicates extreme confidence.

Table 4: Student-reported efficacy of lectures, class discussions and synthesis exercises on self-confidence for peer-discussion of topics

	Lecture			Discussion			Synthesis		
Cohort	Mech	E/O/M	Therm	Mech	E/O/M	Therm	Mech	E/O/M	Therm
DEDP	3.53	3.47	3.20	3.13	3.07	2.93	3.13	2.87	2.93
On-Campus	3.26	3.23	3.15	3.32	3.23	3.17	3.20	3.11	3.00
F.E.	0.43	0.35	0.87	0.74	0.68	1.00	0.69	0.30	0.66

Table 5: Student-reported efficacy of lectures, class discussions and synthesis exercises on self-confidence for discussion of topics with instructor

	Lecture			Discussion			Synthesis		
Cohort	Mech	E/O/M	Therm	Mech	E/O/M	Therm	Mech	E/O/M	Therm
DEDP	3.47	3.40	3.13	3.00	2.93	2.87	2.93	2.73	2.67
On-Campus	2.77	2.68	2.69	2.75	2.65	2.63	2.83	2.69	2.65
F.E.	0.59	0.04	0.37	0.05	0.02	0.15	0.33	0.03	0.40

Table 6 shows students responses to a question about their general understanding of several concepts from the course. Table 7 shows students' reported comfort with how well they know how each concept area applies to engineering. For the purposes of these questions, the three main course segments were subdivided into the following areas:

- Mechanical Properties: Microstructure (M:M)
- Mechanical Properties: Testing (M:T)
- Electrical Properties (E)
- Optical Properties (O)
- Magnetic Properties (M)
- Thermal Behavior: Thermal Properties (T:T)
- Thermal Behavior: Binary Phase Diagrams (T:PD)
- Thermal Behavior: Phase Transformations (T:PT)

Table 6: Student-reported overall understanding in various topic areas (5 = extremely good understanding, 1 = extremely poor understanding)

Cohort	M:M	M:T	E	O	M	T:T	T:PD	T:PT
DEDP	3.40	3.60	3.53	3.40	3.40	3.33	2.93	2.93
On-Campus	3.14	3.40	3.29	3.29	2.97	3.23	2.89	2.94
F.E.	0.61	0.47	0.85	0.93	0.51	0.80	0.55	0.39

Table 7: Student-reported comfort with how well they know how each concept area applies to engineering (5 = extremely comfortable, 1 = extremely uncomfortable)

Cohort	M:M	M:T	E	O	M	T:T	T:PD	T:PT
DEDP	3.67	4.00	3.93	3.67	3.73	3.60	3.27	3.40
On-Campus	3.18	3.52	3.32	3.17	3.17	3.34	3.00	2.97
F.E.	0.40	0.45	0.15	0.07	0.04	0.66	0.94	0.66

Students were asked to quantify their overall confidence in their engineering abilities (5 = extremely confident, 1 = not at all confident). They were also asked to report their confidence in the ability to succeed in engineering. The results for the two cohorts are shown in Table 8.

Table 8: Student-reported overall confidence in their engineering abilities and ability to succeed in engineering

Cohort	Overall Confidence	Ability to Succeed
DEDP	3.20	3.80
On-Campus	3.09	3.51
F.E.	0.68	0.90

Demographic data was also gathered as part of the survey. 92.4% of the on-campus cohort reported their sex as male. 100% of the distance cohort identified as male. Table 9 shows the reported ages of each group.

Table 9: Age demographics of each group of ME 301 students.

	Age Range (years)		
Cohort	20-21	22-23	24 or older
DEDP	0%	0%	100%
On-Campus	57%	31%	13%

Motivations of Distance Students

Thirty-one distance students responded to the survey about motivations for distance learning – a response rate of approximately 18%. This survey was distributed to all distance students in the Mechanical Engineering Department during the Spring 2012 semester. Table 10 shows the reported gender, ethnic, and age demographics of the respondents.

Table 10: Reported demographic information for students in the Mechanical Engineering Distance Education Degree Program, Spring 2012.

Gender	
Male	83.3%
Female	16.7%
Age	
18-22	3.3%
23-25	0.0%
26-30	26.7%
31-40	56.7%
41-50	10.0%
50 or older	3.3%
Ethnicity	
White	90.3%
Black or African American	3.2%
Spanish, Hispanic or Latino/a	3.2%
Other	3.2%

More than 90% of the respondents had attended college elsewhere prior to enrolling in the UND Distance Engineering Degree Program. Figure 1 shows the reported institution type that students had attended previously. The most common reason reported for leaving a previous institution was either completing a degree program (typically an associate degree) or not finding the desired degree/courses being offered. More than half of the respondents reported some combination of these factors. Approximately 15% of respondents reported family issues as a main factor, with about 6% each reporting a lack of financial resources or academic issues. Over 12% reported having gotten a job that lead to their exit from their previous degree program.

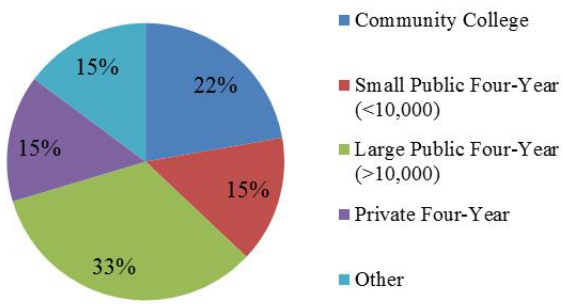

Figure 1: Type of higher education institution previously attended by distance students with prior college-level experience.

For about 44% of the respondents, less than one year had passed since taking courses elsewhere. Conversely, for 37% of respondents, more than five years had passed since their last college courses prior to enrolling at UND. Approximately half of the students (46.7%) had taken distance courses prior to enrolling at UND.

Over half of the respondents indicated that increasing their earning potential was a primary motivator for enrolling in an undergraduate engineering program. Over a third of the respondents indicated they felt an engineering degree would help them change careers or obtain a promotion in their current career. Table 11 shows the reported reasons for choosing a distance degree program for their engineering education. The flexibility of a distance program was a primary motivator, often due to family and/or career commitments that make returning to campus impractical or inconvenient.

Table 11: Reported motivations for choosing a distance engineering program.

Flexible course delivery	74.2%
Relaxed course schedule	29.0%
Prefer one-on-one learning environment	6.5%
Discomfort with college campus	0.0%
Geographic location	45.2%
Job/career commitments	71.0%
Familty commitments	51.6%
Active military	3.2%
Cost of education	6.5%

Twenty percent of respondents reported current job titles that already include the word engineer (e.g. product engineer, engineering manager, etc.) despite not having an engineering degree. Eighty percent of the students reported working in a technical area, with approximately 60% working in a manufacturing setting in an engineering or technician/laborer capacity.

Discussion and Conclusions

Data shows similar preference for teaching methods amongst distance and on-campus learners with two exceptions. Distance students placed significantly less value on class discussions (likely because of both their inability to participate in real-time and difficulties in hearing the input of all participants) and more value on homework assignments. Both groups reported similar efficacy of the teaching methods with regards to exam preparation. Few differences in this category were statistically significant (defined as F.E. < 0.05). The only exception was the benefit of discussion for preparation for the exam on the mechanical section of the course. On-campus students rated the discussions during this course segment as more beneficial than did distance students (3.18 vs. 3.07 with F.E. = 0.02). This is consistent with the overall lower significance the distance students placed on discussions.

No statistically significant differences were reported between the two groups with regards to the efficacy of the various pedagogical methods on understanding of each course segment. This was also true for student confidence in discussing the various course topics with their peers. In response to whether the different teaching methods increased student confidence in discussing course topics with the instructor, on-campus students generally responded lower and their responses were statistically lower than those of distance students in several categories. This may be related to the fact that distance students tend to be older (see Tables 9 and 10) and have more professional experience than the typical on-campus student. As a result, they may be more comfortable discussing difficult topics with someone perceived to be in a position of authority.

The two groups reported statistically similar ratings of their understanding of the course topics. Distance students, in general, did report higher overall confidence with regards to their understanding of the material and how it applies to engineering. However, the difference in confidence was only statistically significant for one course topic. Two others were slightly outside the F.E. < 0.05 threshold (0.07 and 0.12). The differences in this set of responses may also be due to the maturity/professional experience of the distance cohort relative to the typical campus student. Any differences in confidence with the topics in this course did not translate to statistically significant differences in overall confidence in the ability to succeed in engineering between the two groups.

Lawton *et al.*[12] have reported on the effectiveness of formative assessment on student performance in distance courses. Given the structure of distance course in the current study, such feedback was not practical. However, an accompanying study by the authors describes the use of such feedback in a flipped or inverted course structure using chunks of recorded lecture material. Additional work is needed to better understand how this feedback can be optimized for student learning.

Most distance students surveyed had previously taken courses elsewhere. Over 80% of them are between 26 and 40 years of age. Of those with prior post-secondary experience, about half had attended a four-year school. Some combination of work, family or geography made attending traditional classes at an institution offering an undergraduate mechanical engineering degree unfeasible. The potential career benefits of an engineering degree tended to be the primary motivator for participating in the distance program at UND. The school was chosen primarily due to both its reputation and the fact that there are few, if any, other accredited undergraduate distance mechanical engineering degree programs.

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