Anywhere, Anytime Graduate Programs in Engineering

Abstract
While the conventional mode of delivering graduate degree programs in engineering is still the norm, there have been significant advances in more than a decade to expand the program offerings to students and working professionals outside the campus boundaries. The need has necessitated for several reasons but mainly due to changing nature of workforce and advances in technology. However, there is some apprehension about the quality of education and learning that occurs in internet-based programs. The College of Engineering and Computer Science (CECS) at the University of Michigan-Dearborn (UM-D) caters to the needs of traditional and practicing engineers who have time constraints and other limitations that prevent them from participating in on-campus programs but are still interested in advancing their knowledge and career in technical areas. CECS has been offering graduate degree programs in engineering and computer science over more than a dozen years. The program has been quite successful and students welcome the convenience offered to them. This paper analyses the results of performance of DL students vis-a-vis on campus students in some graduate level courses taught by the author of this paper. The paper considers two courses but the focus is on one course that has been taught every year over the last 15 years. The structure of the course is designed to provide exact material and learning opportunities to students in the on-campus section and distance learning section alike. The quantitative and qualitative assessment shows that there is no noticeable difference in students’ learning and competency.

Keywords: Distance Learning, Grad Program Modes, Virtual Learning.

1. Introduction
There has been a dramatic growth in the number of institutions offering degree programs or courses via asynchronous or distance learning (DL) mode [1-3]. The proliferation of DL mode of education has mostly come about due to four major changes that have taken place over the last fifteen years or so. It was estimated that over 4 million students participated in some type of on-line courses [4]

1. Advances in internet and information technology: Access to internet is widely available in major metropolitan areas and, in many countries, outside the metropolitan areas via wired or wireless mode. High speed connections, up to 54 Mbps, are now available in some geographical areas allowing users to download data, graphics and other education related material at very fast speeds.

2. Changing demographics of students and clients: The graduate degree in engineering has become almost a norm amongst many of the major engineering and technology based companies. Employees realize that sound technical fundamentals combined with strong applications oriented education provide a way for career development, enhance marketability, and chart a pathway for upward movement. Yet, time constraints prevent many practicing engineers from attending traditional on-campus programs. This is further compounded by the fact that many large corporations are global and require some of their employees travel to domestic or international sites. Web based or DL mode programs offer an alternative to this group of clientele. Furthermore, this generation of engineers is more tech savvy than in the past and can adjust better to changing technology [4, 5].
3. Travel and related issues: The never ending demand on their time and multi-tasking expectations of practicing engineers employed at small engineering companies allow them very little time to attend on-campus classes. For them quality programs offered through web or DL mode offer an acceptable arrangement to continue their academic programs.

4. Perceived ability to enrol more students: Some academic institutions have forcefully embarked on web-based programs as a way to increase revenue by having the ability to enrol more students without significantly increasing facilities.

The College of Engineering and Computer Science (CECS) of the University of Michigan-Dearborn has had continuous requests from graduate students and corporate clientele to offer at least some courses in an asynchronous mode. After an involved evaluation of these requests CECS decide to offer a limited number of graduate classes via asynchronous or DL mode. Some of the stipulations for students enrolled in the DL mode were:

- They will have the same learning material and access to in-class discussions as on-campus students in the corresponding class.
- There should be no difference in evaluation and assessment of DL and in-class students.
- DL students should have at least a minimum access to course instructor.

To meet these requirements and to have a common learning platform CECS developed an internet based tool, the Virtual Learning Tool or VLT, which allowed students an easy access to several components of the course.

2. Virtual Learning Tool (VLT)

<table>
<thead>
<tr>
<th>ME 532 - Combustion Processes</th>
<th>Course Features</th>
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<tbody>
<tr>
<td>Instructor: Keshav Varde</td>
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<tr>
<td>Description: ME 532 - Combustion Processes</td>
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This course provides basic information on combustion of fuel-air mixtures, how combustion occurs, and chemical aspects of combustion. It includes topics on different types of flames and flame propagation, premixed and diffusion flames in laminar and turbulent environment. The students will have an opportunity to learn ignition of fuel-air mixtures, energy required for ignition and to sustain combustion; flame temperature, structure, and effects of operating parameters on flame temperature and its propagation and droplet vaporization and burning. It would also include a brief introduction to combustion generated pollutants and chemical aspects responsible for pollutant generation.

Figure 1. The Virtual Learning Tool Layout
To meet the requirements CECS developed its own home grown course management software called the Virtual Learning Tool or VLT for use by instructors and students. Some of the characteristics of VLT are similar to those of Blackboard™ or WebCT™ (now a part of Blackboard) which are widely used by many institutions. Figure 1 shows course features and folders available to instructors and students for their use. The courses shown in Figure 1 is one of the courses offered by the author in graduate degree programs. It contains several folders and sub-folders that can be populated by lecture notes, homework assignment, powerpoint slides, reference notes or material, sample problems, class problems, sample tests, and so on.

CECS does not offer any graduate course in DL mode unless it is also offered in live format to in-class students. Students are free to elect the on-campus section or the DL section of the course. Both groups of students use identical textbook and reference material and get the same lecture material, notes, powerpoint, in-class presentation, assignments, projects and tests. The advantage of such an arrangement is that both groups of students have access to identical material except the streaming videos of lectures presented to students in the live section. The later is made available only to DL students. The live lecture and discussions that follow the in-class presentations are automatically recorded, edited and made available to DL students via streaming videos in a 24 hour delayed format. Except for the live interaction with the course instructor and in-class students the students in the DL mode have access to the same learning material as in-class students and are assessed using the same instruments such as homework, projects and tests. The DL students upload their work (assignments, projects, etc) on VLT except the tests. Tests are proctored by an outside designated person and submitted to the instructor in a protected format. The DL students can be near the university or miles away including international locations. In fact, some of the students in our graduate program are indeed international students who can readily access all the material and make effective use of VLT to upload their work in time for grading and assessment. The asynchronous program offered by CECS is for students located anywhere in the world and who wish to attend and learn anytime as they see fit as long as they all abide by the deadlines applicable to all students in the course. This combination of in-class and DL courses allowed us to compare students’ understanding of the technical material and learning outcomes. This approach gives better assessment of in-class and DL students since their assessment is based on identical material, in the same timeframe and uses same assessment tools. This approach is somewhat different than many other studies that have been performed by other investigators [4, 7-9].

3. Difference Between In-Class and DL Students and Programs

Although web-based or DL programs have been offered extensively for almost two decades there are still persistent concerns that students graduating with degrees through DL programs do not have as good a command of the subject matter as their counterparts, or that their performances are assessed using a different yardstick than their counterparts. These criticisms may be due to the lack of knowledge about DL programs or may be more applicable to technical programs where interaction between students is highly encouraged and may, in some cases, add strength to the overall learning process. Diaz and Cartnal [7] compared student learning styles in an on-line or DL class and an equivalent on-campus class and found that students enrolled in the DL class were more independent learners while those in the on-campus class displayed more collaborative learning styles. Their research did not compare student performance in the two classes and did point out that student performance may be related to learning preference of the student. Kirtman [4] assessed students’ learning outcomes in online and in-class courses and found the two groups had similar outcomes. Other researchers arrived at similar conclusions when they compared students’ learning
outcomes in on-line and in-class settings. Most of these investigations were carried out in a setting somewhat different than the environment in which on-campus and DL students enroll in engineering courses. Some had offered a course to on-campus students and the same course was offered to on-line students but in different semester or the same semester but independently taught. In other cases, the investigation focused on non-engineering courses. While this may not seem to be an important issue when considering educational outcomes and students’ performance it is, to some extent, differentiates how the students are assessed in technical programs from non-technical education. The fundamentals and laws and rules of physics and mathematics are more rigorous in engineering education than in non-technical areas. And the assessment of students’ learning and educational outcomes are judged partly based on these aspects, application of mathematics, physics, chemistry to complex engineering problems, interpretation of results, analysis of results, etc. While collaboration is highly encouraged in students’ learning it plays important role in certain types of pedagogical activities such as designs, large and/or multi-disciplinary projects, multi-level analysis.

![Graph showing performance of students](image)

**Figure 2. Performance of in-class and DL students in one of the courses**

The author of this paper has been involved in in-class and DL students and programs over the last fifteen years and has taught many graduate level engineering courses in the format described earlier. An earlier paper by the author considered learning experience of students in a DL course [10]. Although the sample size in the study was not too small considering it was a graduate level course it deemed necessary to include a larger student sample size in the investigation to have better confidence in the results. In this study a larger sample of over 180 students is evaluated, with about a third of them in DL sections and the remaining in in-class portion of the courses.

Figure 2 shows a comparison of overall performance of in-class (C) and DL (DL) students in one of the two courses over the last three years. For clarity, the figure shows data of last three years only. Each mid score represents a range of points the students scored within a range. For example, a score of 85 represents points score by students within 80 and 89.9 points, similarly with a score of 75 which represents a range of 70 to 79.9, etc. The overall performance shown in Figure 2 includes students’ performance in assignments, tests and projects. Both groups were assessed in an identical
manner and there were no distinctions between the two groups until after their assessment on each test, assignment or project. Generally, both groups exhibited Gaussian distribution in their performance and there were no significant differences between the in-class and DL students except in the extreme range of the scale. Such differences are not uncommon; they can be found in most of the classes on year-to-year basis. Similar but with some minor differences were measured in the second graduate level course taught by the author. The first course is a prerequisite for the second graduate course. Table 1 shows a comparison of students’ performance in the two graduate courses taught by the author over a four year period. Of the 58 DL students five were international (enrolled from outside the U.S.) and six were from outside the State; the remaining were local students who preferred to elect DL section due to time constraints, travel, etc. Course #2 had one from outside the U.S. and 2 were from outside the State; the remaining 22 were local students who elected to take DL section.

<table>
<thead>
<tr>
<th>Course</th>
<th>Average score, %</th>
<th>Std. Deviation</th>
<th>COV, %</th>
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<tbody>
<tr>
<td></td>
<td>In-Class</td>
<td>DL</td>
<td>In-Class</td>
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<tr>
<td>Course #1</td>
<td>66.7</td>
<td>65.8</td>
<td>9.4</td>
</tr>
<tr>
<td>Course #2</td>
<td>68.9</td>
<td>70.3</td>
<td>7.8</td>
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An important component of the two courses was a detailed simulation project required of each student. The projects were designed to test students’ comprehension of the material and their fundamentals, manipulation of different steps and stages until the end point. The projects required strong background in thermofluids areas and prerequisites. Each student was assigned similar project yet each was different in many ways and required critical thinking, development of computer algorithms for the processes, working the code, getting results and interpretation of results to assess the impact of variables assigned in the project.

![Figure 3. Performance of students in project portion of the 1st course](image)

The project allowed students to demonstrate their skills in several areas expected of graduate students and were evaluated as if they were technical papers comprising of abstract, development of process, development of computer code, results and their interpretation, and applications. The
project carried 25%-35% of the student’s grade depending on the course. Figure 3 shows performance of in-class and DL students in the project alone in the last two years. In general, the DL students did as well as the in-class students in the overall course as well as the project. Small differences observed from year to year were not significant as they have been observed with both groups of students.

While the instructor assessed students’ performance in graduate courses, the students were also required to evaluate their instructor and the quality of the courses. All in-class and DL students were required to complete the survey, shown in Table 2, at the end of the semester and submit it to the office of Engineering Professional Development. In addition, DL students are required to complete a mid-term survey to help the instructor manage DL educational activities in response to input from DL students. This allowed the instructor to meet students’ expectations as much as possible. The overall satisfaction of DL students in both the courses was over 75%, very similar to that of in-class students.

Table 2. Course and instructor evaluation by DL students

<table>
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<tr>
<th>Course and Instructor Evaluation</th>
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<tr>
<td>Course No:</td>
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1. Was the instructor prepared for class each week?
2. Were the course materials appropriately organized?
3. Did the instructor provide adequate presentation of the course subject matter?
4. Did the instructor demonstrate adequate knowledge of the course subject matter?
5. Did the examinations provide an accurate means for students to demonstrate their mastery?
6. Did the instructor provide timely feedback with regard to assignments and tests?
7. Did the course assignments provide an accurate means to show your mastery of the material?
8. How would you grade this instructor?
9. Did this course fulfill your educational needs?
10. Were there clear course objectives indicated in the course syllabus?
11. Were the prerequisites for this course adequate?
12. Did you find this course challenging and engaging?
13. In your opinion was the course material current and appropriate?
14. In your opinion was the assigned text useful?
15. Was there unnecessary repetition of material already covered in other courses?
16. How would you rate this course?

Additional Comments:

Research shows that collaborative learning is an important part of education and that DL students should be provided the opportunity available to in-class students [11,12]. This was recognized and agreed by CECS faculty when DL programs were developed. To address this need, the instructor scheduled virtual office hour every week for students in the DL program. All DL students were required to attend at least some of the virtual office hours during the semester. The in-class students could participate as well. This provided an excellent opportunity to DL students to interact with
other students outside the office hours. In addition a few DL students attended some of the live classes which further allowed them to interact with their classmates, both in and out the classroom.

4. Issues of Concern

DL education program can match in-class programs but there are issues that course instructors, DL students and the college need to be aware of. Some of these are:

a. A well-disciplined student and a well discipline approach to learning enhance chances of success of DL students.

b. Having complete semester schedule including assignments, tests, reading materials, etc. help DL students plan their learning, schedule their non-academic activities, and help them in time management.

c. It is important for administrators to know that a well designed and managed engineering DL course requires more time and effort on the part of the course instructor than an equivalent in-class course.

d. It is necessary for the course instructor to have scheduled periodic contact with DL students. It could be arranged through weekly virtual office hours, scheduled conference calls, or some other communication mechanism.

e. Timely feedback on their performance in assigned evaluation instruments should be provided to all DL students.

f. Like in-class students collaboration should be emphasized wherever necessary yet keeping individual performance evaluation intact.

5. Summary

The structure of the DL program discussed in this paper provides a true comparison of students’ learning success in in-class and DL programs. A comparison of in-class and DL students’ performance shows both groups can achieve the same learning success provided the DL portion is well designed and managed properly. If not, there could be noticeable learning and performance differences between DL and in-class students. Teaching DL courses could be very time consuming activity on the part of the instructor. This can be addressed by making use of technology to make interactions with students to be effective and efficient.

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