
AC 2011-744: OPTIMIZING QUALITY AND RESOURCES FOR WORLD-WIDE ONLINE DELIVERY OF ENGINEERING EDUCATION

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Optimizing Quality and Resources for Worldwide Online Delivery of Engineering Education

Abstract

University based distance learning programs can be designed to provide high quality online continuing engineering education while leveraging a number of existing campus resources. This work examines the University of Florida's asynchronous combined classroom approach for worldwide online delivery of graduate engineering courses and master's degree programs in Civil, Computer Science, Electrical, Environmental, Industrial, Materials, and Mechanical & Aerospace Engineering.

This body of work begins with a brief introduction to the history of engineering distance learning at the University of Florida, and a one year snapshot of enrollments and students. The core of the work goes through UF EDGE basic model used to optimize resources and time including: the combined distance and campus classroom structure, infrastructure for online delivery, course management system and online optimization tools, curriculum for online delivery, and the distance exam proctoring process.

1. Introduction: UF EDGE History, Departments, and Students.

The University of Florida began offering on-site distance learning instruction at select Florida companies in the 1950's. In 1964, the UF College of Engineering launched the first live graduate engineering courses broadcast from UF with real time two-way question and answer interaction between faculty in main campus classrooms and remote learning locations in select Florida cities, called UF GENESYS (Graduate Engineering Education SYStem). Since 1964 the UF Engineering distance learning program has evolved through different technologies, from sending production quality course tapes to industry sites (~mid 1970s), to shipping VHS tapes of each course lecture, each day to individual students (~mid 1980s), to mailing DVDs of each live course lecture each day to distance students (1990's), to a conversion to online video delivery in the late 1990's. In 2005, the distance learning program was renamed the UF EDGE (Electronic Delivery of Gator Engineering) Program. UF EDGE offers online course video delivery and electronic supplemental materials to distance students worldwide. While the technologies used, and the name of the program had evolved, the basic mission of delivering UF engineering courses to a broader audience of students within industry and the military has remained constant since the distance program inception.

UF EDGE students are generally pursuing an engineering graduate certificate or degree from one of seven UF engineering departments: Civil, Computer Science, Electrical, Environmental, Industrial & Systems, Materials, and Mechanical & Aerospace Engineering. Figure 1 shows a snapshot of the distribution of UF EDGE enrollments by department over a typical one year period.

Students generally have completed a bachelor's degree in engineering or very closely related field before beginning a graduate certificate or degree program. While there is some spread in the number of years since completion of a bachelor's degree, during the 2010 academic year, approximately 82% of UF EDGE students had completed a bachelor's degree within the last nine years of enrolling in UF online courses; and approximately 27% were female.

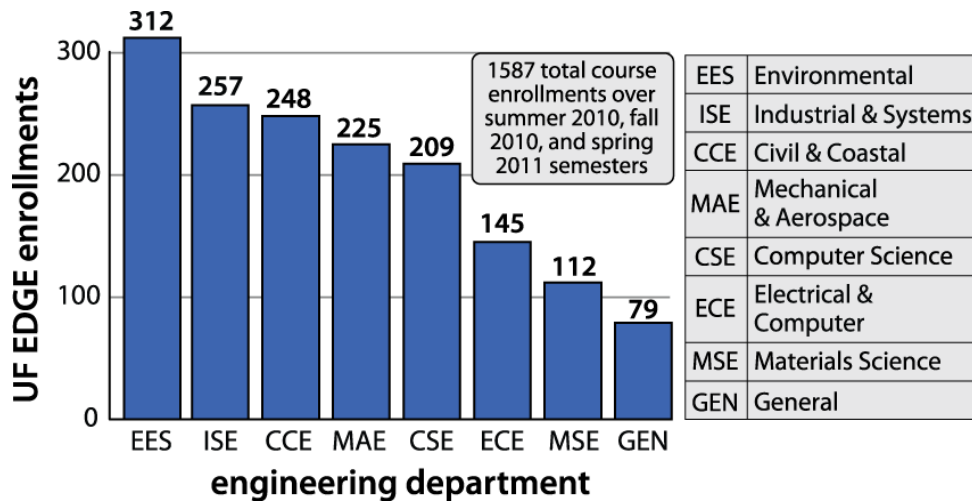


Figure 1: Department distribution of UF EDGE enrollments over 1 year period.

Figure 2 show a snapshot of data on UF EDGE demographics for years since completing bachelor's degree and gender distribution for students enrolling over a one year span (summer 2010 through spring 2011).

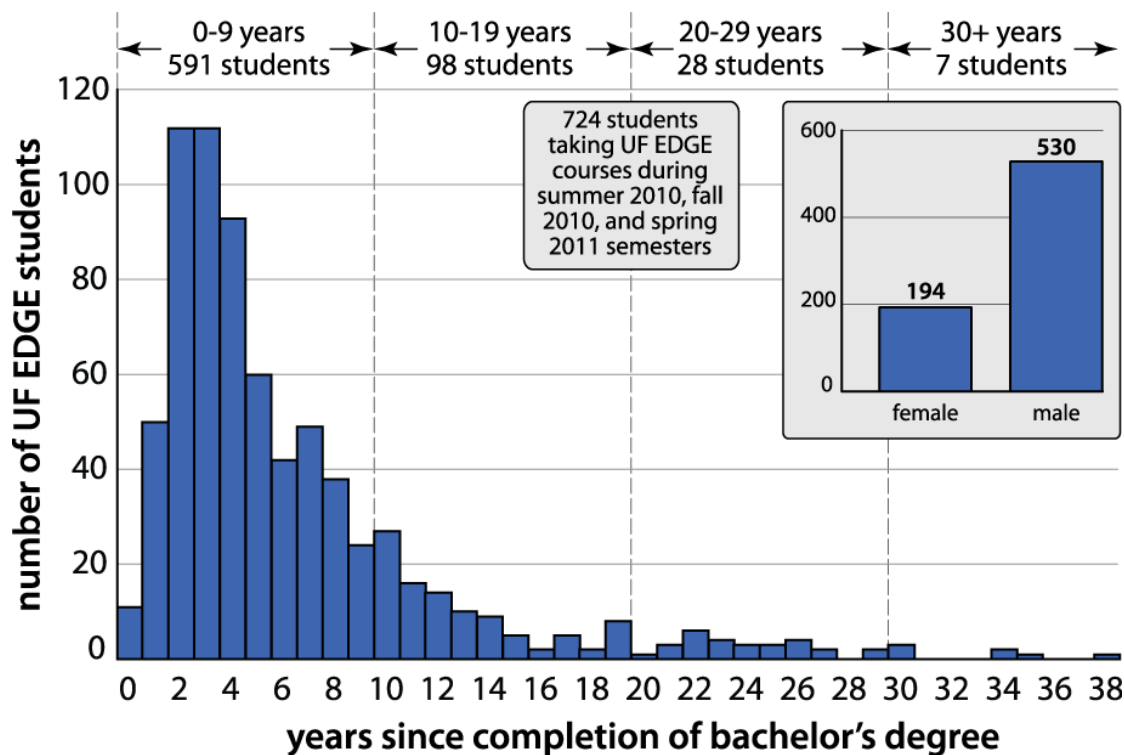


Figure 2: One year student demographics of time since bachelors, gender, and residency.

This introduction was provided to show the general nature of engineering fields, and student demographics participating in UF EDGE Program courses. The remainder of this work will provide information on the structure, tools, curriculum, and proctoring implemented to optimize

a balance of program quality for UF EDGE distance students and efficient use of time and other resources in the UF EDGE online delivery of engineering courses.

2. Combined Classrooms: Campus and Distance

An asynchronous combined classroom format is used to optimize curriculum quality, resources, time, and student interaction. Asynchronous in this instance is defined as the distance students do not watch the individual courses in real time as they are taught, but rather have access to online video of each course lecture one hour after the lecture occurs live on campus. In this combined classroom format, materials are delivered asynchronously to campus and worldwide distance students, with both groups receiving the same curriculum, lectures, assignments, and assessments on the same regular semester schedule. Faculty are only required to instruct each lecture live once to campus students, which is captured in a studio classroom and delivered online for worldwide distance students to view one hour after the campus lecture is complete. The basic structure of the combined classroom approach is designed to leverage the faculty member's time in the classroom to serve a broader academic audience and to maintain the same quality of educational materials for campus and distance students. The course instructor teaches to a live audience of campus students, all interactions, including campus student questions are recorded in a production quality studio classroom. Each video lecture is encoded as it is being recorded, for online delivery approximately one hour after the lecture on-campus. Distance students in industry and the military worldwide can stream or download the course lectures for viewing at their jobs, homes, or on travel. Distance students are expected to stay on the same general schedule for assignments and exams as campus students, with a few day window of flexibility for large project due dates and scheduling times to proctor their course exams where they live or work. Distance students are not required to travel to campus to participate in any courses; all materials can be submitted electronically for course participation. Any course supplemental materials (handouts, web links, software, electronic library access, etc.) are made available to both distance and campus students through the same online environment using the University of Florida implemented course management system, Sakai. Implementing the same curriculum, assessments and supplemental materials for distance and campus students, ensures the course credits, certificates and degrees earned by distance students is held at the same reputable quality as for campus students.

3. Infrastructure for Online Delivery

Faculty instructing in studio classrooms are provided the academic freedom to use the method of instruction they believe best fits the particular curriculum of their course; including standard chalk boards, electronic stylus boards, computer based presentations, and demonstrational prop areas. Studio classroom production quality cameras, instructional technologies, and the video coordination are operated by a trained operator in each classroom, allowing the faculty members full attention to be dedicated to their instruction and students during their course time, and not the equipment around them. If a faculty member uses the chalk board, the operator will follow their writing on the board, and maintain adequate camera magnification to ensure distance students can read the writing on the captured video. If the faculty member combines computer based slide presentations with chalkboard or electronic whiteboard use, the operator will coordinate between cameras and switch electronic feed inputs into the video encoder while recording to capture the information as the faculty member moves about the room or moves between media for instruction. Careful training of production operators is essential to capturing

course lecture content in the full form of educational intent and to ensure minimal disruption to the faculty member's chosen instructional style and media.

Each classroom lecture is captured on video, encoded and then posted online through the Sakai course management system for distance delivery. Both distance and campus students have semester long access to all course videos, making them available as a review tool for both groups of students leading up to course exams. In addition to classroom technologies, the UF EDGE Program maintains its own video servers (and backup video servers) to meet demands for video quality, formats and accessibility for distance students worldwide. Maintaining uninterrupted password protected access to course videos is an integral part of the success of worldwide delivery of the UF EDGE Program engineering educational materials. UF EDGE staff members maintain the video servers and other technologies to link the appropriate course videos through the Sakai course management system for all students to access.

4. Course Management System and Optimization Tools

The UF course management system, Sakai, is the primary user interface for distance learning students to participate in online engineering courses. Sakai is an open source course management system, adopted at UF in 2010. The tools used in Sakai for optimization of time and interaction are common tools found in most university commercial and open source course management systems. These tools can be adopted to save time and resources in delivering distance learning and campus courses regardless of which course management system used at a given institution.

4.1 'resources' tool

The 'resources' tool allows for online organization and sharing of course resources for both distance and campus students. This includes any handouts, lecture slides, web links to supplemental materials, linking to the UF library resources, etc. Faculty and teaching assistants (TAs) can post resources for the entire class in a single location online, and the content is password protected to tie to only those students registered for the particular courses. This electronic posting of materials for campus and distance students also serves to minimize printing and paper waste associated with traditional in-class handouts. Folders within the resources tool can also have student posting permission, where a faculty member or TA can make a folder in which students can upload materials into for sharing with the whole class. Within the UF EDGE online courses, this student uploading ability has been particularly useful as an area for posting and sharing student profiles, so the distance and campus students in a given course can learn more about each other and know all of their fellow classmates regardless of their location.

4.2 'discussions' tool

The Sakai course management system has a 'discussions' tool allowing for threaded discussions within each course. Threaded discussions in this instance are defined as when a student, TA or faculty member post a written topic to the discussion board, and anyone can then post comments or feedback in response to that initial topic. The messages will appear in chronological order of posting for each new topic, and the postings document the name, date, and time of posting. Threaded discussions occur in a similar manner to how an in-class topic discussion may occur, but in writing. In practice, it has been found to save the instructor and TAs time by having the campus and distance students post to the discussion board whenever they have a course related question, then the TA or instructor can answer the question once, online, where all students can

see it, preventing the TA or instructor from receiving multiple emails on the same course question. Also, since both campus and distance students can post and respond to items on the discussion board, it serves as another asynchronous means for distance and campus students to communicate about course materials. Often students will answer another student's question on the discussion boards before the TA or instructor have a chance to reply. All correspondence on the discussion boards is openly viewable by the course TA and instructor, so students know to maintain their academic integrity when using this communication tool with other course students. The discussion tool also serves as a way for campus students who may not be comfortable asking questions orally in class, to take time to craft their question in writing and post to the discussion board for the faculty member, TA, or other student to address.

4.3 'gradebook' tool

The 'gradebook' tool within the course management system allows for electronic assignment collection, online grade submission, online grading, and online return of graded documents. Allowing for the complete cycle of submission, grading, and return to occur electronically permits faculty and TAs to reduce the amount of printing and time in manual grading involved in administration of courses. It also reduces the turnaround time of feedback on graded assignments to distance and campus students, by returning a graded and annotated electronic document online quickly. Additionally, using the 'gradebook' tool through the course management system maintains a university wide level of password protection for viewing of course assignment grades; only students logged into their course through the course management system can see their particular assignment grades, maintaining their student grade privacy.

4.4 online teleconferencing tool

In addition to the Sakai course management system, the UF EDGE Program purchases licenses to commercial software, *Elluminate Live* as a supplemental tool available to college of engineering courses. This tool permits TAs or faculty to hold live online or recorded teleconference sessions. These can be used for online office hours for distance and campus students, or as a way to record an online exam review. The software has a virtual whiteboard, where the session moderator can upload documents or presentations and draw over them or on a blank page using a regular mouse and virtual tools while explaining what they are doing using a standard computer microphone. Users can use a web cam and microphone for online chatting and discussion, or a text box for asking question if non-audio questions are preferred. This tool has also been used for the few UF EDGE courses that have group projects, allowing for teams of combined distance and campus students to successfully setup their own online meetings, to collaborate and work on projects through the teleconferencing tool. *Elluminate Live* has served an additional role for college of engineering faculty to plan and collaborate on research proposals with participants worldwide, at any time of day, without needing a teleconference facility.

5. Curriculum for Online Delivery

The UF EDGE Program delivers online courses from seven engineering departments at the University of Florida; Civil, Computer Science, Electrical, Environmental, Industrial, Materials, and Mechanical & Aerospace Engineering. There are three options for types of credit earning programs through UF EDGE for distance students to participate in; individual courses, specialty certificates, and master's degrees.

Any UF EDGE course can be taken individually by a distance learning student wishing to learn about a particular topic. Certificates are structured as 3-5 graduate courses that center on a common specialty area of engineering. Master's degrees consist of 10 courses that provide a more complete program track in an engineering discipline. Master's degree curriculum is chosen by individual departments from already in-place on-campus master's degree programs of study that are potentially marketable and useful educationally to a broader audience of distance graduate students in industry or the military.

The three educational options can be progressive; an interested student can start with a single course, continue it onto a 3 course certificate, and then transfer the certificate credits earned in towards a 10 course master's degree (as long as the certificate courses and master's degree are in overlapping disciplines, and the student earns a B or better in the certificate courses). The progressive structure of beginning with a single course, moving onto a certificate, and then the option to continue onto a full master's degree provides distance students the opportunity to try out the UF EDGE Program and pace their continuing professional development with their other career and family obligations.

5.1 Online Graduate Certificate Areas

Specialty certificates, consisting of 3-5 graduate courses, are an efficient means for those in industry wishing to participate and earn advanced certification from UF EDGE without committing to a full master's degree. Certificate topics are structured around emerging areas of engineering research and education, such as 'Energy', and 'Sustainable Engineering', to allow those in industry and the military to train themselves into emerging engineering fields without leaving their present location and career. Generally, certificates have a quick online application process, and a certificate can be completed in one year.

UF EDGE Online Graduate Certificates

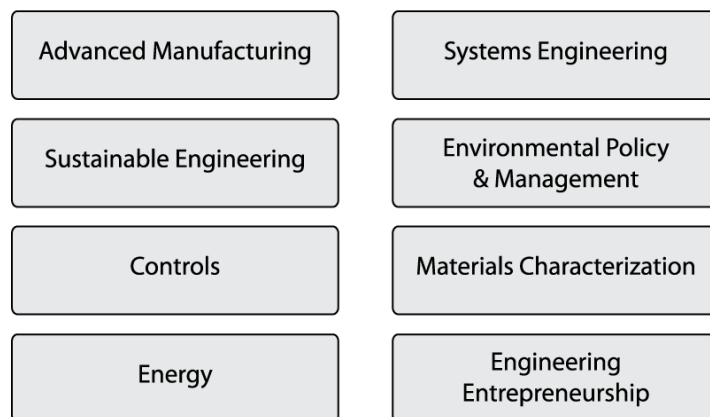


Figure 3: Graduate certificates offered online through UF EDGE Program.

5.2 Online Master's Degree Tracks

Online master's degrees for distance learning students are offered from seven University of Florida engineering departments. A master's degree consist of 10 courses, with some flexibility to cross select elective courses from other departments to structure the master's degree curriculum to meet the particular distance student's educational needs. The usual structure is a student is required to take 7 coursers from the department they will earn their master's degree

from, and then can select up to 3 out of department engineering electives to tune the master's degree towards the multidisciplinary engineering practice the distance students prefer. The systems engineering degree is a notable exception, in it allows up to 5 out of department courses out of the 10 total courses, designed as a 5 course core systems curriculum and a 5 elective option to tune the systems towards the industry the distance students work or potentially desire to work in (electronic systems, manufacturing systems, etc.).

UF EDGE Online Master's Degree Program Tracks

Civil & Coastal Engineering	① general civil engineering
Computer Science & Engineering	② bioinformatics ③ general computer engineering
Electrical & Computer Engineering	④ communications ⑤ semiconductor device technology
Environmental Engineering Sciences	⑥ systems ecology & ecological engineering ⑦ water resources planning & management ⑧ water, wastewater & stormwater engineering
Industrial & Systems Engineering	⑨ communications systems ⑫ environmental systems ⑩ information systems ⑬ manufacturing systems ⑪ logistics & transportation systems
Materials Science & Engineering	⑭ electronic materials ⑯ polymers ⑰ metals ⑱ structural materials
Mechanical & Aerospace Engineering	⑲ solid mechanics & design ⑳ dynamics & controls ㉑ fundamentals of thermal fluids transport

Figure 4: Master's degree program track areas offered online through the UF EDGE.

The application process for master's degrees is an online process, thus making it accessible for distance students worldwide. Distance students can begin as a 'non-degree' seeking student during their first semester (one page application), and then apply for full graduate school admission during that first term. Master's degree admissions do require a standardized examination (GRE most departments, some will accept FE exam in place of GRE), undergraduate transcripts, and letters of recommendation. Admissions to the distance learning master's degree programs are the same standards as for on-campus master's degree students, ensuring the quality and caliber of admitted graduate student are maintained and the student population participating in online graduate courses is adequately prepared for the graduate level course curriculum.

Completion of a master's degree has the same requirements for both distance learning and on-campus students: generally it is successful completion of 10 approved courses, with a 3.0 grade

point average (B or higher), within 6 years of beginning the program. Distance students are welcome to come to the UF campus to walk for graduation, but it is not required. No mention of 'distance learning' is indicated anywhere on the student's transcript or diploma, since all the same admission criteria, course curriculum, assignments, and other requirements are maintained equally for both distance learning and campus students.

6. UF EDGE Exam Proctoring

The UF EDGE Program exam proctoring process involves screened individual proctors for each distance learning student. The distance student identifies who their exam proctor will be, working under a set of guidelines designed to avoid potential academic dishonesty risks. Each proctor is screened by a UF EDGE staff member, and once approved is entered into the UF EDGE database for course exam distribution. Each course instructor fills out an exam cover sheet, which indicates the exam conditions (open/closed book, amount of time, calculator permissions, date due back, where to return electronically, etc.). That cover sheet is sent electronically to both the distance learning student and the exam proctor so they can both prepare the proper time and environment to take their course exam. The proctor is issued an exam document password, and logs into the UF EDGE database to retrieve the individual course exam the day of the exam. The proctor administers the exam to the distance student under the instructor specified conditions, signs the exam cover sheet, and returns the exam and signed coversheet electronically to the instructor via the method they specified on the coversheet. The instructor grades the exams, and returns the graded document to the UF EDGE office, where it is scanned and returned electronically to the distance learning student through a password protected online database.

The UF EDGE exam proctoring process where distance students have their exams proctored at their place of work, local library, or testing center, works well for the majority of engineering distance learning students. Internationally, there are a few areas where the proctor guidelines and verifications are not as easy to apply in practice. For these locations, the UF EDGE Program and the College of Engineering have worked to form services agreements with reputable international universities, where international university representatives serve as exam proctors, ensuring the integrity of the course exams are upheld, and in return the UF EDGE Program pays the international university a fee for their services. This international agreement model allows distance learning students in countries where individual student selected proctoring is difficult to still participate, but with a few locally arranged international university visits for course exams.

7. Conclusions

Overall, the UF EDGE Program combined distance and campus classroom structure has worked successfully in practice to expand the UF College of Engineering to serve a greater educational audience than those physically in UF classrooms. Over the summer 2010 to spring 2011 sample year, this included 724 distance learning students, registering for 1587 graduate engineering courses, that without the distance learning UF EDGE option would likely not participated in UF graduate engineering courses. Maintaining the same lectures, assignments, exams, and requirements for distance learning and campus students, ensures the integrity and value of the certificates and degrees issued to distance and campus engineering students is equitable.

Proper utilization of the UF EDGE Program production quality studio classrooms and the Sakai course management system tools saves instructor and TA time, serves to reduce paper and environmental waste, and increases the distance and campus student interaction and reviewability of course lectures and materials. The UF EDGE combined classroom approach has provided opportunity for distance students worldwide in industry or the military to benefit from continuing education and professional development through a nationally ranked university in an online environment, while maintaining their current career or family obligations.