Session No. xxx

Foundations of Engineering and Technology (FEST) Program

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Introduction

The University of Colorado at Denver has teamed with Arapahoe and Red Rocks Community Colleges to develop the Foundations of Engineering, Science and Technology (FEST) Program. FEST intends to dramatically increase capabilities for online and blended delivery of the core mathematics, engineering science, and information technology courses required for entry into a four-year engineering degree program. In this paper we will describe the:

- FEST Program design and organizations,
- Academic objectives using learning technologies,
- Development of blended online versions of the FEST core courses,
- Integration of engineering applications into the FEST core courses,
- Development of a Collaborative E-Learning Library System (CELLS), and
- Lessons learned.

FEST Program Design and Organizations

The FEST project involves collaboration among faculty and administrators from several institutions, including the CU at Denver College of Engineering and Department of Mathematics, the Arapahoe and Red Rocks Community Colleges. These are the people that develop and deliver pre-engineering courses preparatory to a four-year engineering degree. Engineers from the American Council of Engineering Companies provide guidance on applications of science and math principles in real world design projects. The courses include the basic science, mathematics, information technology and introductory engineering mechanics courses (Figure 1). The FEST Certificate Program intends to allow flexibility of course offerings so that students can complete pre-engineering requirements with assurance of quality and transferability to a 4-year engineering program. The courses are being developed for blended and on-line delivery using learning technologies of web-based courseware and digital media.

Flexibility of course deliveries is obtained by scheduling of FEST courses at each institution and allowing cross-registration for courses that are not offered. For example,

the calculus series at the community colleges show declining enrollments with Calculus I having high enrollments, lesser numbers for Calculus II and very few students take Calculus III. Consolidation of the few students from each community college into a single blended version using on-line technologies reduces student isolation and makes offering the advanced courses viable. Similarly, the Engineering Science courses have low enrollments at the community colleges and finding qualified instructors is difficult. Consolidation of the students from each community college and CU Denver into a single blended course allows those students to move forward in completing the pre-engineering requirements at their home institution.

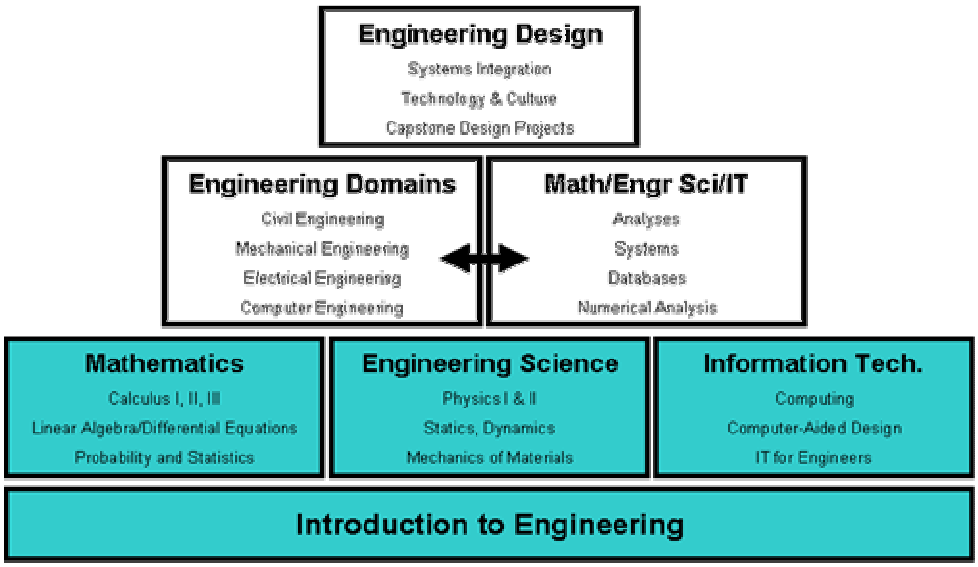

Figure 1. The FEST Program addresses the foundation courses of the pre-engineering curriculum, including mathematics, engineering science and information technology, and an Introduction to Engineering course.

Academic objectives using e-learning technologies

By implementing e-Learning technologies into the FEST project we hope to achieve the following academic objectives:

- Bring real-world problems into classrooms through the use of videos, demonstrations, simulations and Internet connections through learning objects developed in the FEST multi-media studio, stored in the CELLS eLibrary, and delivered in a blended course format.[1,2,3a]
- Increase learning effectiveness through online tutors, teachers, and peers through blended courses that include web-based functions that provide effective and efficient feedback, student centered self-modifying learning exercises, and effective communication on a high abstract level.[3b]
- Build local and global communities of teachers, administrators, students, and others interested in learning by developing an inter-institutional administrative strategy and management system. This system provides academic cooperation, process definition, and logistic collaboration among program partners.[3c]; and

- Create an online environment that facilitates collection of data and research collaboration among FEST participants.[3a,4,5]

Development of online and/or blended online versions of the FEST core courses

Web based technologies are being used to help manage the project comprised of distant partners with disparate environments, including application of a learning management system to act as: 1) a content management system and 2) a course development system for inter-institutional faculty who operate in the disparate computing environments. Implementation and management of the FEST program required an innovative management strategy because the project consisted of diverse higher education entities, each with its own method of managing, developing and delivering online courses, scattered through the Denver Metropolitan area. For example, the Colorado Community Colleges use WebCT©, Blackboard©, or eCollege© learning management software. Faculty at the University of Colorado at Denver use Blackboard© for blended delivery and eCollege© for online courses delivered completely at a distance.

Course materials developed for blended and on-line delivery include a varied mix of documents including digitized syllabi, audio and video recordings of lectures, recitations and lab exercises, presentation materials (e.g., PowerPoint), homework and exam problems with solutions, group project materials, discussion questions, and web site resources. These materials are termed Learning Objects which can be shared and used by participating faculty in their course developments and deliveries.

An important aspect of the FEST Program is the development of Interdisciplinary Lively Application Projects (ILAPs). First developed through the National Science Foundation (NSF) Project Intermath (http://www.projectintermath.org/), ILAPs are carefully designed, real-world, interdisciplinary projects used to motivate students and to reinforce fundamental concepts. For FEST, ILAPs were developed jointly by a mathematics instructor and a partner instructor from another discipline (engineering, physics), and are presented to the class in a discovery-oriented manner. For the FEST Program ILAPs are being developed for other fundamentals courses, as well as for the math courses, combining concepts from a variety of disciplines to help review and reinforce fundamental concepts. From the student's perspective, ILAPs motivate the need to develop mathematical concepts and skills, provide interest in future subjects that become accessible through further study and mastery of mathematics, and enable a broader, more interdisciplinary outlook at an earlier stage of development. From a faculty perspective, ILAPs are valuable tools to accomplish a variety of course goals.

During Phase I, we modified a learning management system (LMS) to serve as a project management system. Faculty and staff used the modified Blackboard© platform to help manage the FEST multi-participant project within the university and at distance to facilitate:

- work flow management;
- inter-institutional communications, including list serve email;
- white paper and other document distribution and collaboration;

- discussion board for FEST program topics;
- distance conferencing for workshops and staff meetings;
- tracking and coordination of FEST courses.

Other uses included online:

- project announcements
- project assignments
- calendar
- paper work, such as reports, scope of work descriptions, etc.
- group management for committee work, etc.

Use of the LMS for project management was straight forward in application. The entire (approximately) 30 faculty and administrative staff participants were established as Instructors in the FEST Project site and provided initial default login privileges. This allowed a natural accommodation to the various participant roles. After initial login, each participant provided their Profile, including personal information and their e-mail. Announcements on scheduled workshops and other events could be posted by those responsible for organizing the events. E-mail reminders could be broadcast to the entire group, or to individuals as desired. Project management documents were posted to the site to allow all participants to review the original proposal, work plan and progress reports. Threaded discussions were conducted to address workshop planning and other topics.

Teams of faculty collaborating on ILAPs and other course materials development were established as Groups, but these restricted access domains were not used very much. It ended up that the Project Documents site was used for each collaboration area, and all participants had open access to each others documents. The Discussion Board was used extensively for follow-up dialogues on techniques for on-line course development and delivery, intellectual property issues and other topics.

Overall, the FEST Course Development application was well received by participating faculty who endorsed the collaborative usage as way to improve their courses. A significant aspect of adoption of a particular ILAP, for example, seemed to be participation as an author, and the interdisciplinary structure of the authoring teams enhanced this process.

Blended courses are courses that combine regular face-to-face teaching with online teaching delivery[6]. Courses taught through this format can broadcast recitations and lectures synchronously and asynchronously while other parts of the course are delivered asynchronously on-line. Such courses are to be supported by an online tutoring with live and asynchronous interaction with graduate teaching assistants[7]. FEST calculus courses are already delivering these components and the FEST technology and culture course has adopted several of these techniques.

Blended courses have the further advantage of facilitating team teaching and the sharing of learning objects. For example, in the case of team teaching, faculty from the same or different institution could teach a course with one or both instructors teaching at a

distance synchronously or asynchronously. Moreover, blended courses can be monitored and evaluated at a distance through the learning management system that delivers the online components of the course. By defining the administrator as a co-instructor in the learning management system that delivers a course, the administrator person will have access to the course with management control privileges before, during and after the semester the course is offered. In short, blended courses facilitate:

- support for faculty in the delivery of high quality courses;
- sharing of course materials and learning objects;
- sharing of faculty workload;
- development of learning communities among students, faculty and support staff;
- online tutoring for students;
- student assessment and feedback; and
- FEST program management and monitoring

Integration of engineering applications into the FEST core courses

Tools and systems used include Web based technologies to help manage a project comprised of distant partners with disparate e-Learning environments. Other technological dimensions included application of a learning management system to act as: 1) a content management system and 2) a course development system for inter-institutional faculty who operate in the disparate computing environments. Also developed were dissemination strategies using Web-based technologies as they apply to producing content for the interdisciplinary pre-engineering curriculum.

Development of a Collaborative E-Learning Library System (CELLS)

Once faculty developed their courses and learning objects for blended delivery, we created an archive to store these leaning objects for continued and shared usage. CELLs is an electronic learning objectives archive where course materials, or learning objects, can be archived and shared by program participants. Participating faculty will use the archive to mix and match contents to deliver FEST courses in a consistent and quality controlled manner. The current instance of the CELLS is located at: http://thunder1.cudenver.edu/FEST/home/.

The FEST CELLS is a content management system built from scratch to mimic systems such as the National Science Digital Library (NSDL) Communication Portal[8]. Such systems allow users and developers to develop and share materials through online collaborative and information dissemination. The collaborative area includes public workspaces for sharing information, discussing management and educational issues, and supporting team building. Similar to the NSDL system, the FEST CELLS will accommodate heterogeneous participants, content, and technologies through a spectrum of interoperability that provides diverse and broad entry into the different components of the system. Eventually, we hope to develop the CELLS in XML format to allow posting and retrieval of FEST teaching materials and other documents in multiple formats[9].

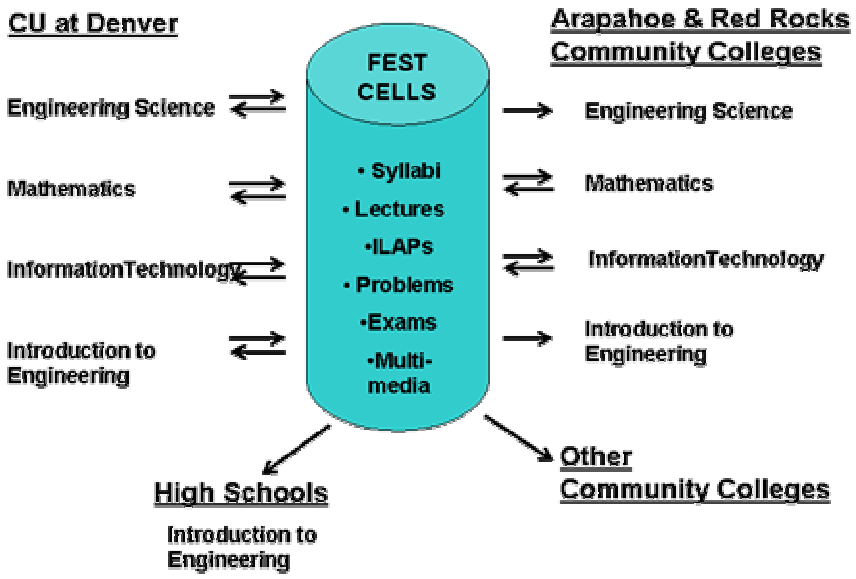

Figure 2. FEST CELLS provides a means for sharing of learning objects by participating faculty who can access and incorporate multi-media materials into their own courses.

FEST Program Evaluations

The basic evaluation theme addresses how well the FEST program meets criteria of effective learning by 1) bringing real-world problems into classrooms; 2) providing "scaffolding" support to students to convey expert knowledge to students; 3) increasing opportunities for student feed back, peer-to-peer and expert to student interaction through new computer technologies; 4) building local and national communities among faculty and other managers; and 5) and expanding teacher opportunities for learning through collaborative learning environments enhanced by the creative use of new communication technologies. We have obtained guidance from various professional evaluation publications and reports.[10,11,12] Specific evaluation activities include: 1) quantified data based on student registration and tracking, 2) pre- and post surveys for program and teaching effectiveness, 3) an on-line evaluation site for students, faculty and administrators (http://www.coloradoit.org/survey.asp), 5) a professional outside evaluator, and 6) system use statistics and trouble reports.

Lessons learned

A systems integration of e-Learning technologies for the FEST project indicates that learning management systems can be used for purposes other than delivering online courses. We developed these systems on an ad hoc basis with some initial success. At the same time, this initial success brought with it several lessons learned. First, advancing technological integration is a people as well as a technical challenge. The difficulty in

getting some faculty to use new technologies to develop courses and learning objects exemplifies this challenge. Research on obstacles for adoption of new technology is relevant here. For example, Nedovic and Budic[13] describe how human factors such as fear of change, computer-related anxiety, and possible interpersonal conflicts prevent organizations from readily adopting new technologies. We also found that content ownership issues need clarification as faculty are reluctant to post their learning objects for shared use until copyright issues are clarified.

Some of the barriers may be overcome with organizational factors such as political and technical support, and time release for FEST faculty. In addition, we propose to seek to identify personal rewards for participation, provide opportunities for exposure and training, and assign technical assistants to help instructors with our mobile multi-media learning studio. In the future technical teaching assistants (TTAs) may be as valuable as teaching assistants in the new e-Learning environment.

In the area of electronic content management, we discovered that using a modified proprietary learning management system such as Blackboard© for purposes other than course delivery had its successes as well as difficulties. The first and most obvious difficulty was proprietary systems such as Blackboard© are platform specific and only available to clients who have a licenses to use the systems. Consequently, to create a more universal and portable system to store and retrieve learning objects and other material, we had to develop and use a regular web site to house the e-Library. This Web site, however, lacks the multiple functions of modified proprietary course management systems. Moreover, it is not directly integrated with the project management system. The main problem with the FEST ad hoc system can be summarized as follows: “too many different software applications for too many purposes.”

One proposed solution to the challenge of using too many ad hoc applications would be to integrate all of the FEST Program’s systems into one content management system. This single system could be used to deliver FEST courses, manage workflow, author, publish and store e-Learning materials.

The benefits of implementing such an integrated content management system, according to Browning and Lowndes[14], include:

- Engender the re-use of information by allowing the ready integration of data from diverse sources.
- Permit the efficient re-purposing of information;
- Allow information maintenance to become devolved but at the same time preserving central control;
- Ensure presentational consistency by separating the design of Web pages from the content they display;
- De-skill the task of putting information on the Web;
- Facilitate good information management practice so that appropriate metadata are captured at the time of content creation or modification; and
- Permit some past state of the content management system to be re-created or restored.

Integrating the present ad hoc FEST system into one content management system may be the next stage in the use of new technologies to help the FEST project achieve its objectives more efficiently and effectively. In such an integrated system, workflow functions become management and course development functions; authoring and publishing functions become learning management functions; and storage and retrieval functions become e-Library functions. Such a system, however, still would not solve the human factor barriers we encountered in integrating new technologies into the FEST project. An alternate design may be one in which faculty authors maintain their learning objects in their own archive (or have control over their portion of a centralized archive). Then, a process of petitioning to these authors for access to share materials could be adopted.

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