

Creating Innovative Curricula: Developing New Programs with New Paradigms*

JUDI DOHN

Principal, VentureCatalysts, LLC 1944 Spyglass Drive, Henderson NV 89074-1043, USA.

E-mail: jadohn@cox.net

DARRELL W. PEPPER and ERIC SANDGREN

College of Engineering, University of Nevada, Las Vegas NV, 89154, USA

Preparing students to adapt and excel in an ever changing technological environment, recruitment and retention of new and continuing students at the freshman/sophomore levels and identifying effective undergraduate and graduate internships are challenges facing all engineering schools. The Colleges of Engineering and Fine Arts at the University of Nevada, Las Vegas are developing a new interdisciplinary program in Entertainment: Engineering & Design that incorporates unique public/private partnerships, introduces engineering opportunities to pre-college student, and expands the creative, technical and entrepreneurial potential in students through this innovative new program.

BACKGROUND

ENTERTAINMENT: ENGINEERING & DESIGN (E²D), in its broadest sense, is a multi-billion dollar, international industry that includes innovative engineering, circuit board design, light and sound production, film post-production, and animation and multimedia software development. E²D professionals work in theater, film, television, clubs, and concerts. They put their multi-faceted talents to use in developing retail environments, sports arenas, convention facilities, musical venues, museums, and theme parks.

Meetings and conventions are already a more than \$100 billion industry, and Las Vegas is one the largest convention and meeting destinations in the world and the top destination in the USA. Meetings technologies are moving beyond computer-based registration assistance into enhanced sound and video capabilities for meeting rooms. The need for entertainment venues to provide the maximum sound experience for all attendees will create new and improved sound technologies that can be readily transferred to conventional business applications.

As concerns grow for the safety and security of large entertainment venues, the need for unobtrusive but failsafe recognition technologies will increase. Technologies developed to satisfy both security and discretion will obviously be applicable to many other industries and have important homeland security ramifications.

Several well-known programs have focused on specific aspects of E²D, primarily multimedia and consumer product design and development, but

few have the blended approach with the major emphasis on engineering required in this new discipline. In order to be successful, these programs must fit well within the mission of the university in which they are located. At the University of Nevada, Las Vegas (UNLV), Entertainment: Engineering & Design—a new program with a new approach that brings together the technological expertise, theatrical design, engineering design and prototyping capabilities, robotics and visual graphics experience of both the university system and the private sector—is being developed with the goal of creating a School of Entertainment: Engineering & Design that offers both undergraduate and graduate degree programs.

A unique aspect of this new program was that much of the initial effort began under the auspices of an EPSCoT grant from the Department of Commerce, Technology Administration, spearheaded by the private sector. Southern Nevada is considered to be one of the entertainment capitals of the world—with exciting live shows such as Cirque du Soleil, themed retail venues, digitally animated billboards, and animatronic entertainment; it was a logical step for a public/private consortium to decide over five years ago to focus on the technology that drives that industry. Partners in the project, including both Engineering and Fine Arts faculty at UNLV, spent a year visiting venues, reviewing existing facilities and programs and exploring options. Private sector involvement in the development and scope of the program has been key in maintaining interest and support both internally and outside the university systems. That support goes beyond funding to include seminar speakers, adjunct faculty, industry guidance and participation in senior design projects and seminars, internship opportunities for students,

* Accepted 16 February 2005.

and employment in cutting-edge fields after graduation.

EDUCATION INNOVATION

As an academic discipline, the UNLV Entertainment: Engineering & Design curriculum is new and unique—an interdisciplinary program that combines the technical rigor of the engineering curriculum with the creative insights and aspects of theatrical arts. It requires students to use both the creative and artistic, the analytical and technical sides of their brains and provides them with real world opportunities to apply their new talents. Traditionally, practitioners in the E²D field have come primarily from fine arts backgrounds. They have had to develop new engineering skills outside the academic setting. Considering that many of the new mechanisms these practitioners first envision and then build must perform without fail and often have lives depending on their reliability, there is an obvious need for a structured program that encompasses solid engineering principles. Whether employed in a traditional theater setting, creating interactive billboards, designing state-of-the-art entertainment venues, or engineering the latest thrill ride, E²D graduates will have the ability, scope and vision to create work in, and create, an entirely new engineering paradigm.

The development of the E²D program has essentially required a rethinking of the entire Engineering College's curriculum, from the freshman experience to the senior design program (Table 1, Table 2). The benefits of such a redesign are extensive: increased retention, improved quality of students recruited to the program, ability to focus on problem-based learning, increased participation of practitioners from industry in the teaching process, team-based learning, interactive teaching, and the incorporation of wireless and distance-learning based technologies. With the



Fig. 1. Tuesday, May 06, 2003, Las Vegas Review Journal; students from ATech H.S. and UNLV engage in friendly competition.

existing pedagogical structure, it is difficult to serve all of the potential populations that could be productive and ultimately contribute to the Entertainment: Engineering & Design field. A redesigned and integrated curriculum eventually could allow for 'anytime, anywhere' learning and appeal to a broader audience, as well as reaching out to international venues and talent.

The diversity and scope of the program itself has provided other challenges in program development. Entertainment: Engineering & Design has its roots in a multitude of disciplines, many of which are already resident at different UNLV colleges. Initiating the first undergraduate program as an interdisciplinary minor for both engineering and fine arts students enables an undergraduate to be credentialed in the major but well versed in the minor. In engineering, majors can include mechanical, civil, electrical engineering and computer science; in fine arts, theater, design/technology, architecture and graphic arts. Additional colleges that are planning to participate in the program include the hotel and business schools, offering entertainment management degrees as well as collaborating with entrepreneurial programs.

There is an innate logic in developing a program and designing a curriculum that is not only cross-cutting educationally but can include the finest practitioners in the field, many of whom, if not resident, are within a few hours drive or a 45-minute plane flight from campus. The location at UNLV in southern Nevada home to the world famous Las Vegas Strip, and its multitude of ever evolving entertainment venues will enable the E²D program to be a one-of-a-kind premier educational experience and provide new and fresh opportunities for internships and design projects. This particular industry is broad based, cutting edge, and in executing its daring vision, is often compared to the technology employed at NASA. In fact, many ex-NASA engineers are employed in the entertainment engineering industry. The concept of unique, one of a kind, high-fidelity products, developed at NASA, has extended to entertainment engineering, with the caveat that these technologies have to perform twice a day, 50 weeks a year, and absolutely cannot fail. The economics behind the industry are formidable; Cirque du Soleil's 'O' alone cost over \$100 million to create and produce.

PROSPECTIVE STUDENT OUTREACH

Throughout the United States, students are exhibiting a decreasing interest in math and science. Too often students, especially those in high school, are asking why they are taking a course, what is the relevance to their careers, how will they apply their knowledge. Because of UNLV's interest in the long-term support of



Fig. 2. Photographs of the entertainment engineering class underneath the scenes, Bellagio Lagoon Show and Disney on Ice.

Entertainment: Engineering and Design as a key area for education and research, beginning the E²D program early with innovative pre-freshman experiences will result in a stream of students interested in the engineering discipline as well as E²D. Whether creating an innovative new museum project, analyzing the complexity of a Cirque du Soleil venue, or extending an interest first developed in childhood into designing interactive retail environments, the opportunities for early student engagement in engineering projects are unique to the E²D discipline.

One example of this potential is the extension of the department's Introduction to Robotics program (MEG 425) into a magnet high school, Advanced Technologies Academy. This program resulted in a friendly but intense competition between UNLV engineering students and the high school seniors as they each designed a mobile robotic dog that could identify and retrieve objects. Using the Lego Robotics Invention System™ and employing the University's distance learning capabilities, Professor Georg F. Mauer was able to introduce prospective engineering students to one aspect of the entertainment engineering program. As students progress through the program, the initial planning and programming efforts can be extended to involve the more sophisticated animatronic figures that populate many of the Las Vegas Strip resorts. To introduce the program to a wider audience, the Engineering College at UNLV plans to host the regional high-school competition for the USFirst Robotics Competition in 2005.

Outreach programs such as this one, often initiated through connections from the private sector, provide prospective students with an opportunity to sample innovative programs in an environment that not only prepares students for entrance into the university, but also encourages them to pursue engineering degrees by relating existing student interests with ongoing faculty research.

INTERDISCIPLINARY APPROACH

The first interdisciplinary course was offered through the honors college in Spring 2001—co-titled THA 793 and MEG 795, Entertainment Engineering—that combined lectures with field trips to entertainment design or production venues and companies. Team-taught by Professors Brackley Frayer of the Theatre Department in the College of Fine Arts and Robert Boehm, of the Mechanical Engineering Department in the College of Engineering, the course now includes seminars from industry representatives and incorporates their advice and counsel to students as they complete their final project. Students are drawn from multiple disciplines and work in teams to develop a unique entertainment event that combines engineering, fine arts and business disciplines.

An outline of the course provides insights into the unique nature of the Entertainment: Engineering & Design Program:

- introduction to entertainment engineering;
- background on theatrical technology: story boarding, set design, lighting, machinery, technology for road shows;
- brief introduction to key engineering technology: including simulation tools, basic materials selection, robotics, electrical concepts.
- introduction to project conception and management;
- presentations by practitioners: designers and operating personnel;
- behind the scene visits at companies and attractions; extensive presentations of technology required for presenting events.
- major design exercise, performed by interdisciplinary groups.

Guest lecturers have included practitioners in pyrotechnics, monorails, theme parks, and themed environments. Student teams research a novel entertainment idea, develop prototypes and story boards, create budgets for actual implementation and present their ideas to classmates, faculty, and industry observers.

Now in its successful third year, the course is continuing to draw attention and interest in the expanding Entertainment: Engineering & Design major. Together with the senior design program, entertainment engineering is providing students with a unique perspective of the scope and potential for incorporating arts and engineering. Students from previous classes are already working in the field, with several employment opportunities arising from the on-site tours and discussions.

Entertainment engineering is a subtle discipline. With all the rigor and attention to detail required for technology to support the venues, it also must be absolutely unobtrusive to the audience. The performers and the performance, the experience, are the critical elements. Viewing the magnitude

and complexity of the behind or beneath the scenes technologies provides only a glimpse into the challenges facing each venue or event. For students, the opportunity to stretch their imaginations and understand the need for close collaboration between engineering and fine arts students to effectively develop both sides of a performance or venue is invaluable. The cooperation of the world-famous Las Vegas Strip venue technologists is certainly one of the many components that come together to make this program unique and effective.

First steps—E²D minor

The Deans of Engineering and Fine Arts have developed the core of the E²D program, debuting in the Fall of 2004, as an approved minor 18 credits required, 24 recommended for Entertainment: Engineering and Design. Courses will be team taught by existing faculty; a nationwide search for a new faculty position to spearhead the E²D effort is currently ongoing. Courses will be cross-referenced in the catalog, listed under both Engineering and Fine Arts curricula and include new and existing courses: Introduction to E²D; Imagineering; Practicum in E²D; Visualization in E²D; Lighting I; Stage Management; Animatronics; Robotics. A Bachelor of Science degree option is currently under discussion, with a Masters program to follow.

- Introduction to E²D: an overview of the entertainment industry and the technology employed in the various entertainment venues with site visits to see behind stage operations
- Imagineering: capstone design course for the application of the principles of entertainment technology to the design of an actual set, performance, ride, game or display
- Practicum: work assignment at entertainment venue to gain exposure to various aspects of the entertainment industry
- Visualization: the creative application of graphics and visual media to the entertainment industry including CAD, multi-media and fundamentals of digital production.
- Lighting I: study of historic, aesthetic, technical and practical aspects of stage lighting with participation in departmental productions
- Stage management: study and practice of the art of theatre stage management including scenery, rigging and motion, sound and light with participation in departmental productions
- Animatronics: employment of microcontrollers, sensors and actuators to produce practical animatronic devices for the entertainment industry
- Robotics: the implementation and control of spatial motion including basic electromechanical devices such as cams, mechanisms and multiple degree of freedom robots

Integrating E²D into the curriculum

Tables 1 and 2 demonstrate the curriculum flow, first for a traditional student in mechanical

engineering and then how this flow is modified for a student pursuing the minor in entertainment engineering. Similar flowcharts can be generated for the other engineering and computer science disciplines.

As the engineering curriculum is one of the more rigorous undergraduate programs, completing required courses and practicum often take more than four or even five years. It is not a mystery that attrition from the engineering is over 50% from freshman year to graduation, with 1/2 of the transfers occurring after the freshman year.

With an engineering major/E²D minor, the standard Introduction to Engineering course is replaced by Introduction to Entertainment Engineering, essentially Introduction to Engineering with creative flair, beginning in the freshman year. The second semester has the first true entertainment engineering course, providing field trips to venues and encouraging creative, team-based project development. While the technical content is limited, the courses provide relief from the traditional first year of math, physics, chemistry and English. Modifying the traditional curriculum to make it more interesting and to provide a more creative outlet for the students answers the national need to attract more students to the field, and particularly women and minority students.

During the sophomore year, the typical CAD course is supplemented with a visualization course. This course, as is the entertainment engineering course in the freshman year, is populated by both engineering and art students. It provides a far more creative treatment of visualization than does a typical course on how to use a CAD package, introducing virtual reality, critique sessions and group projects with artists and engineers issues and situations engineering students are not usually exposed to.

The second semester of the sophomore year includes a theatre course involving lighting, sound and stage management, fulfilling the fine arts requirement of the general core requirements that all majors must satisfy. Providing these windows into the potential of E²D will help retain students and encourage them to begin their final two years with a different perspective.

Modification challenges really occur in the junior year, where technical engineering content is introduced. By introducing an internship program, requiring students to work in some capacity in an entertainment venue, enhancing their previous classroom learning and introducing them to the real-world possibilities of the field. Internships require approximately 5 hours per week, with students working on every aspect of the production and gaining an understanding of production complexities. The UNLV program already has excellent connections with Celine Dion, New York, NY, and Wynn Design and Development locally as well as relationships with

Table 1. Conventional curriculum in mechanical engineering

Fall Year 1	Spring Year 1	Fall Year 2	Spring Year2	Fall Year 3	Spring Year 3	Fall Year 4	Spring Year 4
Intro to Engr	Statics	Dynamics	Fluids I	Machine Design	Dynamic Systems	Comp Methds	Vibrations
Calculus I	Calculus II	Calculus III	Math Diff Eq	Thermo	Dynamics Of Mach	Controls	Ethics
Chemistry	Physics I	Physics II	Circuits	Measurements	Heat Transfer	Sr. Design I	Sr. Design II
English I	English II	Materials	Engr Econ	Core	Thermal Systems	FE Prep	Tech Elective
Core	Core	CAD	Core	Core	Tech Writing	Tech Elective	Tech Elective

Mice Creative and Entertainment Engineering in Los Angeles. A mentor must be assigned and the internship has to be pre-approved in order to guarantee a productive assignment for the student. A technical write-up of the internship and a presentation is required of all students at the culmination of the internship.

Given the proximity of the world-famous Las Vegas Strip, with all the entertainment and technology offered, UNLV E²D internships fit into the normal curriculum and do not necessarily require students to spend a semester off campus. Los Angeles and Burbank are a few hours drive, however, providing students with the flexibility to perform internships during a summer term.

The real flexibility in the program comes in the fourth year. Three technical electives and a two-semester design experience constitute well over half of the required course content. Technical electives can include selections from robotics, acoustics, computer graphics, computer-controlled devices or digital logic. These courses would provide technical content relevant to entertainment engineering and would be taken by the engineering students and not the performing arts majors. The senior design sequence provides for a significant development experience in an aspect of entertainment engineering. Traditionally, this course has been interdisciplinary in nature; here the entertainment engineering minor expands the interdisciplinary

collaboration beyond engineering and science to include fine and performing arts students.

The minor, flexibly built into a solid engineering program, allows students to prepare for employment within the wide spectrum of opportunities in the entertainment industry. In addition, students pursuing this option will have a broader, more creative view of engineering that will serve them well regardless of which job sector they choose to enter. Any program that improves the interest level of prospective students in engineering or computer science careers promises to increase retention rates and to produce a more desirable graduate for the future workforce. The full E²D undergraduate major, which will be introduced in the coming year, will enhance this thesis and attract students from a multitude of disciplines.

Springboarding upon the early success of the entertainment engineering minor, UNLV is launching two separate undergraduate degree options a dual degree engineering/computer science and theatre program and a new degree through the university college which offers a non-accredited degree for those students not wanting or requiring a full engineering option. Within the next two years, an entertainment engineering graduate option will be developed. These options, together with the current minor, enable students to select the educational and professional opportunities they want to pursue.

Table 2. Curriculum modified with entertainment engineering minor emphasis

Fall Year 1	Spring Year 1	Fall Year 2	Spring Year2	Fall Year 3	Spring Year 3	Fall Year 4	Spring Year 4
<i>Intro to Ent Engr</i>	Statics	Dynamics	Fluids I	Machine Design	Dynamic Systems	Comp Methods	Vibrations
Calculus I	Calculus II	Calculus III	Math Diff Eq	Thermo	Dynamics Of Mach	Controls	Ethics
Chemistry	Physics I	Physics II	Circuits	Measurements	Heat Transfer	<i>Sr. Design I</i>	<i>Sr. Design II</i>
English I	English II	Materials	Engr Econ	Core	Thermal Systems	FE Prep	<i>Tech Elective</i>
Core	<i>Ent Engr</i>	<i>Visualization (CAD)</i>	<i>Theatre</i>	<i>Internship</i>	Tech Writing	<i>Tech Elective</i>	<i>Tech Elective</i>

As assessment is a critical part of the success of any program, a process, in line with that conducted for accreditation in each engineering/computer science discipline will be put in place. This process has an internal and external constituency and a feedback loop for program improvement.

ENTREPRENEURSHIP EDUCATION

To encourage and inform engineering students on the feasibility of developing an entrepreneurial venture, engineering professors Zhiyong Wang and Rama Venkat launched the E-Club (this 'E' stands for entrepreneurship) in the Fall of 2000. With the purpose of broadening the educational experiences of students beyond the traditional engineering curriculum and testing the commercial viability of their senior design projects, the E-Club has attracted seed funding from the Lemelson Foundation and support from Fred Cox, founder of Emulex Corporation. Last year, with additional support from Emulex, the E-Club instituted an awards program for the Engineering School's Senior Design project.

Through its interactive seminar format, E-Club students listen to and query successful professionals in a variety of fields to obtain an overview of the necessary steps to go from idea to innovation and from innovation to market. The E-Club is just the beginning of a new engineering entrepreneurship education program that will provide the foundation for participants in the new Engineering: Entertainment & Design program to consider the feasibility of extending their senior projects into potential businesses or be more entrepreneurial when they work for one of the many companies in the field. All practitioners in entertainment engineering are by nature and requirement, entrepreneurial, as the discipline requires innovation,

creativity, teamwork, salesmanship, and having access to fewer resources than desired. From the design phase through implementation, the multi-million dollar field of entertainment engineering is creating unique venues, utilizing and creating platforms to showcase talent in ways that haven't been done before and creating unparalleled audience participation and experiences.

Spearheaded and team taught by the private sector, with full support from the chairs of both mechanical engineering and electrical engineering, the first course in engineering entrepreneurship will be offered in the spring of 2005.

SUMMARY

While still in the early stages, the new Entertainment: Engineering & Design programs at UNLV have already attracted international attention and interest from as far away as Sweden. The demand for professionals schooled in the creative process of entertainment engineering and design will continue to grow as our rapid technological advancement and appetite for sophisticated leisure options increases. Southern Nevada's status as the entertainment capital of the world including internationally renown shows like Cirque du Soleil, themed retail environments, digitally animated billboards, and virtual and animatronic attractions enables the E²D program to tap a wealth of potential collaborative opportunities with high-concept, highly sophisticated entertainment venues. As a new program, based on a new paradigm of public/private partnership, interdisciplinary education, and academic excellence, UNLV's Entertainment: Engineering & Design will be at the forefront of the next generation of education innovation.

Dr. Eric Sandgren is the Dean of the Howard R. Hughes College of Engineering at UNLV. His research interests include computer aided design, visualization and design optimization. He has developed and taught a number of courses involving both fine arts and engineering students. He has industrial experience at IBM, General Motors and TRW and has taught at the University of Missouri, Purdue University, and Virginia Commonwealth University before joining UNLV.

Dr. Pepper is Professor of Mechanical Engineering and Director of the Nevada Center for Advanced Computational Methods. From 2003-2004, he served as ASME Congressional Fellow for the Office of Senator Dianne Feinstein. His industrial experience includes Du Pont at the Savannah River Laboratory in Aiken, SC, the Marquardt Company, an aerospace propulsion company located in Van Nuys, CA, from 1987-1990 where he worked on the National Aerospace Plane Program. Dr. Pepper co-founded and was CEO of Advanced Projects Research, Inc., an R&D company involved with applications in fluid dynamics, heat transfer, and environmental transport.

Judi Dohn was a serial entrepreneur in the personal computer industry in northern California. Since moving to Nevada, she has developed several statewide and regional initiatives to support the growth and development of new technologies and technology companies, including the Manufacturing Assistance Partnership program, the Henderson Business Resource Center, and the Vegas Venture Forum. She is president of the Nevada Technology Council, Secretary/Treasurer of the Technology Business Alliance of Nevada, and a member of the Howard R. Hughes College of Engineering Advisory Board.