

## **AC 2007-2916: INNOVATIVE ENGINEERING TECHNOLOGY PROGRAM IN ENVIRONMENTAL, HEALTH AND SAFETY**

### **Howard Evans, National University**

Dr. Howard Evans was appointed founding Dean of the School of Engineering and Technology, National University, in October, 2003. He received B.S. degrees in Physics and Chemical Engineering from Brigham Young University, and a Ph.D. in Chemical Engineering Science from the California Institute of Technology.

Dr. Evans has over 20 years of executive and senior technical management experience at 3M Company and IBM Corporation, primarily leading multidisciplinary, global technical organizations responsible for R&D; new business and market development; manufacturing engineering; quality; environmental, health and safety; and others.

Before joining National University, he acquired 12+ years of voluntary involvement with higher education, including adjunct teaching and research in engineering at the University of Colorado and formal advisory involvement in both science and engineering at the University of Texas. Other past professional and academic activities include being a founding member and officer in the Central Texas Electronics Association; past chairman of IBM's Materials Shared University Research Committee; Ph.D. Recruiting Coordinator for IBM's Systems Technology Division; and executive sponsor for 3M division's student programs. He has published and presented widely in areas of surface science, electronic materials and processes, project management, and industry/university relations. He holds 4 patents and has received awards for excellence in technical innovation (IBM), technical authorship (IBM), teaching (University of Colorado), and scholarship (National Science Foundation).

### **Shekar Viswanathan, National University**

Dr. Viswanathan is a Professor and Chair of the Department of Applied Engineering and Lead Faculty for Engineering Management and Homeland Security and Safety Engineering. He is the Lead for six full time and fifty two adjunct faculty members. His department offers three undergraduate and six graduate programs and has a student population of three hundred students. Dr. Viswanathan is an educator, researcher and administrator with more than twenty-five years of industrial and academic experience encompassing engineering and environmental consulting, research and development, and technology development. His career experience includes teaching at the University level, conducting fundamental research, and developing continuing educational courses.

# **Innovative Engineering Technology Program in Environment, Health and Safety**

## Abstract

The U.S. economy has been improving in the past two years resulting in job growth in the Environmental Health & Safety (EHS) job market. EHS involves three disciplines, which often overlap or require close coordination. The environmental technician or manager works with compliance issues and the control of pollution that can create an adverse impact on waterways, air, and soil. The plant safety/health officer deals with employee's safety and health and is concerned with providing a healthy environment in which to work. The hazardous materials technician or manager provides insight on proper handling and transport of materials that are considered toxic or dangerous. In addition, the recent focus on terrorism related activities requires close working coordination of EHS professionals with security professionals. This calls for unique academic training. The number of available degree programs for associate degree professionals in this area is quite limited. In addition, there are fewer programs available for associated degree professionals to transition to an engineering technology degree.

This paper describes an innovative undergraduate engineering technology degree program that has been developed in the Environmental, Health & Safety discipline. Key attributes of this program include an effective curriculum transitioning from an associate two year degree offered through community colleges, problem based learning instruction, self-paced tutorial techniques, and personal assessment calibration. In addition, use of technologies such as iPod instructions is explored.

## Introduction

Corporations have realized that the implementation of an effective EHS program has an added advantage in the market place. The Environmental, Health & Safety (EHS) profession is an integral part of every small and large corporation in the world. EHS involves three disciplines, which often overlap or require close coordination. The environmental technician or manager works with compliance issues and the control of pollution to prevent/minimize an adverse impact on waterways, air, and soil. The plant safety/health officer deals with employee's safety and health as well as with providing a healthy environment in which to work. The hazardous materials technician or manager provides insight on the proper handling and transport of materials that are considered toxic or dangerous. All these three areas combined determine the loss prevention and asset protection in every corporation and hence impact the bottom-line. As a result, many corporations are implementing effective EHS programs to reduce liability, improve productivity, and enhance their image. Currently, there are no undergraduate graduate degrees in EHS discipline offered by the Universities located in the San Diego region. There are two community colleges that offer a two year associate degree program in EHS discipline in San Diego. Over 50 students annually graduate with an associate degree from these two local institutions do not have an option to get a four engineering technology degree in the EHS discipline. Most of these students either have to go to an

university in another city or take an online degree in EHS discipline. These two local community colleges approached National University to offer an undergraduate engineering technology degree in EHS discipline with specific transitioning curriculum from two year associate to a four year degree. Local market analysis supported the need for such a program. Preliminary analysis of similar program existence within the U.S. did not result in any positive results. Based on market requirements, there appears to be a need for an undergraduate degree in EHS discipline with focus on adult instruction. This unique Bachelor of Science program, caters to this specific market need.

### Description of National University and its Student Body

Founded in 1971, National University (NU) is an independent, nonprofit institution of higher education. Since its establishment, the university has dedicated itself to providing educational opportunities to a diverse population of working, adult learners. With more than 23,000 full-time students, National University is the second largest private, non-profit California institution of higher education, with a 36-year history of educating traditionally underserved populations. National University is ranked 7<sup>th</sup> nationally and 2<sup>nd</sup> in California for having awarded degrees to ethnic minority populations. Thirty-four percent of National's students are from minority populations and fifty-eight percent are female. NU is ranked sixteenth out of 3,000 in awarding graduate degrees to minority students. NU also received the California Council on Excellence (CCE) Eureka Award for Performance Excellence in 2002 and in 2003. National University's central purpose is to promote continuous learning by offering diverse instructional approaches, encouraging scholarship, engaging in collaborative community service, and empowering its constituents to become responsible citizens in an interdependent, pluralistic, global community. National University students earn their degrees in a unique one-month format and attend classes at night so they can continue to move forward in the workplace. Their programs are accelerated so that they can complete their studies faster than at a traditional university. However, students can take only one course at a time. Each course has 44.5 hours of class room contact, During this period, students are exposed to the challenges and intricacies of the subject taught in that class.

### Program Concept, Goals, and Outcomes

The overall goal is to develop an undergraduate degree program in Environment, Health, and Safety disciplines. Specific objectives for reaching this goal include the following:

- Design and offer a novel BS program that is suitable for working adults in an accelerated format.
- Be accredited and approved by agencies/organizations such as ASSE, ABET and WASC.
- Be flexible with a broad appeal to scientists, engineers, and technologists
- Provide suitable knowledge and capabilities requisite to getting national certification from societies such as Board of Safety Professionals (BSP) and American Board of Industrial Hygienists (ABIH).

Upon completion of the BS program, graduates from Environment, Health, and Safety program will be able to:

1. Assess, plan, and implement environmental, health and safety problems.
2. Encourage flexibility and innovative approaches to problem solving which stimulate independence and develop personal and professional responsibility.
3. Develop appropriate decision making skills and utilize professional judgment, conduct and ethics to provide optimum care for the safety of people and the environment.
4. Enhance communication and interaction skills, which enable students and faculty to work effectively with diverse populations as members of the Environmental Health & Safety team.
5. Advocate active participation and leadership in community activities and professional associations.
6. Instill a commitment to continued education and skill development.
7. Possess the knowledge necessary to become certified as a safety (CSP), hygiene professional (CIH) and Certified Hazardous Material Manager (CHMM) by the national organizations.

#### Program Design, Curriculum Development, and Challenges

A primary challenge is to bring together in a cogent structure the wide array of technical courses relevant to environment, health and safety needs. This can be approached by identifying the common fundamentals and practices that define the theory and effective practice of asset and people protection.

Activities planned to meet the program goal and outcomes included the following:

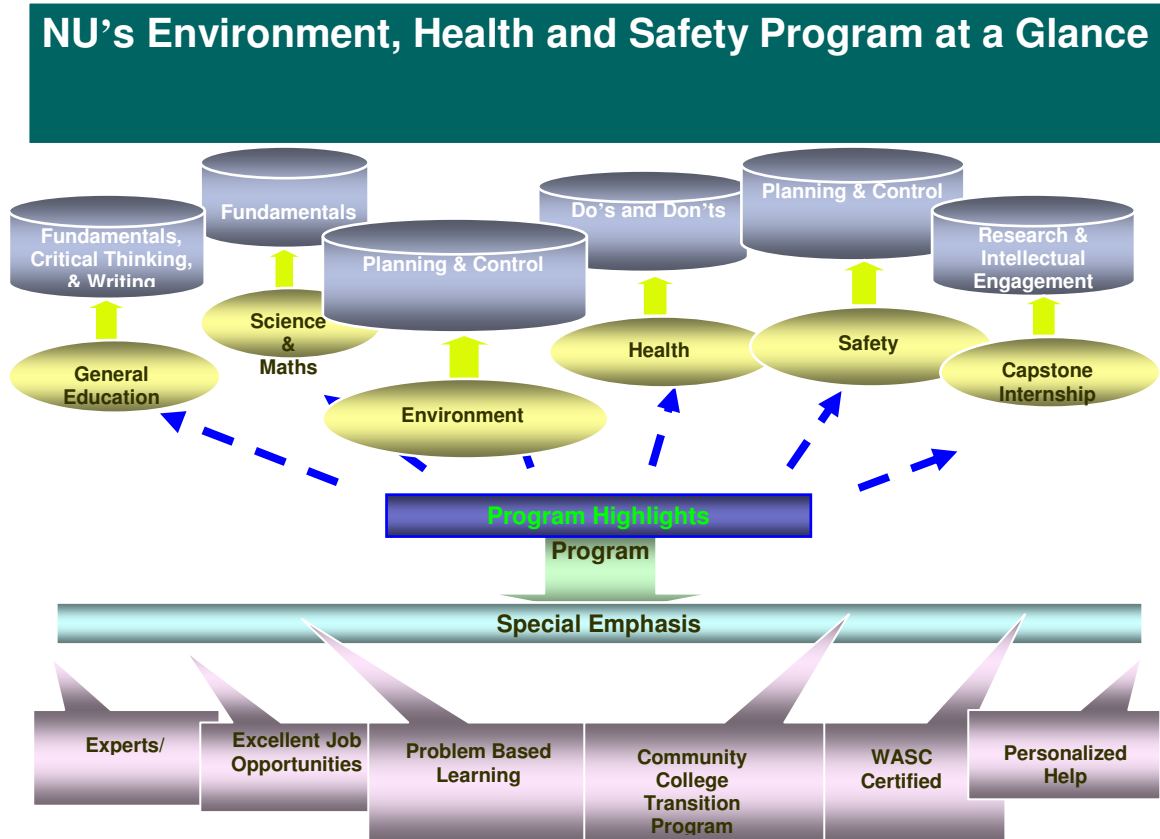
1. Design a curriculum that effectively meets the needs of environment, health, and safety;
2. Identify learning outcomes for each of the courses designed and select appropriate teaching materials such as text books, journals, and other online tools;
3. Develop teaching tools such as weekly lecture notes, tutorials, case studies, simulation, and quiz materials to reinforce the learning outcomes;
4. Establish means of assessment for each course designed;
5. Select appropriate case studies and other tools that may be helpful in reinforcing the proposed program;
6. Collaborate with relevant faculty to ensure content integrity of courses adapted for presentation;
7. Explore new educational technologies to enhance accessibility and appropriateness of instructional materials and media;
8. Consult with the industry and regulatory agencies experienced in EHS area;
9. Identify relevant library collections for the program;

10. Ensure widespread dissemination of project activities and evaluation via national professional conferences, journal articles, and media coverage.

Requirements

To receive a Bachelor of Science degree with a major in Environmental Health & Safety, students must complete at least 180 quarter units as articulated below, 45 of which must be completed in residence at National University and 76.5 of which must be completed at the upper division level. In the absence of transfer credits, students would have to complete additional general electives to satisfy the total units necessary for earning the degree.

Figure 1 provides an overview of National University’s Environment, Health and Safety program. Table 1 provides a description of each course, and its learning outcomes.



**Figure 1: National University’s Environment, Health and Safety Program at a Glance**

A key precept that guided this program development is that this program must accommodate transition from two year community college to a four year engineering technology degree. In addition, it must allow individuals with different learning styles,

needs, and interests. A panel of experts from industries, regulatory personnel, educators and consultants were consulted to provide detailed assessment of courses to be incorporated, learning outcomes to be achieved and importantly, newer concepts to be included in this program. In addition, informal consultations with other academic institutions offering similar programs were held to incorporate their experiences. To cater to this diverse population, each course has been designed to accommodate a wide variety of teaching approaches and features. Specific features are incorporated so as to make the instruction very effective. Some of them would include video and audio presentations, special guest lectures by experts, case study analysis related to several real life examples, and field visits. Each course has been designed to incorporate background review materials relevant to a given course, test materials on various concepts, and continuous progress monitoring. Throughout the design and implementation of this program, consultations are being sought from industry personnel, and from other relevant public sector agencies, in order to ensure that the program is relevant and effective.

**Table 1: Description of Typical Courses and Learning Outcomes**

Course Title	Course Description	Learning Outcomes
Introduction to environmental, health and safety regulations	Overview of Clean air act, Clean water act, hazardous materials regulations including emphasis on the transportation of hazardous materials, OSHA Hazard Communication, Community Right-to-Know, underground tanks, asbestos, Proposition 65, air toxic, and medical and infectious waste regulations. The laboratory will focus on shipping of hazardous materials; interpreting MSD's; and planning and reporting functions	<ul style="list-style-type: none"> <li>• Identify the statutes and regulations which relate to air, water, soil, employee, and public health and safety</li> <li>• Explain the scope and application of these laws, and their liabilities and penalties.</li> <li>• Determine regulatory jurisdiction (federal, state, or local agencies) in hypothetical situations.</li> </ul>
Introduction to Toxicology	Acute and chronic health effects produced by exposure to chemical, physical, and biological agents associated with industrial operations, waste disposal, and remedial sites. Topics include routes of entry, risk management, permissible exposure limits, medical surveillance, control methods, understanding Material Safety Data Sheets, epidemiology, industrial hygiene, and occupational health and safety	<ul style="list-style-type: none"> <li>• Identify acute and chronic health effects of chemicals</li> <li>• Understand and interpret material data sheets</li> <li>• Explain exposure limits, and route of entry</li> <li>• Perform risk assessment and identify medical surveillance for common chemicals</li> <li>• Read and interpret articles in the field of health effects</li> </ul>
Design and	This course provides	<ul style="list-style-type: none"> <li>• Develop an easy safety</li> </ul>

Evaluation of a Modern Safety Program	comprehensive coverage of occupational safety and health fields including concepts such as: technological changes that have introduced new hazards in the workplace; proliferation of health and safety legislation and corresponding regulations; health care and workers' compensation costs; and increasing incidents of workplace violence. This course introduces engineering concepts through case study analysis and provides hands on experience in developing a modern safety program.	<p>checklist for doing safety audits.</p> <ul style="list-style-type: none"> <li>• Train people in health and safety issues they will face on the job, and prepare them for prevention or correction.</li> <li>• Develop reporting forms, enhanced enforcement policy; Fire Standards; and Hazard Communication Standards.</li> <li>• Conduct accident investigations on the types and causes of accidents and develop policies /procedures to eliminate/avoid them.</li> </ul>
Hazardous Waste Management	Overview of hazardous waste and regulations, emphasis on generator compliance, site investigation and remediation, permitting, and waste identification. The laboratory provides hands-on application of a hazardous waste manifest, preparation, storage container management, sampling, and waste compatibility determination.	<ul style="list-style-type: none"> <li>• Identify current statutes and regulations concerning hazardous waste and the liabilities and penalties for noncompliance.</li> <li>• Perform site investigations, develop remedial plans for decontaminating a site</li> <li>• Prepare waste manifest for hazardous waste</li> <li>• Develop sampling plan for hazardous waste determination</li> </ul>

The design of this program is based on the criteria established by the American Board of Engineering Technology<sup>1</sup>. This program consists of four categories, namely, general education courses, fundamental core courses, requirements for the major and electives. The first fifteen general education courses concentrate on building an academic foundation in the areas of mathematics, chemistry, physics, communication skills and technical report writing. The second set of five courses are introductory courses including environmental, safety and health fundamentals, environmental microbiology, introduction to environmental, health and safety regulations, loss prevention techniques, and exposure assessment techniques (both qualitative and quantitative). Besides these are twelve courses that contribute towards satisfying the requirements for the major. These courses include environmental areas such as air pollution, water pollution, solid waste management, and hazardous waste management; occupational health courses including the fundamentals of industrial hygiene, health effects of hazardous materials, epidemiology and industrial toxicology; and safety area courses including Accident/Incident Investigations and Analysis, Industrial and Construction Safety, Human Factors in Safety Engineering, Industrial Environment I: Evaluations and Industrial Environment II: Controls. Finally, students can choose from a list of five

elective courses including Environmental Sustainability, Pollution Prevention, Principles of Management and Organization, Project Management, Management Information Systems, Ethics in Law, Business and Management, and Team Building and Interpersonal Dynamics. In addition to classroom instruction, Cooperative Education Internship, which is equivalent to two courses, is required as a part of the curriculum to give students on-the-job experience while earning college credits. Finally, the program includes the completion of a project that demonstrates a synthesis of learning accumulated. This is the first part of a two-part senior project sequence. Students will be working in teams of 2-3 and doing research leading to preliminary development of the final project product. In this second part of the senior project, students finalize the project, prepare the final project paper, and present project results to faculty and outside experts. The project selected must show a clear indication of learning outcomes of the program and application of the various concepts learned throughout the program. Every course has two components, namely, the theoretical part and the laboratory/tutorial component. The entire program is designed on a problem based learning concept.

This program includes community college transition part where a student with two year associate degree from an accredited community college can obtain a four year degree by taking courses related to a major worth 45 quarter units. Programs from the two of the local community colleges, namely, Southwestern College<sup>2</sup> and Cuyamaca College<sup>3</sup> are being articulated so that the courses are matched with respect to curriculum, syllabi, and learning outcomes. This provides a unique opportunity for the students in the southwest area to obtain an EHS degree without traveling to an outside region.

### Course Design

Each course is designed into 20 mini modules of 2 hour instructional duration. The modules are self-contained, composing of a case study and relevant literature. They also include laboratory exercises and visits to various institutions and workplaces. Besides these, provision is also made for students to attend lectures presented by guest speakers. Instructors are required to prepare a lesson plan for each module. A model lesson plan for a module is depicted in Figure 2. Each module instruction will start with a problem/case study to reinforce the concepts to be discussed. The class is divided into small teams, and each team works on the case study by breaking the issues into mini concepts. The lecture material provides details on the relevant theory. The instructor facilitates the group discussion and answers any questions that each team member may have. At the end of the team discussion, each team presents its ideas related to the case study. The instructor then provides a mini lecture reinforcing the concepts. Every lecture does have many worked out example problems with solutions to reinforce the concepts discussed. In addition, there are many short quizzes at the end of each module for students to practice. The lecture materials are also offered to the students in the form of pod casting and Voice Over Internet (VoIP) facilitated technology. This allows students to learn materials at their own pace and convenience.

### Program Evaluation



The program evaluation starts with the faculty qualification and experience. Some of the qualifications of the faculty include:

- PhD in Chemical Engineering with over 20 years of corporate international experience
- Ph.D in Chemical Engineering with P.E. License with over 20 years of private sector experience
- Vice President of a consulting organization with C.I.H and CSP certifications
- Director of Epidemiology of a large city with over 3 million population
- Safety Director of a city water treatment plant with CSP certification
- Environmental Engineering Manager of a large chemical plant with P.E. License
- Medical doctor with public health management experience

The above mentioned faculty has a collective experience of over 140 years in the public and private sectors.

Each course has a clearly defined set of assessment requirements as shown in Table 2. Although a given instructor can change the type of assessment process (number of assignments, number of questions etc), everyone has to meet the minimum rigor established in Table 2. Each instructor would be evaluated by peers for teaching style and rigor applied. The lead faculty, person in charge of the program would ensure that all requirements, set aside for the program, are maintained. In addition to these evaluation measures, an advisory group of external experts will be convened at regular intervals to assess program status, evaluate up-to-date relevancy, and advise on possible curriculum improvements and updates. In addition to these evaluation measures, a qualified outside evaluator will be hired to measure the program's success. Evaluation will incorporate formative evaluation measures, to provide techniques for improving the program as it progresses, as well as summative evaluation measures, to assess the achievement of the program's goals and objectives. Data obtained should be useful to other colleges and universities interested in developing a similar program.

## Figure 2: Typical Lesson Plan – Shekar Viswanathan

Subject: EHS 301-Air Pollution

---

**Subject(s):** Effects of Air Pollution

**Duration:** 2 hours

**Objectives:**

1. Learn Composition and Structure of the Atmosphere
2. Cause of Primary and secondary pollutants
3. Cause and effect of photochemical smog

**Materials:**

- Power Points
- Video on Oct 2003 fire and transportation pollution
- handwritten notes and web sites (CAL EPA and US EPA)

**Procedure:**

- Define the atmosphere in terms of a major chemical reactor (soup) – contents, compositions
- Ask the students how the ozone is generated at the ground level (time, temperature relationship)
- Ask the students how the pollution impact plants, animals and humans

**Follow-Up DQS:**

- How does the sunlight affect air pollution – positive or negative - why?
- When do you have the highest ground level ozone and why?
- Can we live without carbon dioxide and if so, how and why?

**Additional Notes:**

1. Viswanathan, S., Eria, L., Diunugala, N., Johnson, J and McClean, C., “An Analysis of Effects of San Diego Wildfire on Ambient Air Quality”, Air and Waste Management Journal, 56:56-67 (2005)

**Assessment:**

1. A short quiz on the subject covered
2. Homework – How do you assess the effect of pollutants on humans

**Table 2: Typical Course Assessment Measures**

Course Title		Means of Assessment							
		Mid-term Exams	Final Exam	Writing Assignments	Re-search Paper	Oral Presentation	Graded Home-work	Graded Partici-pation	Case Analysis
1	Introduction to environmental, health and safety regulations	X	X	X	X	X	X		
2	Introduction to Toxicology	X	X	X	X	X	X		
3	Design and Evaluation of a Modern Safety Program	X	X	X		X		X	
4	Hazardous Waste Management	X	X				X	X	X
5	Environment, Health and Safety Capstone Course			X	X	X			X

Outcomes for this program will be measured by 1) the number of target student inquiries; 2) the number of students contacted or enrolled; 3) comparisons of previous and current student education experiences; 4) student, faculty, and mentor assessments; and 5) faculty enhancement data, especially quantity and quality of teacher training opportunities. Long-term success of this program will be measured by increased numbers of individuals who successfully graduate and enter EHS careers as a result of this unique educational opportunity.

**Conclusion**

An innovative undergraduate engineering technology degree program in Environmental Health & Safety discipline has taken into account some key attributes such as problem based learning instruction, self paced tutorial techniques, and personal assessment calibration. This program includes an effective curriculum transitioning from a two year associate degree offered through community colleges to meet the local market needs. pod casting and Voice Over Internet (VoIP) facilitated technology. This allows students to learn materials at their own pace and convenience.

**REFERENCES**

1. “2006-2007 Criteria or Accrediting Applied Science Programs”, Applied Science Accreditation Commission (Oct 29, 2005), <http://www.abet.org>
2. Personal Communication with the Chair of Southwestern Community College (September, 2006 – January, 2007).
3. Personal Communication with the Chair of Southwestern Community College (September, 2006 – January, 2007).