AC 2007-2587: INCORPORATING THE RELEVANCE OF ENGINEERING PRACTICE INTO ACADEMIC PROGRAM CURRICULA

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).

John Bugado, National University

John Bugado has a MBA Degree from San Diego State University with a specialization in Technology Management, and a BS Degree in Mathematics with a minor in Electrical Engineering from Oregon State University.

John is currently enjoying his 20th year at NU, the last 6 years as a full time member of the faculty. A skilled and versatile adjunct faculty member for 14 years, he taught numerous computer science and software engineering courses at National University. After retiring from NCR, he joined National University in 1998 as the lead faculty responsible for the first ever Masters of Science in Electronic Commerce Program. This dynamic and first-of-its type program focuses on the integration of client server network technologies and electronic commerce software with the business processes that interact with customers and suppliers in the changing global business marketplace.

He later was assigned to be the lead faculty of the Software Engineering Program for 2 years. John is currently the CSIS Department chair and Lead Faculty for the Information Technology Management (ITM) Program for the Department of Information Systems and Management Science at National University.

Presentations: Small Business Entrepreneur Seminar, Database design and modeling at AITP meeting, Chamber of Commerce Presentations about NU IT Program, Business Outreach Presentations at NCR, BAE, SONY, SAIC.

Shekar Viswanathan, National University

Dr. Viswanathan is a Professor and Chair of the Department of Applied Engineering and Lead Faculty of the Engineering Management and Homeland Security and Safety Engineering

© American Society for Engineering Education, 2007

programs. He leads six full time and fifty-two adjunct faculty members, offering three undergraduate and six graduate programs, with a student population of three hundred. 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.

Albert Cruz, National University

Albert Cruz has had long-time careers in both income taxes and technology. He held a position as Tax Analyst Programmer at Intuit Inc for 11 years- working on the popular TurboTax and ProSeries software programs.

Mr. Cruz holds a B.S.B. degree in Information Systems, and an M.B.A. in Technology Management, both from the University of Phoenix. He also holds an M.A. in Human Behavior from National University where he is now a member of the Associate Faculty at the School of Engineering and Technology. He teaches both online and onsite courses in computer ethics, information systems, and information technology management. He is currently pursuing a Ph.D. in the emerging field of Knowledge Management.

Mr. Cruz is an Enrolled Agent.

© American Society for Engineering Education, 2007

Incorporating the Relevance of Engineering Practice into Academic Program Curricula

Abstract

In today's competitive environment, employers consistently place high value on graduates that have demonstrated, relevant skills and knowledge. Perhaps the most effective way for acquiring such relevant capabilities is through co-op assignments and internships, yet these generally occur outside of the basic curricula even though they may have some educational credits attached. When incorporating the relevance of engineering practice directly into curricula, the use of input from external advisory boards is valuable and somewhat common. Industry visits, industrial seminar series, and incorporating external lecturers can also be effective in adding relevance to classes. However, while all of these are valuable, the most recognizable measure of having acquired relevant capabilities is achieving industry-specified professional validations and certifications.

This requires carefully pre-designed curricula that account for multiple aspects. Merely providing instruction for professional certification tests and exams can border on training rather than educating, and is therefore more appropriate at a trade or commercial school rather than at a traditional academic institution. Using the advice and direction of external advisory boards, pertinent professional certifications have been identified and the content covered therein evaluated relative to its fit with various engineering and engineering technology curricula. By aligning aspects of professional certifications with established curricula, it is possible to integrate and intersperse the fundamentals and scope of the certifications into the curricula. As students move through their engineering or engineering technology programs they acquire the understanding and capabilities required to obtain appropriate professional certifications if they desire. This has been demonstrated for a variety of programs, including: information technology; engineering management; computer science; environmental, health and safety engineering technology; and homeland security and safety engineering. Graduates of these programs will have acquired the knowledge and capabilities to acquire one or more of the following industry/professional certifications: Certified Information Systems Security Professional (CISSP), Computer Wireless Network Administration (CWNA), Computer Wireless Network Security (CWNS), Project Management Professional (PMP), Certified Safety Professional (CSP), Certified Protection Professional (CPP), Certified Hazardous Materials Manager (CHMM), Certified Industrial Hygienist (CIH) and FEMA Certifications (ICS 100, 200, 700, 800). Details of how to incorporate specific certification capabilities into curricula, along with the role of external advisory boards are described. Including this integration along with the other methods noted above – industry visits, external expert lecturers and seminars, and so forth - results in curricula that help develop graduates with capabilities of demonstrable relevance in engineering practice.

Introduction

In the current competitive business environment, employers expect graduates to have acquired relevant discipline-specific skills and knowledge. These employers expect that graduates meeting their academic degree requirements can also demonstrate specific technology capabilities and skills. It is relatively easy for employers to predict the level of graduates' understanding of engineering fundamentals, and the breadth of their exposure to engineering concepts, tools, and theories. However, employers of new university graduates must typically rely on their experience with previous graduates from a specific program, the reputation of the university offering the program, the grades obtained by students, and/or some brief interviews with graduates in order to assess levels of technical skills and abilities. It is not unusual for such assessments to ultimately be based on 'educated guesses', as direct measures of specific technical capabilities can only be inferred from grades, reputations, history and interviews.

Conversely, it is much easier for employers to accurately identify the technical skills and capabilities of individuals who have obtained industry-supported credentials and certifications. Such certifications are frequently skills and competencies-based, while building on the grounding in fundamental principles that underlies most technical degree programs. Thus, employers can more readily and accurately rely on specific relevant certificates - such as the CISSP certificate for information security[1], and CWNA and CWNS certificates for wireless networking technologies - to reflect specific levels of student skills and proficiencies. Such certifications are usually obtained outside of traditional university curricula, principally for the reasons that they are too specific (as opposed to representing general fundamentals) and that the acquired skills are obtained more by 'training' than by 'educating'. None of these observations are necessarily in dispute. Rather, the purpose of this paper is to demonstrate that the curricula defined by certifications can sometimes be incorporated into the framework of broader learning objectives that make up academic curricula. Graduating students who have successfully completed their degrees, and who can also acquire meaningful certifications, will be in highest demand.

Curriculum Development and Integration for Information Technology

The objective of our academic program curricula is to have the conceptual and fundamental course materials integrated with relevant engineering practices and exercises in a way that enables students to prepare for success with their degrees and in subsequently acquiring specific industry certifications. Designing the most appropriate academic curricula in this integrated context has proven (for us) to be a very challenging and difficult task.

National University's School of Engineering and Technology has taken on this task of incorporating the relevance of engineering practice into some of our academic programs. Initial examples include our information technology and computer science academic curricula where, for example, we have focused on specific technology areas for which relevant industry certifications are defined - such as information security and wireless technologies - to achieve the integrated goal of effective student learning of both fundamentals and competencies through innovative ways of presenting content, engaging students in the learning process, and providing professional opportunities for our students. These specific technologies were selected because of the job opportunities and employer needs identified for NU's primary market area (traditionally California). Identification of needs and opportunities included an evaluation and assessment of

valuable input from industry advisory groups, interviews and visits with dozens of leading industry executives and technical professionals, evaluation of a wide range of possible industry certification programs, an assessment of other university and community college curricula, and so forth.

To meet the expectations set by our advisory group and program lead faculty (each degree program at NU has a 'lead faculty' who has responsibility for ensuring the relevance and appropriateness of curriculum content), we are challenged to ensure that any program curriculum that is developed must facilitate the accomplishment of the following:

1. Comprehend real world needs and applications.
2. Identify all relating components of the selected technologies and their relation to each other and to the real business world.
3. Help improve students' knowledge and understanding of the selected technological concepts.
4. Help with the acquisition of relevant skills and methods that can be retained and applied as necessary.

Following sections will detail the approach and application specifically for our undergraduate program in information technology. Subsequent to this illustration, application of the principles to other specific programs in National University's School of Engineering and Technology will be described.

1. Comprehend real world needs and applications. [3]

The proper classroom environment was the key element of our academic curricula strategy because we knew that our program would fail if the students did not have the technology infrastructure to relate concepts to meaningful hands-on engineering practices that are recognized by businesses. We created a set of meaningful activities related to each of the following course objectives so students could learn new skills and relate these skills back into the work environment.[4]

- **Gain student attention** – Start the course or module by gaining students' attention using an analogy, business case, paradox, startling claim, photograph, news or journal article, or problem. Display an outline of the lesson in a visual form (e.g., an illustration, a summary, a diagram, a map, or chart) to give students a framework into which they can organize subsequent content.

- **Inform students of course objectives** - Describe what is planned to be achieved, what students will be doing and what they may be using. State, "At the end of this lesson you will be able to…." Create expectations with objectives and a description of the structure of the module and/or learning unit. Relate this expectation to the certificate-focused types of pre-assessment and post-assessment questions.

- **Stimulate recall of prior learning** - Relate a new lesson to situations or knowledge with which the students are already familiar; e.g., material from a previous course,

lesson or module. Describe the key points in the lesson, emphasizing distinctive features, using a variety of techniques if possible. For example, use photos, drawings, simulations, role play, etc. Vary the format in order to maintain attention and to increase comprehension.

- **Guide student learning** - Present instruction in small steps (chunking) leading from simple to complex. The use of informal and/or formal assessments can ensure that each "small step" is comprehended before moving to the next, more complex material.

- **Make learning relevant** - Make the instruction relevant to the students' needs and goals. Tie in the instruction to the students' experience and help them to see the relevance. Use concrete examples with which students are familiar.

- **Elicit performance** - Involve students in discussion and demonstration to confirm that they have learned from the instruction, to increase comprehension and to maintain attention through active participation.

- **Provide feedback** - As students respond to questioning, provide them with reinforcement or remediation when necessary. Maintain consistent standards and consequences for task accomplishments. Manage reinforcement: keep outcomes of student's efforts consistent with expectations.

- **Assess student performance and build confidence** - Use a quiz or assignment to confirm mastery of the unit and module objectives. Make sure that the learning experience helps students to display competence and success as a result of their efforts and abilities. The lesson or module should be an achievable, rather than overwhelming, learning experience.

- **Enhance retention and learning transfer and satisfaction** - Provide the opportunity for students to apply the outcome of their training in a real world environment: e.g., a realistic assignment using real data and equipment. (Alumni, advisory board members, professional colleagues in the external community, and students concurrently employed in relevant industries can be valuable sources of these "real world" exercises, examples and scenarios.) Incorporate the full experiential learning cycle into activities so that students are encouraged to reflect on and analyze their experiences. Encourage and support an intrinsic enjoyment of the learning experience as well as provide extrinsic rewards for their successes. Provide opportunities to apply newly acquired knowledge or skills in a real or simulated setting, especially if the learned concepts form the basis of any actual IT hardware or software procedures or protocols. Taking learning from a lecture or demonstration and translating it into actual system or subsystem functionality can provide the strongest reinforcement for the students.

- **Learning-through-guided-experience** - Teach the processes that experts use to handle complex tasks. Focus on cognitive and meta-cognitive skills, rather than on

the physical skills and processes of traditional apprenticeships by externalizing processes that are usually carried out internally.

- **Model processes** - Carry out an activity or task so that students can observe the steps and build a conceptual model of the processes that are required to accomplish the task. For example, the instructor might present a problem solving scenario for virus situation, and then have the students attempt to solve a similar problem in another system.

2. Identify all relating components of the selected technologies and their relation to each other and to the real business world. [7]

Creating an infrastructure and developing course materials and specific course content to meet these varied educational demands are challenging tasks. National University's School of Engineering and Technology includes programs in computer science, information technology, information systems, software engineering, and technology management (among others). Given the wide variety of courses taught - from introductory to master's level courses - one style of course design will not fit all disciplines or programs. Flexibility is a key consideration. Recommended approaches need to allow for differences in instructional style, assessment and disciplinary/rewards standards, and professional goals but some general principles of design can be adapted and applied to any course taught at NU. Instructors adapt them to specific content and competency areas that increase students' knowledge and understanding of the technological concepts.

For example, information security and wireless networking administration and security are very important topics for most organizations. Such organizations are searching for talented and experienced professionals. The Certified Information Systems Security Professional (CISSP) certification identifies the student as a security professional who has successfully met defined, recognized knowledge and capability levels respected by external organizations. The Certified Wireless Network Administrator (CWNA) is the foundation level wireless LAN certification for the industry standard Certified Wireless Network Professional (CWNP) Program. The students must first complete the CWNA certificate, and then prepare for the CWNP.

3. Help improve students' knowledge and understanding of the selected technological concepts. [1]

In close conjunction with learning associated fundamental concepts and principles, students are challenged to understand requirements, solve problems and present information technology solutions. In this sense, they must increase their knowledge and understanding of the basic CISSP security and CWNA wireless network technological concepts through repetition and experimentation, trial and error, case study analysis, and exercises. The CISSP certificate covers specific areas that correspond with the essence of concepts presented in sequence of courses in our IT program. The courses focus on security trends, security management practices, network access control, security models and architecture, physical security, telecommunications and networking security, cryptography, business continuity planning, and legal and ethical aspects

of IT. Upon completion of this course sequence, students are prepared for the comprehensive CISSP exam consisting of 250 questions. Details of course materials are listed below:

Security Management Practices
Security management entails the identification of an organization's information assets and the development, documentation, and implementation of appropriate policies, standards, procedures, and guidelines. Management tools such as data classification and risk assessment/analysis are used to identify threats, classify assets, and to rate system vulnerabilities so that effective controls can be implemented.

Key Areas of Knowledge

- Security Management Concepts and Principles
- Privacy
- Confidentiality
- Integrity
- Availability
- Authorization
- Identification and Authentication
- Accountability
- Non-repudiation
- Documentation
- Audit
- CIA Triad
- Protection Mechanisms
- Change Control/Management
- Data Classification
- Information/Data
- Employment Policies and Practices
- Policies, Standards, Guidelines and Procedures
- Roles and Responsibilities
- Security Awareness Training
- Security Management Planning

Security Models and Architecture
The Security Architecture and Models domain contains the concepts, principles, structures, and standards used to design, monitor, and secure operating systems, equipment, networks, applications and those controls used to enforce various levels of availability, integrity, and confidentiality.

Key Areas of Knowledge

- Principles of common computer and network organizations, architectures and designs
- Principles of common security models, architectures, and evaluation criteria
- Common flaws and security issues associated with system architectures and designs

Business Continuity Planning
The Business Continuity Plan (BCP) domain addresses the preservation and recovery of business operations in the event of outages.

Key Areas of Knowledge

- Business Continuity Planning
- Disaster Recovery Planning
- BCP/DRP Events

Law, Investigations, and Ethics
The Law, Investigations, and Ethics domain addresses computer crime laws and regulations. It covers the measures and technologies used to investigate computer crime incidents, and also emphasizes the ethical responsibilities of professionals working in the IT field.

Key Areas of Knowledge

- Laws
- Major categories and types of laws
- Investigations
- Major categories of computer crime
- Incident handling
- Ethical responsibilities of IT professionals

Operations Security
Operations Security is used to identify the controls over hardware, media, and the operators and administrators with access privileges to any of these resources. Audit and monitoring are the mechanisms, tools, and facilities that permit the identification of security events and subsequent actions to identify the key elements and report the pertinent information to the appropriate individual, group, or process.

Key Areas of Knowledge

- Administrative Management
- Concepts such as Need-to-Know/Least Privilege, and Standards of Due Care/Due Diligence
- Control Types
- Operations Controls
- Resource Protection
- Auditing
- Audit Trails
- Monitoring
- Monitoring Tools and Techniques
- Intrusion Detection
- Types of Intrusion Detection
- Penetration testing Techniques
- Inappropriate Activities

- Threats and Countermeasures
- Violations, Breaches, and Reporting

4. Help with the acquisition of relevant skills and methods that can be retained and applied as necessary

The following emerging security and wireless technologies address the needs for maintaining and establishing competitive advantages and considerations of academic curricula. Emerging technologies such as these listed below are changing the educational requirements for our students. Students must acquire facts, skills, and methods that can be retained and applied as necessary for the next five years or more. Best of all, these emerging technologies are can be embedded in many applications or added as components to other computer system platforms. [6]

Information Security

The ease and convenience of online education through the World Wide Web brings with it the need to assure that our computers do not become targets for unwanted and often malicious attacks and intrusions by computer viruses and/or hackers. To prevent these problems, antivirus software and/or internet security software is recommended (i.e., Norton Utilities). Along with internet security, online education must address the need to authenticate all students during an online course. Authentication is crucial to insure the integrity of the online education experience for individual students.

Students will use login to one Internet Service Provider (ISP) to connect to the internet. It is essential that the students understand the performance impact (response time, bandwidth, etc) of their selected ISP to their computer system. To address the computer and internet security issues, continuing application of security software, firewalls, and proxy servers are studied and evaluated as methods to prevent any unwanted virus software or hackers. [5]

Wireless Technologies:

As affordable access to high bandwidth increases, and as the cost of wireless devices that will be able to incorporate all the features of a PC decrease, the educational possibilities become unlimited. It might mean the end of paper-based teaching and learning, lost homework, missing tests, and costly textbooks. Newer applications, available using small devices, are opening up the possibility of using wireless to deliver graphics and video to users no matter where they are. Learning becomes universally accessible. We are currently experiencing a major breakthrough with the use of wireless telephones that support data, voice, and images. The convergence of data, voice and images will drive another level of applications that will be accessible by students anywhere and anytime.

There will be more than 350,000 wireless hotspots by the year 2008. The wireless network market continues to grow because of the additional productivity that wireless network access brings to any organization, but properly trained and certified personnel are needed. Certified Wireless Network Administrator (CWNA) is the foundation level

wireless LAN certification for the industry-standard Certified Wireless Network Professional (CWNP) certificate, and is thus the starting point for wireless training and certification.[2] Professionals holding CWNP certifications are in the top five industry salary groups for 2004 and 2005. Our wireless course sequence will prepare students to administer any wireless LAN, no matter which vendors' products are used, and provide basic preparation to pass the CWNA Certification exam. Each of our two courses contains subsections that relate directly to the CWNA exam. Each subsection is explained in detail followed by quizzes that allow the students to master the terminology as well as comprehensive review questions of the technology. With this knowledge, the students then are able to apply their knowledge to solving real world problems or applications scenarios.[5]

The CWNA and the CWNP certificates identify a standardized set of measurable wireless LAN skills whereby network professionals and employers can gauge the level and scope of acquired capabilities. Our one-course-per-month format provides the students with an ideal way to prepare for these certificates. Courses provide the fundamental concepts of wireless network administration. The focus is on 802.11 standard wireless solutions including: Fundamentals of 802.11 WLANs; Radio Frequency Fundamentals; Antennas; RF Math and System Operating Margin; RF Power Output Regulations; Wireless LAN Operation; 802.11 Analysis and Troubleshooting; and Site Surveying. [2]

The CWNA exam requires preparation in the following areas. Our IT curriculum prepares students by integrating these in with the fundamental educational elements of the program described above. In order to assist with CWNA exam preparation, students in our program are required to:

- Demonstrate knowledge of Wireless Network (WLAN) systems and their impact on the information technology industry.
- Demonstrate knowledge of Wireless Network (WLAN) technologies including Medium Access Control (MAC) Layer, Frequency Hopping Spread Spectrum (FHSS) Physical Layer, Direct Sequence Spread Spectrum (DSSS) Physical Layer, Infrared (IR) Physical Layer and Roaming Standards.
- Identify hardware and software components of applied WLANs.
- Discuss basics of wireless solutions including: 802.11
- Assess the elements of the network development life cycle

Additional preparation for certificate exams is incorporated through the inclusion in midterm and final exams of questions similar to those that will be encountered during certificate exams. Also, correlated laboratory hands-on exercises help provide students with the confidence (as well as the skills) that they are ready for these certificate exams.

Additional Applications

Similarly, the competencies of specific industry certifications have been integrated into our curricula for programs in engineering management, security and safety engineering, and a

program currently being developed in environmental, health and safety engineering technology. Details of integration will not be elaborated here, as they occurred along lines very similar to those presented above for NU's information technology program. However, the programs and their associated certifications are as follows:

Academic Program	Associated Certifications
MS Engineering Management	• Project Management Professional (PMP) offered through Project Management Institute • DoDAF (Department of Defense Architecture Framework) Certification • FEA(F) (Federal Enterprise Architecture Framework)Certification
MS Homeland Security and Safety Engineering	• Certified Safety Professional (CSP) offered through Board of Safety Professionals • Certified Protection Professional (CPP) offered through American Society of Industrial Security • Federal Emergency Management Authority (FEMA) Certifications (specifically ICS 100, 200, 700, 800)
BS Environmental, Health and Safety Engineering Technology	• Certified Safety Professional (CSP) offered through Board of Safety Professionals • Certified Hazardous Material Management (CHMM) by the Institute of Hazardous Materials Management • Certified Industrial Hygienist by the American Board of Industrial Hygienists

Conclusions

Incorporating the relevance of engineering practice into academic curricula is an approach to continuous improvement and involvement with the business organizations. This approach facilitates graduates to secure necessary skills to meet the current and future business job requirements. National University's School of Engineering and Technology will monitor the ongoing activities related to this goal and will report on its progress during the next academic year.

References

1. CWNA Certified Wireless Network Administrator Official Study Guide, Third Edition Planet 3 Wireless 0-07-225538-2 Osborne/McGraw-Hill 007225538204/2005

2. CISSP All-in-One Exam Guide, Third Edition (All-in-One) (Hardcover) by Shon Harris ISBN 0-07-222966-7

3. Kruse, K. (2004). "The Magic of Student Motivation: The ARCS Model." Retrieved November 15, 2004 from http://www.e-learningguru.com/articles/art3_5.htm.

4. Malachowski, M. (2002) "ADDIE Based Five-Step Method Towards Instructional Design." Retrieved November 18, 2004 from http://fog.ccsf.cc.ca.us/~mmalacho/OnLine/ADDIE.html.

5. Tucows. (2003). Mobile/PDA. Retrieved November 9, 2004, from http://pda.tucows.com

6. Jackson, M.H. (2007, January) Should emerging technologies change business communication scholarship? Journal of Business Communication, 44 (1), 3-12

7. Mitchell, V.L. (2006, December) Knowledge integration and information technology project performance, MIS Quarterly, 30 (4) 919-939