AN ACADEMIC MODEL TO IMPLEMENT INFORMATION TECHNOLOGY INTO THE ENGINEERING CURRICULUM

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Abstract *--- In this paper, a comprehensive academic model to implement IT into the engineering curriculum is presented. This curriculum model will provide students with the applied knowledge needed to attain the professional certification that is in high demand within the IT industry. With the depth of expertise required in several content areas, the curriculum model provides education and training involving application of current technologies in various content areas via a variety of distance and/or distributive learning (synchronous and asynchronous) delivery modes. The proposed model will ensure that students in a virtual academic environment will be able to incorporate IT skills as part of their life-long learning and professional development. The Academic Model encompasses the teaching of courses at all levels (i.e.: Associate, Baccalaureate and Master's) identifying competencies achieved at each degree level. A particular "IT-Model" developed at Kent State University, Ohio, USA will be referenced throughout this paper.*

Index Terms ¾ Curriculum, Information Technology, Microsoft Certified Solution Developer (MCSD), Microsoft Certified Systems Engineer (MCSE).

INFORMATION TECHNOLOGY: AN OVERVIEW

Information Technology (IT) is defined as the design, development, implementation, support or management of computer based information systems, particularly computer hardware integration and software applications. In addition, the term IT encompasses all forms of technology used to create, store, exchange, and use information in its various forms, such as: burning data, voice conversations, still and motion images, multimedia presentations, engineering design and graphics, animation and simulations. IT is the driving force and has been called the "information revolution".[1]

NEED FOR "IT-WORKFORCE" IN USA

Advances in Information Technology (IT) have dramatically transformed the way in wh ich our entire society lives, works, learns, communicates and does business. In particular, IT has impacted the disciplines of science, engineering and technology, and has profoundly altered the problem solving and research capability with an unprecedented level of speed, precision and detail. In education and training, IT has the potential to make available in the remotest corners of the earth the highest levels of learning, information and analysis. Therefore, to enhance the positive effects of these transformations, and to compete effectively in a globalized knowledge economy, the USA must invest in IT research and the supply of high-quality trained personnel must be substantially increased.[2]

As we move into a new century dominated by a global information-based economy, IT professionals are in high demand and the opportunities in those careers are unprecedented. For a person to enter into and to remain current within an IT profession, they must have flexible, focused academic and training programs available to them that offer cutting-edge technological content when and where they need it.

There is an immense need for information technology professionals in the United States, with estimates that between 1996 – 2006, more than 1.3 million information workers will be required, averaging about 137,000 per year.[3] According to a 1998 study done by the Information Technology Association of America with Virginia Tech[4], there was a shortage of nearly 350,000 workers in IT job categories nationwide at that time. That represented a vacancy rate of about 10%. Many reports now suggest that the situation has worsened to the point that business, industry and government sectors are beginning to call the IT worker shortage a major national crisis for the U.S. economy and for the accelerated knowledge-based society.

According to the International Data Corporation[5] the IT worker shortage is magnified further as the 21st century society enters a new era in which on-line commerce and internet economy will grow 20 times to $2.5 trillion in the next 5 years.

COMMON JOB CATEGORIES IN THE IT FIELD

The Computing Research Association[6] categorizes Information Technology jobs into a variety of occupational skills including technical knowledge in IT, business knowledge and experience, and organizational and communication skills. The common job categories within IT are:

1. Networking and Operating Systems Management
   - Job Titles: Computer Engineer, Network Technician, Network / LAN Manager, IT Security Engineer, Systems Engineer and CIO.
   - Levels of delivery from Associate to Master's degrees.

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- Certification: MCSE and MCSE + Internet.

2. Software Development and Database Management
   - Job Titles: Systems Analyst, Programmer, Software Engineer, Software Developer, Database Administrator, MIS Director, CIO.
   - Levels of delivery from Associate to Master's degrees.
   - Certification: MCSD and MCDBA.

3. Internet and Multimedia Development:
   - Job Titles: Webmaster, Graphic Designer, Internet / Web Developer, Multimedia Developer, Web Technologist, Information Architect, Web Systems Administrator, E-Commerce Developer.
   - Level of Delivery from Associate to Master's degrees.
   - Certification: MCP + Internet.

4. Software Applications, Power Users and Trainers:
   - Job Titles: Application Specialist, Support Specialist, Software Trainer, Help Desk Technician, Desktop Publishing Specialist.
   - Level of Delivery from Associate to Bachelor's degrees with support courses at the graduate level.
   - MOUS Certificates.

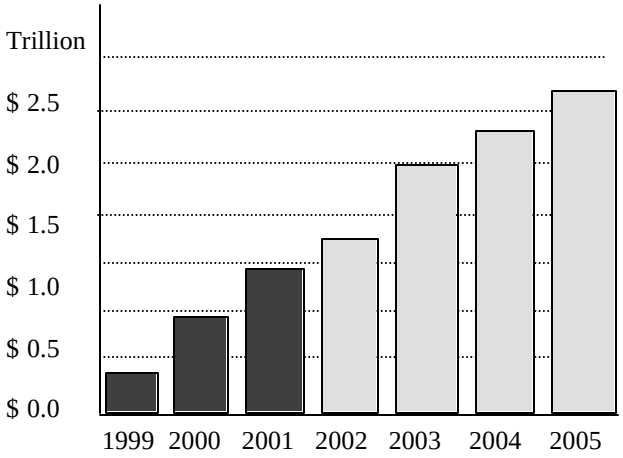

FIGURE 1
INTERNATIONAL DATA CORPORATION
ON-LINE COMMERCE AND INTERNET ECONOMY
PROJECTED GROWTH 1999 - 2005

ACADEMIC LEVELS OF PROGRAM DELIVERY

It is clear that IT covers too broad a spectrum of technologies, and too varied requirements of the depth of knowledge to possibly address all the needs with one curriculum or level of delivery. At Kent State University, Ohio[7] a curriculum model is developed which provides a seamless transition from one level to others for those students who wish to continue in their professional development in Engineering, Business and Technology.

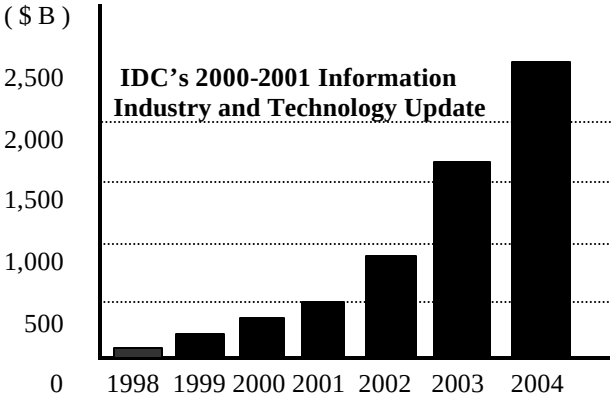

FIGURE 2
E-BUSINESS MEANS COMPETING
AT A NEW SCALE

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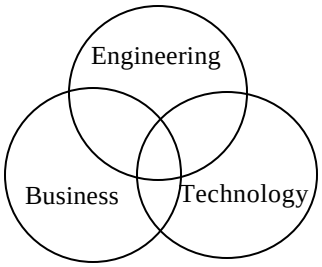

FIGURE 3
INTERDISCIPLINARY APPROACH TO TEACH INFORMATION TECHNOLOGY

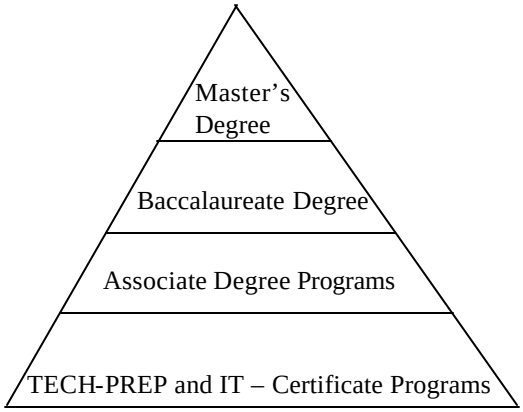

FIGURE 4
IT - DELIVERY MODEL AT KENT STATE UNIVERSITY

It is important to note that "Tech Prep", which is an approved high school curriculum, is included in the above model because there are several computer-related Tech Prep programs[8] existing in secondary education institutions throughout the State of Ohio. These institutions work

directly with Kent State University – School of Technology to ensure a smooth transition from high school to college for students wishing to pursue careers in IT fields. Secondary and post-secondary teachers work cooperatively in delivering the competencies of the curriculum. Some of those students may be placed in advanced courses after successfully completing credit-by-examination requirements for the introductory courses. Such students have a strong interest in academic programs that prepare them for IT professional certifications.

With the steady proliferation of information sources, and networks, and the diversity of information resources from libraries to internet and from hardware to software, access to timely, appropriate, manageable and relevant information is critical. This is particularly important to business, industry and government sectors in order to gain a competitive advantage or to make well informed decisions. Information Technology (IT) and its retrieval is a function of two technologies:

1. Computer Technologies (hardware and software)
2. Intellectual Technologies (knowledge organization, management, indexing and design)

The fundamental objectives of Information Technology is to model, simulate and design a curriculum which will have the following curriculum goals:

- Information Services and Support: To prepare engineering students for careers dealing with information technology deployment. Students will gain necessary skills to implement computer systems and software, provide technical assistance and manage information systems.
- Interactive Multimedia Development: To prepare students in the area of interactive multimedia with competencies in creating, designing and producing multimedia products and services.
- Network Systems: To prepare students for careers dealing with network systems analysis, planning and implementation which includes design, installation, maintenance and integration of network systems.
- Programming and Software Development / Applications: To prepare students for careers in software engineering with competencies to design, develop, test, document, implement and integrate software applications and computer systems.

ROLE OF DISTRIBUTIVE LEARNING (DL) MODES OF DELIVERY

Information Technology should be viewed as a "life-long" learning and re-engineering tool with regard to location and time of course delivery. Therefore, it seems obvious that Distance or Distributive Learning (DL) must play a key role in developing and implementing IT program delivery.

In addition, with the depth of expertise required in several content areas, we need to adopt a new view of computer engineering and technology faculty with system-wide expertise and an industry knowledge base. As students move up the "ladder" as shown in the Kent State University IT model, they should have more and more of their education delivered from those "virtual experts" via a variety of asynchronous and synchronous delivery modes (i.e.: web based, web enhanced, I-Linc, V-Tel). This will ensure that students, regardless of their location, will be able to progress up the ladder while receiving the best instruction available within the system. As a side benefit, the student will begin relatively early in their education to use a variety of technologies to learn about IT, having access from their classrooms, schools, communities and homes.That experience can only help them as they continue their careers in the "wired 21st century".

INTEGRATING INFORMATION TECHNOLOGY IN THE UNDERGRADUATE ENGINEERING CURRICULUM

The demand for integrating IT into the engineering and technology curriculum (including industry certifications) has emerged indirectly from the exploration of community colleges, universities and labor market interactions through posted criteria for hiring in entry and mid-level information technology jobs. A report published by the Office of Educational Research and Improvement, U.S. Department of Education[9], and as indicated in Table 1[9], demonstrates only 21% of posted job advertisements in *The Washington Post* mentioned a formal degree as a criteria for employment in the IT field. However, specific competencies and skills in computer graphics, physics, higher mathematics, programming languages, computer experience, logic and creativity were strongly evidenced through the market expectations in IT – job employment fields.

TABLE 1
EDUCATION SPECIFIED IN POSTING FOR ENTRY AND MID-LEVEL IT POSITIONS, "TECHNOLOGY EMPLOYMENT" SECTION, SUNDAY *WASHINGTON POST*, APRIL 1998 THROUGH APRIL 1999.

Requirement(s)	Number	Percent
Master's Degree	13	0.4%
Master's Preferred	27	0.8%
BS in CS/MIS/EE/CE	206	5.8%
BS + Certification	17	0.5%
BA/BS Required	98	2.8%
BS Preferred	47	1.3%
BA or Equivalent	73	2.1%
Associate Degree in IT	80	2.2%
Certification Required	184	5.2%
No Degree Mentioned	2799	78.9%

Table 2[9] provides a competence matrix from *The Washington Post* IT job postings requiring fluency in HTML, Java, PERL, C++, Visual basic and SQL. Most job postings indicated no requirement for a resume. Statements like *"...send us your URL. We'll log on and observe your technical skills, communication skills, your knowledge, and your artistic sensibilities"* were evidenced in job searches.

TABLE 2
THE COMPETENCE MATRIX IN IT JOB POSTINGS FOR ENTRY AND MID-LEVEL POSITIONS OF 3,500 ADS, THE NUMBER SPECIFYING PROGRAMMING LANGUAGES.

Programming Languages And Software applications	Total	Percentage
• C++	251	13%
• Visual C++	88	5%
• Java, Java Script	274	14%
• SQL	176	9%
• PERL	93	5%
• HTML	85	4%
• Cold Fusion	53	2%
• Other and Combination	946	46%

Note:
SQL = Structured Query Language (a standardized language for requesting information from a data base)
PERL = Practical Extraction and Report Language (an interpretative text processing language)
HTML = Hypertext Markup Language (the current standard authoring language for creating documents on the world wide web).

THE CONTENT AND THE CURRICULUM MODEL

Given the breadth and the technical depth inherent in Information Technology discipline, Kent State University and its School of Technology[7] has designed and developed a seamless (and articulated) academic degree programs connecting Certifcates in IT to Associate, Baccalaureate and finally to its Master of Technology degree. Realizing that professionals in the rapidly changing computer-related fields must, by necessity, continually upgrade their knowledge and skills, the Associate Degree in Computer and Information Technology has been designed to have 100% articulation with the Bachelor of Science in Technology (2+2 option) offered through the eight campus system of Kent State University.

Certificate Programs

Certificate programs are available in three levels of competency in Computer and information technology. They are Lower Division, Upper Division and Graduate Certificates. These programs varying from 18 to 24 credit hours are developed to focus on specific content areas. They are:

- Certificate in Micro -Computer Applications
- Certificate in Internet and World -Wide-Web Applications
- Advanced Internet Applications
- Solution Developer (leading to the preparation of MCSD exam)
- Database Administrator (leading to the preparation of MCSD exam)
- Systems Engineer (leading to the preparation of MCSE exam)

Associate Degree Program

The Associate Degree programs in Computer and Information Technology at Kent State University is built upon a 15 credit hours of core courses and four technical concentrations (program options) each with 17 credit hour requirements. The Associate Degree is a well balanced curriculum with required courses in general education, humanities, mathematics and the sciences formated to meet accredittaion standards. The following are the required technical vcourses in IT which make-up the Associate Degree program.

Required Core Courses = 15 credit hours
- Visual Basic Programming
- Survey of Information Technology
- Introduction to Operating Systems and Network Tech
- Introduction to Website Technology
- Workgroup Productivity Software

Option- I : Network Technology Concentration = 17 credit hours
- Computer Assembly and Configuration
- Network Setup and Configuration
- Technology of Operating Systems
- Technology of Networking
- Elective Course (i.e: Computer Science or Engineering)

Option –2 : Application Development Concentration = 17 hours
- Visual C++ Programming
- Advanced C++ Programming
- Visual Basic Database Programming
- Developing Desktop Applications
- Elective Course (i.e: Computer Science)

Option-3 : Internet/Multi-Media Concentration = 17 credit hours
- Internet Ethics and Policies
- Techniques of Multimedia Web-design
- Web-scripting
- Multimedia Development Tools
- Web-database Integration
- Elective Course (i.e: Computer Systems Engineering)

Option – 4 : General IT-Concentration = 17 credit hours
- Computer Assembly and Configuration
- Network Setup and Configuration
- Visual C++ Programming
- Visual Basic Database Programming
- Computer Elective Course

Bachelor's Degree Program

At Kent State University, the Bachelor of Science in Technology degree with the 2+2 option was designed to offer 100% articulation with the technical associate degree and provide flexibility for students with a wide variety of technical backgrounds and career goals. The upper division courses which support the BS in Technology programs are:

- Computer Animation and Design
- PC/Network Engineering and Troubleshooting
- Design of Online and Multiuser Systems
- Application of Technology Management Software
- Special Topics in Microsoft Certification
- Multimedia and Virtual Reality
- UNIX Scripting and Applications
- Microprocessor Systems
- Technology of Operating Systems
- Technology of Networking

Master's Degree Program

In an effort to provide easier access to high quality, technology-based education, Kent State University's School of Technology provides academic program leading to a Master of Technology Degree with a specialization in Computer and Information Technology. The Degree Program has three core courses (i.e: 9 credit hours) in:

- Research in Technology
- Project Management in a technological environment
- Quality Standards

Courses that make-up the Computer and Information Technology specialization area are :

- Computer Controlled Systems
- Introduction to Microprocessor
- Connectivity and Interoperability in Industry
- Technical Programming
- Information Technology and Automation in Industry
- Special Topics in Computer Engineering and Technology
- Individual Investigation in Communication Technology

TEACHING STRATEGIES

Information Technology should be taught by creating both a knowledge-centered and learning-centered environments [10] inside and outside the classroom. To provide technical currency and life-long learning, IT-educational environment should provide an environment of critical and creative thinking. Information Technology should provide a program flexibility which will aloow students to complete courses via the World Wide Web, Interactive Telecommunications (I-Link and Learn-Link), V-Tel Video conferencing technology. Work based learning (i.e: Coops, internships, clinics) are also recommended for IT students as industry applications has become an integral part of the IT productivity.

CONCLUSION

Information Technology (IT), in a knowledge-based economy, is a broad term covering all aspects of managing and processing information. Computer hardware, software, internet and systems integration (networks) are keys to systems that IT workers design, develop, support and manage. The information age of the millennium era requires all students to enter the workforce with functional literacy in Information Technology. Therefore, an interdisciplinary approach to integrate "Information Technology" into the engineering curriculum continues to increase in importance, as technology becomes a dominent part of teaching and learning.

The success in the 21st. Century society will be grasped not by strong hands but by strong minds. The future abilities of individuals, organizations, and nations to survive and thrive will largely depend on their abilities to generate, apply and share knowledge.

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