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Computing and IT Education: What, Where and Why?

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BACKGROUND

Traditional academic programs in Computer Science (CS) and Computer Information Systems (IS) are waning in their attractiveness to career-oriented students. Recent publications quoting statistics from premier academic programs in CS, IS, and Computer Engineering (CE) or Electrical Engineering (EE), clearly indicate that students are choosing fields other than computing for their career paths (Frauenheim, 2004; Kessler, 2004; NWCET, 2004). The primary drivers for students selecting out of Information Technology (IT) are primarily related to job opportunities. The army of unemployed IT workers resulting from the dot.com bust and from IT offshore outsourcing is well publicized (Mears, 2004). The experience in the CS and IS programs at Metropolitan State College of Denver (MSCD) emulate the statistics from the above referenced universities with a significant decline in enrollments in both CS and IS programs during the last three years.

Since 1968, the Computer Information Systems (IS) department in the School of Business at MSCD has been in a waxing and waning "turf-war" with the Computer Science program (CS) in the Mathematics department. As the IS program was established almost 15 years earlier than the CS program, it matured into highly attractive computing curriculum contributing more than one third of the full-time-equivalent (FTE) enrollments in the School of Business and became the fourth largest department at the college (18 full-time faculty, 35+ adjunct faculty, and 4000+ credit hours per term). In fall 2001, the CS program embarked on a concerted effort to expand their teaching domain by proposing more than 20 new courses in IT, the vast majority of which were currently being taught in the IS program. The previously simmering turf-war between the two programs exploded, which resulted in a College-level blocking of curriculum proposals in both programs for more than three years. To resolve these domain conflicts, the acting provost hired an external consultant to review both programs and make a recommendation for a "final solution." The consultant's final report was delivered on September 17, 2004 with the following recommendations:

- provide a mechanism to protect the resource allocations to both programs (the hypothesized bases for the turf battles);
- preserve the core disciplines in the CS and IS programs;
- jointly (IS, CS + Others) create cross-discipline solutions for 1) a campus computer literacy requirement, 2) computing service course(s), and 3) certificates of completion in specific computing disciplines;
- develop a cooperative venture (taskforce) for creation of a jointly managed IT degree program that would incorporate the strengths of both programs; and
- stimulate faculty development and implementation of creative solutions to current and future curriculum by providing administrative rewards.

The consultant's final report was met with mixed levels of skepticism by faculty in both programs.

COMPUTING AND IT EDUCATION

In response to declining enrollments and other rapidly changing technology externalities, existing CS, IS and CE programs have been reinventing themselves as Information Technology (IT) programs. This transformation was first noted by Peter J. Denning (2001) as a welcome change addressing the issues of (1) curriculum breadth vs. depth, (2) a changing professional body of knowledge relative to computing, and (3) institutional-espoused leadership in educating IT workers.

The transition to an IT program from traditional CS, IS and CE academic programs is not an easy road to travel. The resistance to change by tenured full professors is legendary (Gruba, et al, 2004). A study by Berghel and Sallach (2004), concluded that new IT schools and colleges were being driven at an accelerated rate by external stakeholders and new constituencies. Often the goals and objectives of these emerging IT units were defined less by discipline than by the level of institutional responsiveness. Consequently, IT programs are evolving outside of the traditional CS, CE and IS programs to overcome "perceived inflexibility and slow response" of these programs to the changing IT landscape.

These new IT programs dramatically increased the number of course offerings in the current "hot topics" of the computing industry (Subramanian & White, 2004). It is obviously more "sexy" (attractive to students) to be talking about new and emerging technologies in the IT field than the traditional high-level academic requirements. Offshore outsourcing is apparently here to stay and needs to be directly addressed through "Efficiency in Service Delivery" topics as suggested by Sevenspace (2004). Buzzwords like peer-to-peer (P2P), business-to-business (B2B), business-to-consumer (B2C), enterprise-resource-planning (ERP), customer-relations-management (CRM), supply-chain-management (SCM), etc. are far more interesting to the new, Internet-smart students who already know where the "money" is being passed out.

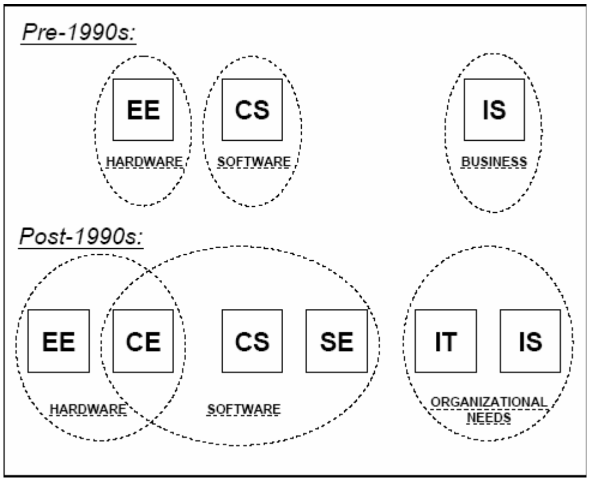
IT CURRICULUM DEVELOPMENT

Evolution of IT program curricula has been extremely varied as creative academic minds search for the "best fit" within the traditional CS, IS and CE paradigms. A recent study (Reichgelt, et al, 2004) of universities that offered "stand alone" CS, IS and IT programs approached this dilemma by investigating the quantity of 3-semester-credit-hour courses in each program in each topic area. The IS programs studied appeared to be the most uniform in their curricula content primarily due to availability of specific IS "model curriculum" (Gorgone, J.T., et al, 2002). The study concluded that IT programs are more similar to each other than they are to programs in either CS or IS. In other words, the typical IT program curriculum falls somewhere between the typical CS program curriculum and typical IS program curriculum.

In an effort to bring curriculum uniformity and "academic legitimacy" to evolving computing programs including IT, CE, CS, IS, EE and Software Engineering (SE), a model curriculum is being developed by the cooperative project of the Joint Taskforce for Computing Curricula 2004 consisting of The Association for Computing (ACM), The Association for Information Systems (AIS), and The Computer Society (IEEE-CS). The Strawman draft of Computing Curricula 2004 was published in June 1, 2004.

The Strawman mapping of the Computing disciplines before and after the 1990's is shown in Figure 2.2.

Figure 2.2. Computing Disciplines, Before and After the 1990s



(Source: Strawman draft of Computing Curricula 2004)

This taskforce has further delineated computing programs based on descriptions of the various computing disciplines, weight of topics taught by discipline, and performance capabilities by discipline. These descriptions appear to be comprehensive and consistent with other descriptions currently available from other accrediting bodies such as ACM, ABET, IRMA and other publications on the subject (Reichgelt 2004). Portions of the Strawman "discipline descriptions" mapped above are shown below:

- **Information Technology (IT):** is a label that has two meanings. In the broadest sense, we often use "information technology" interchangeably with "computer technology". In a more focused sense, it refers to academic degree programs that prepare students to meet the technology needs of business, government, healthcare, schools, and other kinds of organizations.
- **Degree programs in Information Technology arose because degree programs in the other computing disciplines failed to produce an adequate supply of graduates capable of handling these very real needs** (bold added). IT programs exist to produce graduates who possess the right combination of knowledge and practical, hands-on expertise to take care of both an organization's information technology and the people who use it. IT specialists assume responsibility for selecting hardware and software products appropriate for an organization, integrating those products with organizational needs and infrastructure, and installing, customizing and maintaining those applications for the organization's computer users.
- **Information Systems (IS):** specialists focus on integrating information technology solutions and business processes to meet the information needs of businesses and other organizations and enable organizations to achieve their objectives in an effective and efficient way. This discipline's perspective on "Information Technology" emphasizes *information,* and sees *technology* as an instrument to enable the generation, processing and distribution of needed information. Professionals in this discipline are primarily concerned with the information that computer systems can provide to aid the organization in defining and achieving its goals and the processes that organizations can implement using information technology. Information systems professionals often work in organizations that are large and complex, and with information systems that are correspondingly large and complex. They understand both technical and organizational factors, and must be able to help the organization determine how information and technology-enabled business processes can provide the organization with a competitive advantage. Most departments offering programs in *Information Systems* (IS) are located in business schools, and most IS degrees are combined computing and business degrees.
- **Computer Engineering (CE):** is concerned with the design and construction of computers, and computer based systems. It involves the study of hardware, software, communications, and the interaction between them. Its curriculum focuses on the theories, principles, and practices of relevant areas of traditional electrical engineering and mathematics, and applies them to the problems of designing computers and the many kinds of computer-based devices.
- **Computer Science (CS):** spans a wide range, from its theoretical and algorithmic foundations to cutting-edge developments in robotics, computer vision, intelligent systems, bioinformatics, and other exciting areas. We can think of the work of computer scientists as falling into three categories:
  - They develop effective ways to solve computing problems. For example, computer scientists develop the best possible ways to store information in databases, send data over networks, and display complex images. Their theoretical background allows them to determine the best performance possible, and their study of algorithms lets them develop new problem-solving approaches that provide better performance.
  - They devise new ways to use computers. Progress in the CS areas of networking, database, and human-computer-interface came together as the world-wide-web, which changed the world. Now, researchers are working to make robots be practical aides and even demonstrate intelligence, databases create new knowledge and, in general, use computers to do new things.
  - They design and implement software. Computer scientists take on challenging programming jobs. They also supervise other programmers, keeping them aware of new approaches.
- **Software Engineering (SE);** is the discipline of developing and maintaining software systems that behave reliably and efficiently, and are affordable to develop and maintain. However, more recently it has evolved in response to the increased importance of software in safety-critical applications and to the growing impact of large and expensive software systems in a wide range of situations.

The Strawman draft of Computing Curricula 2004 mapped the computing disciplines knowledge areas into the five computing education disciplines by comparative weight by discipline. This mapping is shown in Strawman Table 3.1 with the shading added on specific knowledge areas as related to the overall recommendations of this theoretical approach to computing and IT education transitions.

IT EDUCATION TRENDS

The National Workforce Center for Emerging Technologies (NWCET) recently published "Applications of Information Technology Trends Assessment for 2004" (Royer, M. and Stephan, L., 2004). This National Science Foundation (NSF)-funded research study concluded the following:

Growth industries, in terms of revenue and employment, over the next 5 to 10 year period are plainly evident. Growth industries for IT-related professions are as follows:

- Health services, business services, social services, engineering, management, and related services will be the major contributors of additional jobs in the next decade both at the national and state level.
- Even though the Information Technology jobs are not seeing the strong growth they experienced in the 90's, IT jobs are still in demand. In Washington State, eight of the 10 fastest growing occupations are computer-related.

Table 3.1. Comparative Weight of Topics Across the Five Kinds of Computing Degree Programs

Knowledge Area	CE		CS		IS		IT		SE	
	min	max	min	max	min	max	min	max	min	max
Programming Fundamentals	4	4	5	5	2	4	1	3	5	5
Algorithms and Complexity	2	4	5	5	1	2	0	1	4	4
Computer Architecture and Organization	5	5	2	4	1	2	1	2	2	4
Operating Systems Principles & Design	2	4	3	5	1	1	1	1	3	4
Operating Systems Configuration & Use	2	3	2	4	2	3	5	5	2	4
Net Centric Principles and Design	1	3	2	4	1	3	3	4	2	4
Net Centric Use and configuration	1	2	2	3	2	4	5	5	2	3
Theory of Programming Languages	1	2	3	5	0	1	0	0	2	4
Human-Computer Interaction	2	5	2	4	2	5	4	5	3	5
Graphics and Visualization	1	3	1	5	1	1	0	0	1	3
Intelligent Systems (AI)	1	3	2	5	1	1	0	0	0	0
Information Management (DB) Theory	1	3	2	5	1	3	1	1	2	5
Information Management (DB) Practice	1	2	1	4	4	5	2	4	1	4
Scientific computing (Numerical mthds)	0	2	0	5	0	0	0	0	0	0
Organizational Theory	0	0	0	0	1	4	1	2	0	0
Management of Info Systems Organ'tion	0	0	0	0	3	5	0	0	0	0
Decision Theory	0	0	0	0	3	3	0	0	0	0
Organizational Behavior	0	0	0	0	3	5	1	2	0	0
Organizational Change Management	0	0	0	0	2	2	0	1	0	0
Legal / Professional / Ethics / Society	2	5	2	4	2	5	2	4	2	5
General Systems Theory	0	0	0	0	2	2	1	3	0	0
Information Systems Development	0	2	0	2	5	5	1	3	2	4
Risk Management (Project, safety risk)	2	4	1	1	2	3	1	4	2	4
Project Management	2	4	1	2	3	5	1	3	4	5
Analysis of Business Requirements	0	1	0	1	5	5	1	2	0	2
Engineering Foundations for SW	1	2	1	2	1	1	0	0	2	4
Engineering Economics for SW	1	1	1	1	2	2	1	1	2	2
Software Modeling and Analysis	1	3	2	3	3	3	0	0	4	5
Software Design	2	4	3	5	1	3	1	1	5	5
Software Verification and Validation	1	3	1	2	1	2	0	0	4	5
Software Evolution (maintenance)	1	3	1	1	1	2	1	1	2	4
Software Process	1	1	1	1	1	1	1	1	2	4
Software Quality	2	3	2	3	1	2	1	1	3	4
Comp Systems Engineering	5	5	1	2	0	0	0	0	2	3
Embedded Systems	2	5	1	3	0	0	0	0	2	4
Circuits and Systems	5	5	0	2	0	0	0	0	0	0
Electronics	5	5	0	0	0	0	0	0	0	0
Digital logic	5	5	2	3	1	1	1	1	1	3
E-business	0	0	0	0	4	4	1	1	0	3
Distributed Systems	3	5	1	3	2	4	1	3	2	4
Digital Signal Processing	3	5	0	2	0	0	0	0	0	2
VLSI design	2	5	0	1	0	0	0	0	0	1
HW testing and fault tolerance	3	5	0	0	0	0	0	2	0	0
Security: issues and principles	2	3	1	4	2	3	1	3	1	3
Security: implementation and mgt	1	2	1	3	1	3	3	5	1	3
Systems administration	1	2	1	1	1	3	3	5	1	2
Systems integration	1	4	1	2	1	4	4	5	1	3
Digital media development	0	2	0	1	1	2	3	5	0	1
Technical support	0	1	0	1	1	3	5	5	0	1
Mathematical foundations	5	5	4	5	2	4	2	4	4	5
Interpersonal communication	3	4	1	3	3	5	2	4	3	4

Current trends in IT workforce and employment qualifications were identified as follows:

- As IT matures and the penetration of IT products increases in a wide range of industry sectors, there is an increasing need for IT workers in "technology-enabled" organizations, companies that use or modify technologies for their specific needs. These industries will experience significant growth in the employment of IT-trained professionals. Examples of these industries include healthcare, local-state-federal government, insurance, banking, finance and e-commerce. This shift requires IT professionals to focus more on the applications of information technologies, as opposed to focusing on the technology itself, and to develop cross-disciplinary knowledge with a strong business emphasis.
- Outsourcing combined with the large number of IT workers looking for work allows employers to require significantly higher levels of IT skills and knowledge, higher educational degrees, and a higher level of industry experience than they used to require a few years ago. IT jobs that required only a 2-year degree now require a minimum of a 4-year degree.
- IT literacy and expected IT skill level are increasing in non-IT jobs, squeezing out of the market IT trained-workers with only entry-level/basic IT skills.
- The emphasis on collaborative work will continue to increase and the trend to telework—as delivered through virtual workplaces—will intensify.

A recent study by Miller and Luse (2004) supports the need for written, oral and interpersonal communication skills and collaborative skills by IS staff during systems development. This study involved a total of 324 participants including IS managers, IS staff, and IS users who completed questionnaires ranking the importance of various skills within specific skill sets.

The key management issues identified by Miller and Luse are:

- communication is important between IS staff, IS users and IS managers to ensure successful development projects; and
- ineffective communication skills of IS staff is often cited as the cause for IS project failure.

The key skills identified by Miller and Luse are:

- the ability to ask appropriate questions and have effective oral communications; and
- the ability to accomplish assignments and to work cooperatively in a one-on-one and project team environment.

The curriculum (pedagogy) changes recommended by Miller and Luse to address the key issues are:

- encourage faculty to require independent and collaborative written and oral communication assignments;
- require IS students to take a business communications course to refine their written and oral communication skills;
- require IS faculty to include written, oral and collaborative assignments within the IS curriculum.

An Information Systems Education Journal article by Kang Sun (2004), an IT manager at Smart Energy and a professional with many years of experience, described his perspective of the different IT roles and the qualifications for each. His conclusions emulate those of many others in the field and are as follows:

"IT curriculum is aimed at preparing students for (the) *real world. However a real world job requires experience, which is something most of new graduates do not have. Some schools send students to companies for internships. Should curriculum or accreditation require schools to have internship programs?"*

"IT is a fast growing field and dedicated roles are evolving daily. No matter what role one takes, fundamental knowledge of computers and networks are indispensable. It is also worth emphasizing that social skills such as communications, organization, (and) *interpersonal skills are as important, for IT needs spirits and practices of cooperation, and team works are essential for success."*

Bob Evans in Information Week (August 30, 2004) says that "When Change is Inevitable, Embrace It." In this article Evans concludes: "Universities and colleges are realizing they need to revise their thinking about computer-science requirements to give their students more well-rounded educations. Ohio State's Stuart Zweben, chair of the computer- and information-science department, says there needs to be a greater emphasis on how computers affect business operations as well as on communication and collaboration. When it comes to imparting that wider perspective, "I don't think most schools do that great of a job" Zweben says. "We don't do it here." Others insist that that broader view must not be limited to business but, rather, the impact of technology on all types of organizations. "The one thing that's more important now than before is having an understanding of the applicants' domain," says Gerald Engel, a University of Connecticut computer-science professor.

Further in his article, Bob Evans quotes Mark Stehlik, assistant dean of undergraduate education, "At Carnegie Mellon University, we are helping our students develop communications and interpersonal skills, so they can communicate with those who are not necessarily as tech-savvy… my colleague Eric Chabrow, put it this way: 'This interdisciplinary approach might be the salvation for computer science and could eventually attract a different breed of student than from an earlier generation'… The students who come in want to do more than just hack, some students have political designs; they are interested in greater issues that confront society: security, privacy. We are seeing students who are extending the notion of computer science."

CONCLUSION

After review of the current literature relative to computing education, it is evident that a consensus is emerging among practitioners and some academics relative to the skills that graduates in the computing field must posses. However, it is somewhat disheartening that the rapid decline in student enrollments in traditional computing disciplines (CE. CS, IS, IT, EE, SE) has not precipitated a more rapid embracing of the obvious.

An unpublished study by the CIS department at MSCD of the curricula of seven Universities in the US that have both CS and IS ABET-accredited programs, concluded that 6 of the 7 had included (some required) "professional" courses (9 to 15 credit hours) in communications and business topics. It was encouraging to see the implementation of "token" courses to broaden the communications and business core knowledge of their graduates.

A review of the Strawman draft's proposed topics across the five computing degrees clearly points out this dilemma (reference the shaded topics in Table 3.1 on page 5). There still appears to be reluctance on the part of academics serving on the Joint Taskforce for Computing Curricula 2004 to address the practitioner's often expressed need for written, oral and interpersonal communication skills and collaboration (teamwork) skills for all graduates in computing disciplines. As suggested by the proposed Strawman curriculum, these essential skills for computing discipline graduates are generally relegated to the IS curriculum.

RECOMMENDATIONS

As a result of this analysis and our experience at MSCD, the following are recommended for serious consideration by emerging IT programs as well as reengineering (revitalization) of existing academic computing programs:

- revitalize the curriculum to incorporate the "hot topics" that are increasingly evident in net-enhanced businesses (outsourcing, P2P, B2C, ERP, CRM, SCM, etc.);
- develop a cross-discipline curriculum model incorporating core business topics;
- require a course in business and/or technical writing;
- require a communications course that emphasis both written and oral communications;
- require a course that emphasizes teambuilding and interpersonal communication skills in a business environment; and
- require a business internship (or co-op education) experience for all seniors who have little or no work experience in their field. Numerous undergraduate and graduate IT internship and co-op programs are available locally and nationally. Traditional IT programs have been delinquent in taking full advantage of this powerful learning and placement tool (Internship, 2004).

Although the curriculum approach recommended above would be difficult (impossible?) to implement under many current academic organizational structures, it is the contention of the authors that a "real" computing paradigm shift has occurred at both small and large employers of computing technology graduates. Traditional academic computing and IT education must respond to this fundamental change in employer needs lest they suffer the same fate as the dinosaurs when their environment changed.

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