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Business Technology Education in the Early 21st Century: The Ongoing Quest for Relevance

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Executive Summary

The field of information technology is changing and those responsible for educating the next generation of technology professionals have responded with a new computing curriculum, which identifies five distinct technology majors: computer engineering, computer science, software engineering, information systems and information technology. Unfortunately, the new curricula fail to address the depth and speed of the changes in the practice of the field. In fact, the gap between "theory" and "practice" is widening. If relevance is a desired goal, alternative curricula can be developed that will satisfy the field's emerging requirements designed around five layers and two flanks: business strategy, strategic business applications, enterprise architecture, technology infrastructure, technology support, technology acquisition and technology organization and management. There are also curriculum bridges that we can build between more traditional computer science and newly relevant information systems degrees.

Introduction

The interplay – and sometimes conflict – between "theory" and "practice" in technology education is well documented (Becher, 1989; Cohen, 2002; Cougar, 1973; Drysdale, 1996; Hoffman, 2003; Lethbridge, 1998a, 1998b; Mehic & Al-Soufi, 1999; Reichgelt, Lunt, Ashford, Phelps, Slazinski, & Willis, 2004; Trauth, Farrell, & Lee, 1993; Verton, 2004; Wohlin & Bjorn, 1999). Scholars and practitioners have been writing about it for decades – and are likely to continue to do so. Many of these discussions have been about the roles that each community should play: educators should educate; practitioners should apply; educators should communicate principles; practitioners should train. But the relationship is far more complicated than the simple definition of roles. There are issues that surround the pace and trajectory of change in theory and practice. There are issues surrounding the evolving roles of "educators" and "trainers," and there are even issues surrounding the responsibilities that theory and practice have to their constituents: as careers get more difficult to build around academic technology majors steps should be taken to improve professional opportunities.

The pace and trajectory of change is especially salient to the discussion here. The field of information technology (IT) is changing dramatically. Some would mark the beginning of the transformation with the crash of the dot.coms which began in 2000. Others would mark it as 2001 when annual IT spending declined dramatically after an almost ten years of steady annual increases.

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Others might even mark the beginning of the transformation with the publication of Nickolas Carr's "IT Doesn't Matter," the article that triggered a huge debate about IT as a commodity versus strategic weapon (Carr, 2003). Still others point to increases in near- and off-shore outsourcing as another indicator of change which as reduced the demand for U.S.-educated computer scientists who might want to enter the field of programming.

The way we educate future technology professionals is also changing. There have been several curriculum changes and guidelines proposed over time that attempt to address the changes in technology and design optimal pedagogical approaches in response to these changes. One of the most recent changes recommends that five technology majors be developed to prospective students seeking professional careers in broadly defined computing and communications technology.

This paper examines the direction of the changes in theory and practice with specific reference to relevance. The analysis presented here is based on survey data collected from 2001 – 2004 and upon on-going work of the academic professional associations' attempts to redesign technology curricula. The paper concludes that the gap between the practice and the education of IT is widening. Some recommendations are also made for shrinking the gap between theory and practice.

The Practice of IT

During the period from 2001 – 2004, an on-line survey sponsored by the Cutter Consortium (a technology industry research organization; www.cutter.com) collected data from Chief Information Officers (CIOs), Chief Technology Officers (CTOs), technology managers, Chief Executive Officers (CEOs), Chief Financial Officers (CFOs), technology consultants and vendors about the content of the field, the skill sets necessary to succeed, and the technologies most likely to be applied, neglected or decommissioned (Cutter Consortium, 2004). Over one thousand professionals responded to the survey. The survey data was subsequently presented to – and validated by – the Villanova University CIO Advisory Council, which consists of twenty-five Chief Information Officers from the Philadelphia region.

The data suggested that the practice of the field is organizing itself around five layers and two flanks. Figure 1 presents the business technology layers and flanks that can be used to identify and describe the skills necessary to succeed in the early 21st century. The knowledge and skills areas that follow are derived from the five layers and two flanks and presented in Appendix A.

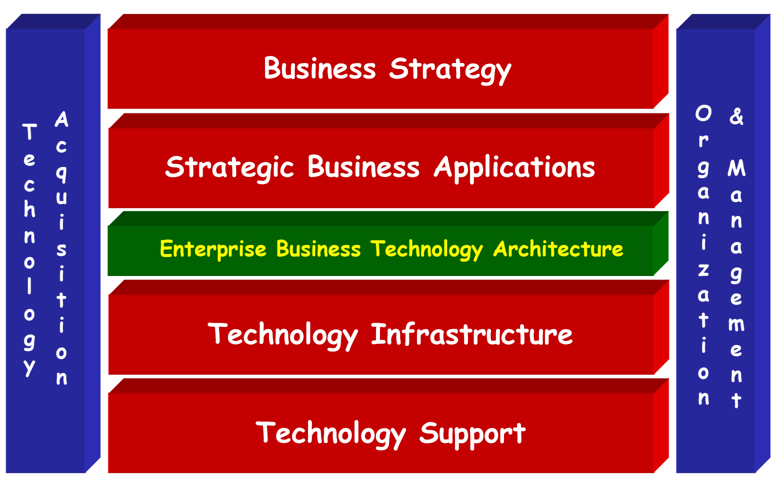

Figure 1: The Layers & Flanks of the Practice of IT

The Joint Task Force on Computing Curricula

The draft report of the Joint Task Force for Computing Curricula on Computing Curricula for the early 21st century identifies five areas of computing degree concentrations (Joint Task Force on Computing Curricula, 2004):

- Computer Engineering
- Computer Science
- Information Systems
- Information Technology
- Software Engineering

These areas represent the academic programs that the Joint Task Force believes represent the state of the field and the educational outcomes we should pursue. They identify a suite of "computing" and "non-computing" areas they believe comprehensively represent the knowledge and skills areas that students in each of the five degree areas should understand. These areas appear in Appendix B.

Theory versus Practice

The list of knowledge and skills areas identified by the Joint Task Force that define the components of the five degree programs were derived from academic programs and curricula that have evolved over a long period of time. The Cutter Consortium survey data discussed above, however, identified knowledge and skills areas from a practitioner's perspective. Table 1 presents the two sets of knowledge/skills areas side-by-side. The contrast is dramatic. The Joint Task Force's list only barely correlates with the list developed from our practitioner surveys.

The lack of correlation between the two lists suggests that we re-visit the distinction between "theory" and "practice," and the role that we would like relevance to play in the design and delivery of early 21st century technology curricula. The Joint Task Force list speaks directly to enabling technology and very indirectly – almost not at all – to the industry problem-solving context in which technology lives – or dies. Twenty years ago this distinction made much more sense than it does today. But today it is hard to distinguish between business and technology at all, given that nearly all business transactions are enabled by technology.

Academic programs should acknowledge the widening gap between theory and practice, especially since it has enormous implications for their graduates' ability to find work – which leads to the second point about the lack of correlation between the Joint Task Force/ACM and practitioner skills lists. A not so close inspection of the Joint Task Force list indicates a failure at least on some level to fully comprehend the trends in near-shore and off-shore outsourcing. Increasingly, operational and tactical tasks like systems development, application maintenance and help desk support are being outsourced to near- and off-shore partners. Too many skills areas on the ACM list ignore these outsourcing trends. In fact, if we correlated the Joint Task Force list with outsourcing trends, we would find another widening gap.

Regardless of what we call the academic majors and degrees – computer engineering, computer science, information systems, information technology or software engineering – it is the content of each degree's curriculum that will determine our students' ability to find gainful employment.

Table 1: ACM Joint Task Force Knowledge & Skills Areas & Practitioner Areas

ACM Task Force Areas

Computing Knowledge and Skills

Programming Fundamentals
Integrative Programming
Algorithms and Complexity
Computer Architecture and Organization
Operating Systems Principles and Design
Net Centric Principles and Design
Platform Technologies
Theory of Programming Languages
Human-Computer Interaction
Graphics and Visualization
Intelligent Systems (AI)
Information Management (Data Base) Theory
Information Management (Data Base) Practice
Scientific Computing (Numerical Methods)
Legal/Professional/Ethics/ Society
Information Systems Development
Analysis of Technical Requirements
Engineering Foundations for Software
Engineering Economics for Software
Software Modeling and Analysis
Software Design
Software Verification and Validation
Software Evolution (Maintenance)
Software Process
Software Quality
Computer Systems Engineering
Digital Logic
Distributed Systems
Security: Issues & Principles
Security: Implementation and Management
Systems Administration
Systems Integration
Digital Media Development
Technical Support

Non-Computing Knowledge and Skills

Organizational Theory
Management of Information Systems Organization
Decision Theory
Organizational Behavior
Organizational Change Management ...
E-business
General Systems Theory
Risk Management (Project, Safety Risk)
Project Management
Analysis of Business Requirements
Embedded Systems
Circuits and Systems
Electronics
Digital Signal Processing
Very Large Scale Integrated Circuit (VLSI) Design
Hardware Testing and Fault Tolerance
Mathematical Foundations
Interpersonal Communication

Practitioner Areas

Business Strategy Knowledge and Skills

Collaboration
Customization and Personalization
Supply Chain Management
Business ←→ Technology Convergence Strategy
Competitor Intelligence
Business Process Management

Business Applications Knowledge and Skills

Business Application Optimization
Core Business Applications Management
Business Analytics

Enterprise Architecture Knowledge and Skills

Applications Architectures
Communications
Data Architectures
Security Architectures
Business Scenario Development
Enterprise Technology Architecture Modeling
Enterprise Architecture

Technology Infrastructure Knowledge and Skills

Messaging/Workflow/ Calendaring
Automation
Data Base/Content/ Knowledge Management
Integration and Interoperability

Technology Support Knowledge and Skills

Desktop/Laptop/PDA/ Thin Client Support
Data Center Operations
Server Farm Design and Maintenance
Network Design and Support
Security and Privacy
Procurement and Asset Management
Asset Disposal

Technology Acquisition Knowledge and Skills

Business Technology Acquisition Strategy
RFP and SLA Development

Organization & Management Knowledge & Skills

Reporting Relationships
Centralization & Decentralization
Governance
Procurement and Asset Management
Business Case Development/ Business Technology Metrics
Project/Program Management
Procurement and Asset Management
Partner Management
Vendor Management
Regulatory Trends
Professional Communications

When we layer outsourcing trends on to the situation, we see industry turning to off-shore providers to satisfy their operational requirements rather than US-educated professionals who are not receiving enough of the knowledge or skills that industry values (or is willing to pay for, compared to off-shore provider rates). Today those requirements are relatively low level operational requirements but over time off-shore providers will rise up the food chain to more strategic technology capabilities (from the lower to higher layers in Figure 1). It's these latter areas that should catch the attention of US educators since the sourcing battle for Layers #4 and #5 is nearly over.

Other important areas to consider are architecture and optimization. One of the most important corporate knowledge areas today – in fact, the essence of business technology convergence – is enterprise architecture. Enterprise business-technology architecture is the linchpin among business strategy, strategic applications, technology infrastructure and technology support. As business is enabled by technology and technology defines new business models and processes, the importance of enterprise business-technology architecture is growing by leaps and bounds. This emerging core competency for the practice of the technology profession is unrepresented in the Joint Task Force's list of knowledge and skills areas – though is an entire layer in our practitioner survey. Similarly, business technology optimization is an opportunity area for educators. More and more companies are struggling to optimize the performance of their software applications, networks, data base management platforms and infrastructure.

Another aspect of curricula design that deserves attention is the velocity of the change in the technology field. Ten years ago IT played a very different role than it does today – or is likely to play five years from now. The trends in practitioner knowledge and skill sets are indicative of the direction and velocity of change that is occurring in the practice of the field. But curricula changes much more slowly, often requiring years to evolve. While the evolutionary approach works for many disciplines, it does not work in fields like information technology or biotechnology that change quickly.

The relevance problem is real and growing. It is becoming an acute problem because of the decline in the number of undergraduate students choosing technology majors, outsourcing trends, the velocity of change in the field, and changes in how technology is developed, acquired, deployed and supported.

Recommendations

Perhaps technology curriculum should not be so finely tuned. It is not clear why we need five different overlapping flavors of technology degrees. While distinctions between computer engineering (CE) and the other disciplines are relatively easy to appreciate – especially because of the role that hardware plays in CE programs – the difference between information systems, information technology, software engineering and computer science are much harder to understand.

Perhaps there should be only three flavors: computer engineering, computer science and information systems that address the relevance problem from several perspectives. (The focus here will be on the relationship between computer science [CS] and information systems [IS]; CE will likely remain primarily hardware focused and in engineering colleges within the nation's universities.)

CS programs may need to focus a little less on alternative programming languages and much, much more on architectures, integration and interoperability; a little less on algorithms and discrete structures and much more on software engineering best practices. Another way of saying this is that CS programs should focus a little less on Layers #4 and #5 and a little more Layers #1, #2 and #3.

In addition to the basics like data communications, database management and enterprise applications, 21st-century IS programs should focus on business analytics, supply-chain optimization, digital security and lots of technology management skills – in short, the list of practitioner knowledge and skills areas. Gomolski (2004), for example, has suggested three areas for concentration: business process design and management, information management, and relationship and vendor management. Over and over again we also hear companies express interest in hiring people who know how to write business cases for technology projects, how to mange technology projects (and portfolios), how to manage vendors and how to communicate all this effectively orally and in written documentation – all with constant reference to enterprise business technology architecture.

A related option would be to "verticalize" IS curricula, re-defining courses around the requirements of specific industries, like pharmaceutical, financial services, manufacturing and insurance industries.

Perhaps the way to approach all this is to organize IS programs around the five layers and two flanks that appear in Figure 1, and then add some vertical courses to the curriculum. These suggestions are consistent with the data we've collected about industry's business technology requirements.

CS programs can enable IS programs while at the same time maintaining their own identity. The knowledge and skills areas proposed by the Joint Task Force should all be extended to link to the knowledge and skills on the IS side. Clearly the programs need to be coordinated. Figure 2 suggests how this might work. The Joint Task Force knowledge and skills areas appear on the left and the practitioner knowledge and skills appear on the right side of the figure. In the middle are some "bridges" that might shrink the gap between the two areas. These bridges might become required for both CS and IS curricula and help CS programs become more relevant and IS programs more grounded in the enabling technology that supports business processes and transactions.

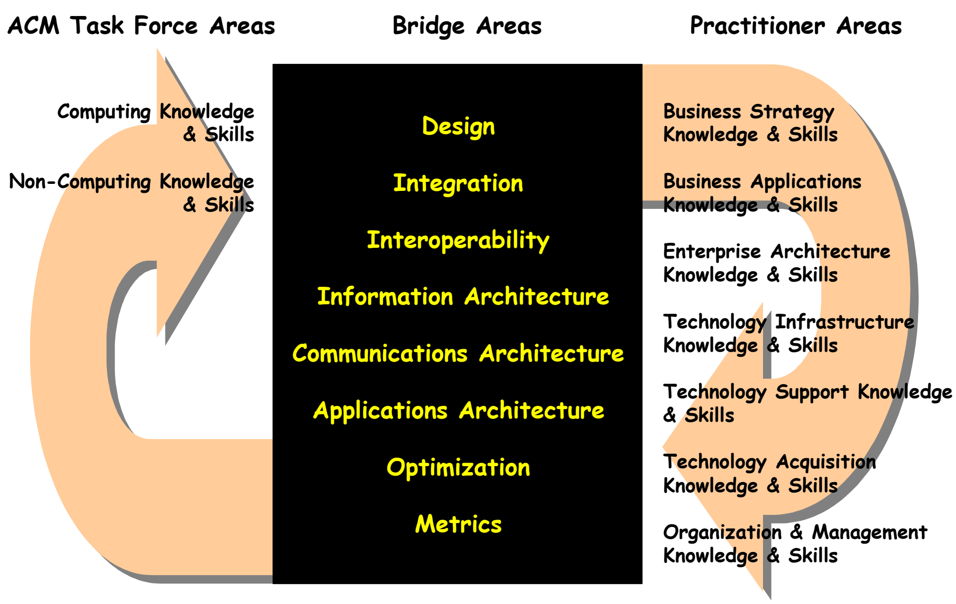

Figure 2: Knowledge & Skills Areas & Bridges

Conclusion

The gap between what we teach and what we do is widening. But there are steps we can take to narrow the gap and respond to where business technology is going and what the world expects from our technology graduates without compromising the essence of computer and information science education. This paper argues that relevance is a desirable goal and that steps should be taken to shrink the widening gap between theory and practice. First, we need to better understand the breadth of the relevance problem. This paper offers a start. Next we need to better understand the bridges from "theory" to "practice." Some are suggested here. The underlying issues are philosophical: what are the roles and responsibilities of early 21st century technology educators? Next generation CS programs should pay homage to their roots but also tilt toward practitioner requirements. Next generation IS programs should speak directly to practitioner requirements and acknowledge the underlying technologies that make business technology optimization possible.

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Appendix A

Business Strategy Knowledge & Skills (Layer #1)

We begin with business strategy knowledge and skills and proceed through the seven areas.

- **Collaboration** - knowledge about the inter-connected marketplace and inter-networked companies; knowledge about what happens inside and outside of companies: the collaborative mindset; knowledge about how customers, employees, partners and suppliers interconnect; skills to make collaboration work across application, data and communications architectures.
- **Customization & Personalization** – knowledge about mass personalization, behavioral models to correlate online and offline behaviors, wireless personalization and personal and professional customer relationship management (CRM), among other related areas; skills that customize and personalize collaborative interaction.
- **Supply Chain Management (SCM)** – knowledge and skills that include supply chain concepts, models and tools. Integrated supply chain management (by vertical industry) is a central focus here along with the technologies that enable supply chain management as well as SCM standards, technologies (such as trading exchanges), and the leading SCM technology platforms.
- **Business Technology Convergence Strategy** – knowledge that examines methods for developing and assessing collaborative/ integrated business technology strategies; knowledge about the current scenario that's driving your collaborative business strategy and the plan for integrating computing and communications technologies.
- **Competitor Intelligence** – knowledge about specific competitors including information about their sales, marketing, profitability, key employees, strategy and tactics.
- **Business Process Management** – knowledge about alternative business process modeling methods, tools and techniques; the ability to measure business processes and models.

Strategic Business Applications Knowledge & Skills (Layer #2)

- **Business Application Optimization** – knowledge that looks at major technology and business processes and how they can be optimized with a variety of business applications, like customer relationship management (CRM), enterprise resource planning (ERP), and other applications.
- **Core Business Applications Management** – knowledge that identifies the applications that make money for companies as well as the applications that define the company's competitive advantages; knowledge about how to make them perform optimally together.
- **Business Analytics** – knowledge about the processes and technologies that yield insight from sales, marketing, customer service, finance, accounting, technology infrastructure and competitor data; knowledge about the forms those analyses can take.

Enterprise Business Technology Architecture Knowledge & Skills (Layer #3)

- **Applications Architectures** – knowledge that looks at how mainframe (single tier), client-server (2 tier) and Internet/ Intranet (3 tier → n tier) applications have changed and how the trade-offs among the architectures (defined around flexibility, scalability, reliability, etc.) can be managed.
- **Communications Architectures** – knowledge that focuses on existing and emerging communications networks including especially the role that wireless access and transaction processing will play in emerging collaborative business models and processes.
- **Data Architectures** – knowledge about the role that data, information and knowledge will play in collaborative transaction processing; knowledge about existing data base management platforms, data warehousing, data mining and knowledge management, especially as they contribute to business intelligence.
- **Security Architectures** – knowledge about security and privacy inside and outside of corporate firewalls; knowledge about authentication, authorization and administration technologies and tools; knowledge about security integration and interoperability.
- **Business Scenario Development** – knowledge about current and emerging business models and processes and the ability to map them in current and future competitive contexts.
- **Enterprise Technology Architecture Modeling** – knowledge about the overall organization of technology that supports business goals, especially as all of this integrates and works as seamlessly as possible.
- **Enterprise Architecture** – knowledge about the overall business-technology architecture, especially how it is defined and how it adapts to changes in business and technology; the overall blueprint for business technology optimization.

Technology Infrastructure Knowledge & Skills (Layer #4)

- **Messaging/Workflow/Calendaring** – knowledge that examines the platforms that support all varieties of communication and how communications technology enables communication and transactions among employees, customers and suppliers inside and outside of the corporate firewall.
- **Automation** – knowledge about intelligent systems technology and the application of that technology to personal and professional automated transaction processing, monitoring, e-billing, and the like, including methods (neural nets, fuzzy logic, expert systems) and how these methodologies can be embedded in tools and applications.
- **Data Base/Content/Knowledge Management & Analysis** – knowledge that positions data, information, knowledge and content – of all varieties (static, dynamic, text, video, etc.) – and how it can be managed for alternative purposes, as well as data, knowledge and content management platforms, next generation data base management applications (especially object oriented DBMSs).
- **Integration & Interoperability** – knowledge that describes the technical requirements for making disparate, incompatible applications, standards, data, platforms and architectures communicate with one another, focusing on enterprise applications integration (EAI) and Internet applications integration (IAI), wrapper/glue technologies like XML, as well as more conventional middleware. The knowledge should focus on the need for – and objectives of – integration and interoperability including cross-selling, up-selling, customer service and alliance building.

Technology Support Knowledge & Skills (Layer #5)

- **Desktop/Laptop/PDA Support –** knowledge and skills about how to maintain network access devices.
- **Data Center Operations –** knowledge and skills about how to organize and manage data center operations.
- **Server Farm Design & Maintenance** – knowledge and skills about how to design server architectures and support server farms.
- **Network Design & Support** – knowledge and skills about how to design and support communications networks including local area networks, wide area networks, virtual private networks and the Internet.
- **Security & Privacy** – knowledge that examines the concepts, models, tools and technologies that enable security architectures, authentication, authorization, administration and business resumption planning. The technologies would include encryption, biometrics, public key infrastructure (PKI) and smart cards, among others.
- **Procurement & Asset Management –** knowledge about how to optimally procure and management computing and communications assets.
- **Asset Disposal –** knowledge about how to cost-effectively dispose of technology hardware.

Technology Acquisition Knowledge & Skills (Left Flank)

- **Business Technology Acquisition Strategy** – knowledge that examines all aspects of the technology procurement and support process, including especially in-sourcing, co-sourcing and outsourcing.
- **RFP & SLA Development** – skills to develop diagnostic requests for proposals (RFPs) and service level agreements (SLAs) necessary to optimize the business technology sourcing process.

Organization & Management Knowledge & Skills (Right Flank)

- **Reporting Relationships** – Knowledge about alternative organizational structures that optimize the business technology relationship.
- **Centralization & Decentralization** – Knowledge about optimal centralized and decentralized organization structures; knowledge about how to assess the relative merits of alternative structures.
- **Governance** – Knowledge about the allocation of responsibilities across organizations and organizational structures; ability to match corporate cultures to practical governance strategies and tactics.
- **Procurement & Asset Management –** knowledge about how to optimally procure and management computing and communications assets.
- **Business Case Development & Business Technology Metrics** – knowledge designed to introduce professionals to ROI, EVA, TCO (and other) models for assessing business technology effectiveness. Business case development and due diligence should also be included here.

- **Project & Program Management** – knowledge about project management processes, methods and tools as well as program management processes, methods and tools. The range of areas would include several varieties of business technology project management and several varieties of program management including business technology acquisition strategies, managing outsourcing, service level agreements (SLAs), etc.
- **Procurement & Asset Management –** knowledge about how to optimally procure and management computing and communications assets.
- **Partner Management** – knowledge that includes approaches, methods and tools for managing relationships with distributors, re-sellers, service providers, etc.
- **Vendor Management** – knowledge that includes approaches, methods and tools for managing relationships with distributors, re-sellers, service providers, etc.
- **Regulatory Trends** – knowledge about regulations and regulatory trends in specific industries and hit lists for tracking legislation that could significantly impact business policies, processes and procedures.
- **Professional Communications** – knowledge that helps people understand the form and content of professional written and verbal communications especially as it involves the communication of business technology.

Appendix B

Computing Knowledge and Skills

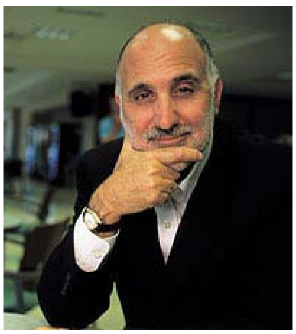
- Programming Fundamentals
- Integrative Programming
- Algorithms and Complexity
- Computer Architecture and Organization
- Operating Systems Principles and Design
- Net Centric Principles and Design
- Platform Technologies
- Theory of Programming Languages
- Human-Computer Interaction
- Graphics and Visualization
- Intelligent Systems (AI)
- Information Management (Data Base) Theory
- Information Management (Data Base) Practice
- Scientific Computing (Numerical Methods)
- Legal/Professional/Ethics/ Society
- Information Systems Development
- Analysis of Technical Requirements
- Engineering Foundations for Software
- Engineering Economics for Software
- Software Modeling and Analysis
- Software Design
- Software Verification and Validation
- Software Evolution (Maintenance)
- Software Process
- Software Quality
- Computer Systems Engineering
- Digital Logic
- Distributed Systems
- Security: Issues & Principles
- Security: Implementation and Management
- Systems Administration
- Systems Integration
- Digital Media Development
- Technical Support

Non-Computing Knowledge and Skills

- Organizational Theory
- Management of Information Systems Organization

- Decision Theory
- Organizational Behavior
- Organizational Change Management ...
- E-Business
- General Systems Theory
- Risk Management (Project, Safety Risk)
- Project Management
- Analysis of Business Requirements
- Embedded Systems
- Circuits and Systems
- Electronics
- Digital Signal Processing
- Very Large Scale Integrated Circuit (VLSI) Design
- Hardware Testing and Fault Tolerance
- Mathematical Foundations
- Interpersonal Communication

Biography



Dr. Steven J. Andriole was the Director of the Cybernetics Technology Office of the Defense Advanced Research Projects Agency (DARPA). He was also the Chief Technology Officer and Senior Vice President of Safeguard Scientifics, Inc. and the Chief Technology Officer and Senior Vice President for Technology Strategy at CIGNA Corporation. Dr. Andriole is currently the Thomas G. LaBrecque Professor of Business Technology at Villanova University where he teaches and directs applied research in business technology management. He is formerly a Professor of Information Systems & Electrical & Computer Engineering at Drexel University and the George Mason Institute Professor and Chairman of the Department of Information Systems & Systems Engineering at George Mason University.

Some of his books include *Interactive Computer-Based Systems Design and Development* (Petrocelli Books, Inc., 1983), *Microcomputer Decision Support Systems* (QED Information Sciences, Inc., 1985), *Applications in Artificial Intelligence* (Petrocelli Books, Inc., 1986), *Information System Design Principles for the 90s* (AFCEA International Press, 1990), the *Sourcebook of Applied Artificial Intelligence* (McGraw-Hill, 1992), a (co-authored with Len Adelman) book on user interface technology for Lawrence Erlbaum Associates, Inc. entitled *Cognitive Systems Engineering* (1995) and a book for McGraw-Hill entitled *Managing Systems Requirements: Methods, Tools & Cases* (1996). He has recently published articles in Software Development, IEEE Software, the Communications of the ACM, and the Cutter IT Journal. His most recent book – *The 2nd Digital Revolution* – was published by IGI Press in 2005.