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Information Systems Curricula: A Fifty Year Journey

Herbert E. Longenecker, Jr.
longeneckerb@gmail.com

David Feinstein
dfeinstein@usouthal.edu

School of Computing,
University of South Alabama
Mobile, AL 36688, USA

Jon D. Clark
jon.clark@colostate.edu
College of Business
Colorado State University
Fort Collins, CO 80524-1277, USA

Abstract

This article presents the results of research to explore the nature of changes in skills over a fifty year period spanning the life of Information Systems model curricula. Work begun in 1999 was expanded both backwards in time, as well as forwards to 2012 to define skills relevant to Information Systems curricula. The work in 1999 was based on job ads from 17 major national news papers. The ~3000 ads enabled generation of 37 skills and defined major areas of skills: software development, web development, database, operating systems and telecommunications, strategic organizational development, interpersonal and team skills, and project management. During the development of this research a ninth skill area was added: information and security assurance. The original 37 skills had been expanded to 69 skills, and within this effort, 69 additional skills were added. Analysis of the skills as of today suggested elimination of retired (24) and too new (13) skills. Of the remaining skills a set (35) of skills was common to all curricula, a large set of current skills (64) was abandoned by IS 2010 which added new skills (2). Deletion of programming as a requirement of IS 2010 accounts for a significant proportion of deletions.

Keywords: Information Systems Curriculum, IS 2002, IS 2010, AITP Model Curriculum, ACM Model Curriculum

1.0 Introduction

The ACM, the Association for Information Technology Professionals (AITP), formerly the Data Processing Management Association (DPMA), and more recently the Association for Information Systems (AIS) have taken the task of developing curricula for information systems for the past fifty years.

By the late 1960s it was recognized that computers were going to play a very important

role in business and industry, and there would also be a need for a highly trained work force. Likewise, it became apparent that there were significantly different interests in the nature of the needs for academic curricula.

Initial studies funded by the NSF were carried out by an ACM committee. The committee became known as the Committee *on Computer Education for Management*. Its work, *"Curriculum Development in Management Information Systems Education in Colleges and Universities."* was published in November 1965 (ACM, 1965). It became very clear to the committee that considering the program as an extension of the computer science curriculum would not solve the problem.

The ACM developed Curriculum 1968 for Computer Science (ACM, 1968), and a different group within the ACM developed model curricula for information systems for graduate programs (Ashenhurst, 1972) and for undergraduate programs (Couger, 1973).

Teichroew (1971) originally identified the need for information systems professionals: he cited department of labor figures that there would be a need for systems analysts (165,000) and computer programmers (154,000) over the subsequent five year period extending through the mid 1970s. He also established that there was inadequate preparation by academia, and a lack of clarity in communicating the needs expressed by business managers. He further recognized there was a lack of agreement regarding an expressed body of knowledge. It was further recognized that much of the education relating to the business application of computing was being provided by vendors.

All of the IS curriculum models have as a common goal to provide advice for college and university faculty that will guide the preparation of graduates. These graduates will be better prepared to enter the work force successfully. To clarify the expectations for graduates, all of the models present a conceptual framework of the exit level characteristics. Ashenhurst (1972) describes the characteristics of people, models, systems, computers, organizations, and society.. Appendix Table 1 is a presentation of this material. You will notice the use of learned capability verbs (knowledge, ability) to explain the depth of knowledge expected. Similar writing has been used in the subsequent models expressing as learning outcomes.

In this paper, our goal was to find a way to compare the model curricula. While the goals of the curricula may seem very similar, the detailed skill requirements have evolved over 50 years. Some issues remain unchanged: for example, programmers and analysts are still outputs from most of the model curricula. Likewise, the demand for our graduates has remained high since the very beginning of the discipline. While some of us may remember a heavy focus on accounting information systems, since the beginning there has been a much broader organizational focus. Dramatic changes occurred with the introduction of machines: mini-computers in the 1970s, pcs in the 1980s, and, more recently, PDAs. This brought computing into the realm of almost everyone in the developed world. The technology also went from individual stand along machines in the 50s and 60s to the ubiquitous connectivity we have today. These changes have had dramatic impacts on the information systems community on how we develop and deploy systems today.

Yet, because of the focus of information technologies enabling people to do their work, and thereby creatively support organizational success we find many similarities over the fifty year span. In order to try to find a consistent way to compare the various models we decided to examine the skills enabled by the various models. Haigood(2001), Landry(2000) , and Colvin (2008) examined approximately 3000 job ads in 17 major national news papers. Using a qualitative research technique of aggregating skill words associated with the ads and produced a list of about 50 skills. Surveys of faculty members in the US along with a factor analysis revealed that 37 of the skills were related to 8 factors. As it turns out, the 8 factors related to the exit characteristics expressed in IS'97 (Couger et al, 1997). These skill categories included: software development, web development, database, operating systems and telecommunications, strategic organizational development, interpersonal and team skills, and project management. The same 37 elements were re-surveyed in 2007 and were found to be almost identical in identifying the same 8 factors, and skill depths found (Landry, 2000; Colvin 2008). The skills are not product specific; but rather they are general in nature.

Since 2000 we have updated these skills with increasingly more current information by analysis of the curricula of IT (2008) and the ACM/AIS groups. We also have added material based on the DAMA body of knowledge (Henderson, et al 2004; Longenecker, et al, 2006), and the Department of Defense NICE specification (NICE, 2010, 2012). As a direct result of studying the NICE skill set, we added a skill category in Information Assurance and Security. . The result of these additions produced an expanded list with 69 skills compatible with current documents.

2.0 Method of Study

The following model curricula were included in this study: IS'72 (Teichroew, et al, 1971; Ashenhurst, 1972; Couger, 1973), IS'81 (Nunamaker, et al, 1982), DPMA '86 (DPMA, 1986), IS'90 (Longenecker, et al, 1991a, 1991b, 1991c), IS'97 (Longenecker et al, 1995; Gorgone, et al, 1995; Davis, et al 1997; Couger 1997), IS 2002 (Gorgone, et al, 2003), and IS 2010 (Topi, et al 2010). In our work here we did not report separately on IS'97 since it was totally included within IS2002.

For all elements mapped we used the skill depth criterion established in IS'90 (Longenecker, et al, 1990) and utilized in subsequent models. The criterion was based on the Bloom (1956) task force which described a taxonomy of cognitive skills. The Bloom task force was trying to utilize a uniform method for describing learning objectives. The IS'90 modification to Bloom's taxonomy split the first level into two categories:

Level	Meaning
1	Recognize
2	Differentiate
3	Use (or translate, explain)
4	Apply (without direction or hints)

IS'97, IS 2002, and IS 2010 present a table that contains examples of the use of learned capability verbs characteristic of knowledge specifications at each level. We utilized our understanding of these tables to grade the complexity of the curriculum learning outcomes, or equivalent.

Not all items mapped exactly, so we found it necessary to add new skills to our initial list. The revised list added 69 newly written skills giving a total of 138. Skills were added to this list because of a lack of fit to the original 69 skills. As new skills were added, we went back through all of the curriculum models used and made additional mappings for the newly abstracted skills if that seemed necessary.
A criterion for mapping a skill to a curriculum was that there had to be a learning outcome (or equivalent, e.g. learning unit) that specified the requirement for that skill as a course outcome. That is, general pronouncements about the nature of the curriculum were not used, unless they were codified in learning outcomes.

3.0 Results

Appendix 2: Table 2 and Appendix 3: Graphs summarizing the same information is summary of all of the curriculum mappings to the skill sets. The left set of columns show the mapped result from the various curricula reviewed. The right set of columns is the skills. The skills are presented as a three level hierarchy. The categories of sub-skills were described in Landry (2000). A new category 1.5 was added due to the increasing awareness that information security assurance is becoming of increasing importance for information systems (Dhillon, 2007; Whitman, et al 2007, 2010, 2012). The sub-skills in this area are based on statements within the NICE objectives for professionals (NICE, 2011).

Subsequently, we broke the skills into categories base on their historical placement in the various curricula. Table 3 shows the result of this analysis. Categories A through G were created, and tabulated for each category:

A. 21 skills relatively common to all models

B. 14 skills relatively common to later models

C. 53 skills relatively common to later models yet were dropped by IS 2010

D. 11 skills relatively common to all models except dropped by IS 2010

E. 24 skills relatively common to earlier models but dropped in all later models

F. 2 Skills added uniquely in IS 2010

G. 13 Skills based on NICE (2012) specifications but not in any curriculum model

In order to begin to understand the current situation, we grouped some of the above categories:

138	Total Number of Skills
24	Retired Skills (E)
13	New Skills not in any model (G)
101	**Active Skills**
21	Skills mostly in all programs (A)
14	Skills added in later models (B)
65	**Skills Current Through 2010**
53	Later skills, dropped by IS 2010 (C)
11	All models, dropped by IS 2010 (D)
2	Skills New from IS 2010 (F)
0	All Skills Accounted

It makes sense for the Skills in Category E s to become extinct. They were based on support for very different types of computers than those in use today. They relate specifically to problems that had to be solved to make old mainframe computers work.

Category G skills are sufficiently new that there has not been time for curriculum writers to include them in newer models. Since security issues are being recognized only currently, it seems that it is a matter of time before such specifications will emerge. However, for today skills categories E and G reflect skills that are not immediately relevant. This leaves 101 skills for consideration.

It might be argued that Categories A, B, and D (46 skills) have always been relevant in IS curricula, except that Category D (11 skills) were dropped by IS 2010.

In addition, Categories C (53 skills) and D (11 skills) are arguably still considered relevant; however they were not included in IS 2010. These 64 skills represent a very considerable contraction of focus in information systems curricula. Of these skills Applications Development represents almost ¼ of the skills that were not included.

An inspection of 240 business school information systems curricula (Apigian, 2010) found that a significant majority of IS programs offered courses with titles similar to:

Fundamentals of IS
Data and Information Management (database)
Systems Analysis and Design
IT Infrastructure (network communications)
Application Development (programming)

Interestingly, 99% percent of schools offered one or more courses in programming thus the lack of its inclusion in IS'10 is a significant change. This is one of the skills may be questionable.

The work of Apigian and Gambill (2010) represents a reasonable way of formulating an update to the current model curricula. University faculties live under many constraints, one of which might be addressing a new curriculum model. With the pressure to prepare their graduates to be relevant to the working world, attention must be paid to many factors. It is important to note that Apigian and Gambill gave numerous examples of the ability of faculty to take approaches to solve their own unique environmment. Therefore, they state that no program is in full alignment with any model curriculum.

4. Conclusion

We have found that IS curricula have evolved significantly over the past fifty years. We have used the skill set in IS 2000 and augmented it back in time. We have also worked forward in time through 2012 incorporating IS 2010, NICE, and DAMA additions to the skills. Using this expanded skill set we were able to score curricula from 1972 through 2012 for their ability to generate the specific skills.

Then by grouping the skills according to use by the various models, we were able to show that of the 138 total skills, 37 skills were either retired of too new to be included in any of the models. Of the remaining 101 skills, some were common to all programs (35), remaining skills were common for programs up to IS 2010 when a significant number were abandoned (64). IS 2010 two skills in the enterprise computing realm. Possibly the most significant loss of skills in IS 2010 can be attributed to the deletion of a programming requirement. This appears to be inconsistent with the data of Apigian and Gambill that showed the overwhelming majority of IS programs housed in a school of business.

While the world advances, many of the principles and skills of our discipline are recurring; they have existed over the fifty year period. These skills partially define the discipline. There is no doubt that new technology can and will effect the curriculum. With a current and future focus

on powerful smart phones and similar devices, our definition of ubiquitous computing will have to evolve another level. Likewise, security issues have risen to the level of extreme importance. Indeed, the curriculum Over the next 50 years curriculum may change more dramatically than the past 50 years Who will be the individuals making the important decisions in 2060?

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ISSN: 2167-1435
v29 n1967

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v29 n1967

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ISSN: 2167-1435
v29 n1967

Appendix

Table 1: Output Characteristics of Graduates

(a) people
ability to hear others, as well as listen to them;
ability to describe individual and group behavior and to predict
likely alternative future behavior in terms of commonly used variables of psychology and economics;
ability to describe and predict task-oriented, time-constrained behavior in an organizational setting.

(b) models
ability to formulate and solve simple models of the operations research type;
ability to recognize in context the appropriate models for situations commonly encountered.

(c) systems
ability to view, describe, define any situation as a system—specifying components, boundaries, and so forth;
ability to apply this "systems viewpoint" in depth to some class of organizations--manufacturing firms, government bureaus, universities, hospitals, service providers, etc.;
ability to perform an economic analysis of proposed resource commitments (includes ability to specify needs for additional information and to make a set of conditional evaluations if information is unavailable);
ability to present in writing a summary of a project for management action (suitable to serve as a basis for decision);
ability to present in writing a detailed description of part of a project, for use in completing or maintaining same.

(d) computers
knowledge of basic hardware/software components of computer systems, and their patterns of configuration;
ability to program in a higher-level language;
ability to program a defined problem involving data files and communications structures;
ability to develop several logical structures for a specified problem;
ability to develop several different implementations of a specified logical structure;
ability to develop specifications for a major programming project, in terms of functions, modules and interfaces;
knowledge of sources for updating knowledge of technology;
ability to develop the major alternatives (assuming current technology) in specifying an information processing system, including data files and communications structures, to the level of major system components;
ability to make an economic analysis for selecting among alternatives above, including identification of necessary information for making that analysis, and also to identify noneconomic factors;
ability to make "rough-cut" feasibility evaluations (in terms of economic and behavioral variables) of proposed new techniques or applications of current technology, identifying critical variables and making estimates and extrapolations;
ability to develop specifications for the computer-based part of a major information system, with details of task management and data base management components.

(e) organizations
knowledge of the function of purposeful organizational structure, and of the major alternatives for that structure;
knowledge of the functional areas of an organization--operations, finance, marketing, product specification and development;
ability to identify in an ongoing organizational situation the key issues and problems of each functional area;

ISSN: 2167-1435
v29 n1967

knowledge of typical roles and role behavior in each functional area;
ability to identify possible short-term and long-term effects of a specified action on organizational goals;
ability to identify information needs appropriate to issues and roles above;
knowledge of how information systems are superimposed on organizational patterns, on the operational, control, and planning levels;
knowledge of techniques for gathering information;
ability to gather information systematically within an organization, given specified information needs and/or specified information flows;
ability to specify, given information needs and sources, several alternative sets of information transfers and processing to meet needs;
ability to make "rough-cut" feasibility evaluations of such alternatives;
ability to develop positive and negative impacts of a specified information system on specified parts of an organization;
ability to develop specifications for a major information system, addressing a given organizational need, and determine the breakdown into manual and computer-based parts.

(f) society
ability to articulate and defend a personal position on some important issue of the impact of information technology and systems on society (important, as defined by Congressional interest, public press, semi-technical press, etc.);
ability to develop several positive and several negative impacts of a specified information system in a specified part of society;
ability, given such specifications of impacts, to perform a "'rough-cut" feasibility analysis of them in terms of behavioral and economic variables.

Output Characteristics of Graduates: The text in this table is taken from Ashenhurst (1972) in its entirety. It is typical of similar tables expressed in later curriculum models.

ISSN: 2167-1435
v29 n1967

Appendix 2

Table 2. Skill Depths Achieved for Indicated Model Curricula

Model Curriculum						Each skill was mapped to course outcomes in the applicable model curriculum. Only courses which were part of the requirements for the degree were considered—electives not required of all students were not included. Skill depths were originally defined in IS'90 and refined in IS'97—they were used in IS'97, IS2002 and IS2010 without change.		
73	81	86	90	02	10			
Skill Depths **1 – Recognize** **2 – Differentiate** **3 – Use** **4 – Apply**						**Skill**	**Skill Name**	**Skill Words**
						1.0 Information Technology Skills **1.10 Software Development**		
2	3	1	3	2	2	1.1.0	Low level data structures	bits, bytes, number representation, money representation, character representation, rounding operations, overflow
3	3	3	4	3		1.1.1	Programming-principles, objects, algorithms, modules, testing	principles, concepts, control structures (sequence, selection, iteration); modularity, objects and ADTs, data structures, algorithmic design, verification and validation, cohesion, coupling, language selection, user interface design, desk checking, debugging, testing, error correction, documentation, installation, integration, operation; writing code in a modern programming language (e.g., Java, C#); interpreted and compiled computer languages; design tools; secure coding principles and practices
	3		3	2		1.1.2	Application Development-requirements, specs, developing, HCI considerations	principles, concepts, standards; requirements, specifications, HCI planning, device optimization (e.g. touch screen, voice), development and testing, utilization of IDEs, SDKs, and tool kits; configuration management, installation, module integration; conversion, operation
2	2	2	3	3	2	1.1.3	Algorithmic Design, Data, Object and File Structures	analysis, design, development, debugging, testing, simple data structures(arrays, records, strings, linked structures, stacks, queues, hash functions). Functions, parameters, control structures, event driven concepts, OO design, encapsulation, classes, inheritance, polymorphism, sorting, searching

ISSN: 2167-1435
v29 n1967

	3	2	2	3		1.1.4	Problem Solving-identify problems, systems concepts, creativity	devise questions to help identify problems, apply systems concepts to definition and solutions of problems, formulate creative solutions to simple and complex problems, Fishbone-root cause, SWOT, Simon Model, Triz, ASIT; embracing developing technology; methodologies (waterfall, object, spiral etc.), dataflow, structured
			2	2		1.1.5	Client Server Software Development	thin/full client; software specs, development, testing, installation, configuration, trouble-shooting, enhancement, maintenance, training and support; report/interface, development, documentation standards, application configuration management--e.g. Source-safe; Drop box, project documentation
			3	1		1.1.6	HCI Principles and Paradigms	human-computer interfaces, user interfaces, man-machine interfaces, "8 golden rules"; keyboards; touch technology, voice, video, real-time signals, GPS
						1.1.7	Digital Media	standards for sound, video (still and full motion) including wav, jpeg, tiff, raws
						1.1.8	Software Security	vulnerability, dependability, trustworthiness, survivability, resilience, threat and vulnerability analysis; software assurance; translation of security requirements in application design; secure code documentation; developing countermeasures to identified risks; assessment of vulnerabilities and risks
		2		2		1.1.9	Prototype	storyboard, build, simulate, test, re-develop
			1	1		1.1.10	Code Generators	Compilers, interpreters, specialized code segment generators
3	1					1.1.11	Storage Management	real and virtual storage, allocation and deallocation, distributed systems; stacks; garbage collection
1	1					1.1.12	Multiprogramming and Multiprocessing	jobs, job linkage, modes (batch, interactive processing), performance monitoring
3	3	2				1.1.13	File Systems	physical allocation, devices, capacity management, access modes (sequential, indexed sequential, random)
1	3		1			1.1.14	Machine Structures	words, addressing, sequential allocation, linked allocation, pointers and indirect addressing, pointer manipulation; Machine and assembler languages
	3					1.1.15	Computer Operations	input, output, jobs, job control, performance control
2	2					1.1.16	Systems of Programs	programming a system of related program components, intertask communication and linkage, run-time data storage; code sharing, reentrancy, relocatibility, dynamic linking and loading; multi-tasking
2	2	2	3	3		1.1.17	Testing	segment testing, module testing, program testing, system testing; test data, and testing strategies
3	3	2	3	3		1.1.18	Procedural Languages	FORTRAN, COBOL, PL1, BASIC, C; advanced functions (sorting, searching, mathematical and statistical routines); functions; subroutine libraries
				1		1.1.19	Object Oriented Languages	C++, C#, VB
						1.1.20	Logic Programming	Lisp, Prolog
2	2	2				1.1.21	Input Devices	cards, tape, terminals, work stations, thin clients, microphone, video, data capture, data entry mechanisms
2	2	2				1.1.22	Output Devices	cards, tape, terminals, work stations, printers, audio, video, controlled devices
	2			2		1.1.23	Information Systems	users, business process, programs, hardware, communication systems, applications,

ISSN: 2167-1435
v29 n1967

								projects, services
						1.20 Web Development		
				3		1.2.1	Web page Development-HTML, page editors, tools	FrontPage, HTML, page building/edit tools, frames; http, Dreamweaver, Photoshop
				2		1.2.2	Web programming-thin client, asp, aspx, ODBC, CGI,E-commerce, web services, scripting	thin client programming: page design; HTML, *.asp/aspx coding; session variables / page security; ODBC; CGI programming; integration of multi-media; e-commerce models; tools: Perl, Visual Studio, Java, Web services, XML server / client side coding, web services, hypertext, n-tier architectures; integration of mobile technology
				2		1.2.3	Web Systems Development Tools	e.g, sharepoint, Joomla, Drupal, IDEs, SDKs, snagit, Jing
						1.2.4	Web Security and Vulnerability	vulnerability, penetration testing, vulnerability scanning; browser security; external memory issues
						1.30 Database		
2	2	1	3	4	4	1.3.1	Modeling and design, construction, schema tools, DB systems	Data modeling, SQL, construction, tools -top down, bottom up designs; schema development tools; desk-top/enterprise conversions; systems: Access, SQL Server/Oracle/Sybase, data warehousing & mining; scripts, GUI tools; retrieve, manipulate and store data; tables, relationships and views
	1	1	2	3	2	1.3.2	Triggers, Stored Procedures, Audit Controls: Design / Development	triggers, audit controls-stored procedures, trigger concepts, design, development, testing; audit control concepts/standards, audit control Implementation; SWL, concepts, procedures embedded programming (e.g. C#)
	1	2	1	1	2	1.3.3	Administration: security, safety, backup, repairs, Replicating	monitoring, safety -security, administration, replication, monitoring, repair, upgrades, backups, mirroring, security, privacy, legal standards, HIPAA; data administration, policies
						1.3.4	Metadata: architectures, systems, and administration	definition, principles, practices, role of metadata in database design, repository, dictionaries, creation, ETL, administration, usage, tools
					2	1.3.5	Data Warehouse: design, conversions, reporting	star schema, ETL, data cleansing and storage, reporting tools, business intelligence, analytic queries, SQL OLAP extensions, data mining
	1			2	2	1.3.6	Data Quality: dimensions, assessment, improvement	Data Accuracy, Believability, Relevancy, Resolution, Completeness, Consistency, Timeliness; Data definition quality characteristics, Data model / requirements quality characteristics; Data clean-up of legacy data, Mapping, transforming, cleansing legacy data; Data defect prevention, Data quality employee motivation, Information quality maturity assessment, gap analysis
						1.3.7	Database Security	SQL injection attacks and counter measures; encryption; limiting exposure in internet

								applications; risk management: attacks and countermeasures
		1	1	2		1.3.8	Data sources and advanced types	Accessing external data sources; use of search engines; purchasing data; image data; knowledge representations
	2	2				1.3.9	Data Models	Hierarchical, Network, Relational; DDL, DML considerations; GUI, script representations
						1.40 Systems Integration		
2	3	2	2	3		1.4.1	Computer Systems Hardware	fundamentals: cpu computer system block diagram, firmware, digital logic, serial vs parallel, bus, interface components; memory addressing, coding, data representation; assembler, multi-processors, DMA,, disk, tape, interrupts; embedded systems; fault tolerance; microprocessors
	1		1	4	2	1.4.2	Networking (Lan/Wan) and Telecommunications	fundamentals: encoding, data transmission, noise, media, devices, layered models, TCP/IP, telephony, network architecture; communication protocols such as TCP/IP, Host configuration, Domain Name Server
		1	1	2		1.4.3	Operating Systems Management-multi platforms/protocols, Win/Unix/Linux/VM	multi platforms, multi protocols; systems Win XP, Win 2003 Unix; Linux, installation, configuration; security; connectivity, performance monitoring, virtual machine emulations; Open Systems models; distributed computing
2	3	2	1	2		1.4.4	Computer Systems Software-OS fundamentals, resource mgt concepts	OS fundamentals: memory, disk, tape and resource management, remote scheduling, memory management, device management, security, file systems, real-time and embedded systems, fault tolerance, scripts; interoperability
				3	2	1.4.5	LAN/WAN Design and Management	Ethernets, hubs, routers, TCP/IP, internet, intranet; enterprise networking, Lans/Wans, network administration, design, configuration, installation , optimization, monitoring, testing, troubleshooting, router configuration, router, protocols, switches, firewalls and security, wireless considerations; network security architecture-defense in depth principles; network access and authorization (e.g. public key infrastructure); security objectives, operational objectives and tradeoffs; security controls; identification and vulnerabilities
				2		1.4.6	Systems Configuration, Operation, Administration	architecture, configuration, conversion, management, economics, installation, integration, administration, monitoring, maintenance, upgrades, documentation service pack scheduling, client services, users and user groups, replication backups, disaster planning and recovery, site management, COOP, power management, multi-site fail-over mechanisms, user education; security audit procedures; virtualization; fault tolerance
2						1.4.7	Inter-systems Communications	Customer Information Control System/Inter-systems Communications(CICS/ISC)
						1.4.8	Data mapping and exchange	types include bidirectional, unidirectional, translation key (ex. SNOMED to ICD-9)
	2		2	2		1.4.9	End-user interface	Terminals, GUI, multimedia, browsers; resource requirements, operating system drivers, communication protocol

ISSN: 2167-1435
v29 n1967

2	1					1.4.10	Communication system hardware	channels, channel capacity, noise, error detection/correction; regulatory agencies, tariffs; transmission codes, transmission modes
	1					1.4.11	Communication system organization	single line, point to point, multi-drop; networks: centralized and decentralized; control protocol; switched, store forward; concentrators
						1.50 Information Assurance and Security		
			1	2	2	1.5.1	Information Assurance Model	Security services, information states, security countermeasures, Security implementation: gates, guards, guns; cryptography, Disaster recovery, Business continuity planning, forensics; IA architecture
						1.5.2	Security Mechanisms	cryptography: cryptosystems, keys-symmetric/asymmetric, performance authentication (who you are, what you have/know), passwords bio-authentication; Redundancy, intrusion detection
				3	2	1.5.3	Security Operations	ethical/legal issues, auditing, costs/benefits, standards-DES, ISO 177799 risk identification/mitigation, physical security implementation business impact analysis, CASPR, technology innovation and risk incident management, enforcement
		2			2	1.5.4	Security Policy	IAS policy/procedure creation, vulnerability, countermeasures security technology and system access (multi-levels classification e.g. unclassified, top secrete ...), property seizure information management/system administration and security,security services: availability, integrity, authentication user education; develop/update security policies and implement system designs which meet objectives (confidentiality, integrity, availability...)
						1.5.5	Security Attacks	denial of service, protocol attacks, active/passive attacks, buffer overflow attacks, viruses, Trojan horses, worms, adware, penetration testing, digital forensics, legal evidence, media analysis, threat analysis: risk assessment and cost benefit to business processes vulnerability--perpetrators: inside / external, hacker / cracker; hardware / software. Firewalls, demilitarized zones, and encryption; Use of tools to detect network intrusions and vulnerability
2	1	2	2	3	2	1.5.6	Privacy Impact	Requirements for confidentiality, integrity and availability; privacy impact analysis of application security design protecting personal identifiable information.
						1.5.7	Information Assurance Systems	documentation of information assurance components which allocate security functions
				3		1.5.8	Information Systems Email Management	application of confidentiality, integrity and availability principles; threat and vulnerability analysis; detection of security gaps in application and system architectures
				2		1.5.9	Information Technology Security Principles	IA certification and accreditation; process activities and related documentation, system life-cycle support plans, concepts fo operations, procedures and trainng materials; security risks and countermeasures; security controls needs; security management; concepts of policy-based and risk adaptive access controls
						2.0 Organizational and Professional Skills **2.10 Business Fundamentals**		

3	1	2	2	2	2	2.1.1	Learning Business Process and Environment	learning business process and environment, exchanges, competitive position, e-business, global concepts, business models, Creating value, Value chain, improving value creation; financial markets, determining value of securities; organizational models
			2	2		2.1.2	Accounting, Distribution, supply chain management, Finance, HR, Marketing, Production, payroll, inventory processing	accounting (language of money, representations of accounts, reports), distribution (purchasing, supply chain management, distribution systems), finance, human resources (laws, compensation, recruiting, retention, training), marketing (the market, customers and customer satisfaction, market strategies, cycle time and product life cycle; environment scanning), production, international business
		2		3	3	2.1.3	Business Problems and Appropriate Technical solutions, end-user solutions	business problems and appropriate technical solutions; quantitative analysis and statistical solutions; decision formulation and decision making; business intelligence systems; business use of spreadsheets, desk-top databases, presentation software, word processing and publishing
	1		2	2	1	2.1.4	Business Law	legal system, courts, dispute resolution processes (mediation, arbitration, conciliation, negotiation, trial); types of organizations, contracts, warranties, and product liability; policy and management of intellectual property
			1		3	2.1.5	Disaster Recovery	identify essential system functions to support business functions for restoration and recovery after a catastrophic failure; define requirements for critical system performance and continuity of business function; backup, replication, fail-over processes in support of system performance subsequent to a disaster
				2	3	2.1.6	Enterprise Information Systems and Business Intelligence	Alignment of business processes with large system structures; configuration of large systems; implementation and training; integration with business intelligence capabilities and optimization of business procedure.
	1			2		2.1.7	Modes of Business	B to B, B to C, C to C, B to G, C to G; organizational span (individual, work group, department, enterprise, inter-organization)
			1	1		2.1.8	Regulations	Federal and State Regulations; compliance, audits, standards of operation (e.g. FAR); agencies and regulatory bodies
				1	1	2.1.9	IT Standards	ITIL, CORBA
3	2	2	2	3		2.1.10	IT Support for Business Functions	Business systems (budget, personnel, capital, equipment, planning, training, control); Specific systems (production, financial, accounting, marketing, supply chain, securities, taxation, regulation compliance)
3	1					2.1.11	Operational Analysis	scheduling, allocation, queuing, constraint theory, inventory management models, financial models, forecasting, real time analysis; linear programming, simulation
2	1					2.1.12	Managing the IS Function	Development, deployment, and project control; managing emerging technology; data administration; CIO functions; security management
		2		1		2.1.13	Information Center Service	PC Software training and support; application and report generators, IS Development, Development and operations staff; corporate application management, data safety and protection, disaster recovery
						2.20 Individual and Team Interpersonal Skill		

			1	2		2.2.1	Learning to learn	attitude of personal responsibility, journals, learning maps, habits of reading, listening to tape/cd, attending professional seminars, teaching others, meta-thinking, life long learning; human learning: recognition, differentiation, use, application, analysis, synthesis and evaluation
	1	2	2	3		2.2.2	Professionalism-self directed, leadership, time management, certification, conferences	being self-directed and proactive, personal goal setting, leadership, time management, being sensitive to organizational culture and policies; personal development (conferences, read literature, use self-development programs)
	1		2	2		2.2.3	Personal Skills-encouraging, listening, being Organized, principles of motivation	encouraging, listening, negotiating, being persuasive, being organized Personality types and relationships (DISC, MBTI, COLOR)
	1	1		1		2.2.4	Professionalism-committing to and completing work	Persistence, committing to and rigorously completing assignments, can-do
2	2	1	2	2	2	2.2.5	Teams-team building, vision / mission development, synergy building and problem solving; leadership	team building, vision and mission development, planning, synergistic consensus team leadership, leadership development, negotiation, conflict resolution
2	1		3	2		2.2.6	Communication-oral, written, multimedia, empathetic listening	oral, written, and multimedia techniques; communicating in a variety of settings; empathetic listening, principle centered leadership, alignment technical memos, system documentation, technical requirements; necessity for involvement; development of resistance
			3	3	2	2.2.7	Ethics-theory/concepts, setting an ethical example	ethical theory and concepts, codes of ethics--AITP/ACM; setting an ethical example; ethical policies, intellectual property, hacking, identity theft
	1			2		2.2.8	Critical Thinking	fact recognition, argument strength, analysis (break into components), synthesis(assembling the components); abstraction; qualitative research principles
2	2	2	2	2		2.2.9	Mathematical Fundamentals	Mathematics (algebra, trigonometry, variables, operations, expressions, logic, probability, limits, statistics)
	1	1	2	2	2	2.2.10	Collaboration support by IT	It Solutions for Individuals and Groups, Problem solving mechanisms in support of meetings, consensus development
	1		3	2	2	2.2.11	Impact of IT on Society	IT impact on individuals, on groups, on enterprises, on societies; knowledge work and support by IT; computer industry and society, work force requirements
		1		2		2.2.12	IT Career Paths	Programmers, Application Developers, Information Analyst, Systems Analysis, Data Management, CIO, CTO
			1	2		2.2.13	HCI Principles: underpinnings	Cognitive Process, education learning levels, interface design, concepts of usefulness, the 8 golden rules
				2		2.2.14	Individual behavior	learning styles (visual, auditory, kinesthetic), motor skills, linguistic mechanisms, auditory mechanisms
	1			1		2.2.15	Cognition	concepts of learning; sequential levels of learning (recognition, differentiation, use /

ISSN: 2167-1435
v29 n1967

								translation, apply); relationship of learning and emotion
	1	1	1	1		2.2.16	Develop Consultant Characteristics	build relationship, identify need, present alternatives, provide assistance as needed, make recommendations, be supportive
						2.30 Social Implications of Technology		
1		2				2.3.1	Historical perspectives	economic and social issues of technology development; benefits and threats of technology; availability of information; technology and the quality of life
1		2				2.3.2	The computer industry	competition, technology advances, pricing, government regulation, increasing cpu power, increasing storage capacity, higher speed communication, higher speed processors
1		1				2.3.3	Job displacement	technologic advances generate efficiencies in work flow generate a need for fewer people for current tasks; need for continuous re-training
2				2		2.3.4	IT effects on Individuals	Automated record keeping (academic transcripts, checking accounts, mortgage accounts, legal system, government services, welfare management); weather forecasting, national repositories of information; healthcare systems and management
		3		2		2.3.5	PC Impact	changing responsibilities, decentralization, increase in personal productivity, direct executive support and power
						2.40 Personal Computer		
		2				2.4.1	History	Initial introduction by IBM, Apple; PC as '83 Man of the Year, Growth of Intel, growth of entire related industry
		2				2.4.2	Work station	LAN connection, PC-operating system, end-user software, browsers
		3		3		2.4.3	Personal productivity	PC tools, PC applications, personal application development
				3		2.4.4	Internet access	Browsers, http, e-commerce, email, access to the world
		1		3		2.4.5	E-mail	instantaneous access to people, access to search engines, access to storage
		1		3		2.4.6	Business software	personal applications, enabling of work-from-home, remote work group support, project management, collaborative software, group information systems, access top accounting systems and banks, entertainment
		3		3		2.4.7	Spread sheets	executive tool, financial accounting, graphics, what-if analysis
		1		3		2.4.8	Database	Relational DBMS, application support, spread sheet integration
						3.0 Strategic Organizational Systems Development **3.10 Organizational systems Development**		

ISSN: 2167-1435
v29 n1967

1	3	2	2	4	4	3.1.1	Strategic Utilization of Information Technology	use of IT to support business process, integration of customer requirements; team development of systems, reengineering concepts and application, methodologies, interfaces, systems engineering, CRM and ERP concepts; Agile, Object, Lean UX and other methodologies; identification of security issues, incorporation of security concepts into designs ensuring security principles; development of IS policy
	3		2	2	4	3.1.2	IT Planning	value of IT, integration of IT in reengineering, IT policy, end user advocacy and optimization, IT advocacy and alignment outsourcing / off-shoring (risks, benefits, opportunities), training; capture security controls and requirements, ensure integration of security objectives, assurance of people and information protection; ensure security in interface considerations
	2		2	2	3	3.1.3	IT and Organizational Systems	types of systems relationship of business process and IT, user developed systems, use of packaged software, decision systems, social systems; information assurance and security designs; IT support of end-user computing, group process and computing, and enterprise solutions
3	3	3	3	4	3	3.1.4	Information Systems Analysis and Design	investigate, information analysis, group techniques / meetings design, systems engineering, Information architectures, enterprise IS development with strategic process; consideration of alternatives; application and security planning; conversion and testing, HIPAA, FERPA, ISACA, GAAP; requirements analysis. cost analysis, cost/benefit, satisfaction of user need / involvement, development time, adequacy of information assurance controls; consideration / adoption of emerging technology (e.g. mobile computing), consideration of optimal life-cycle methodologies and tools; physical design (database, interface design, reports design, programming, testing, system testing)
	2	2	2	2	2	3.1.5	Decision Making	personal decision making, Simon's model, structured, unstructured decisions, decision tools, expert systems, advanced problem solving (Triz, Asit); business intelligence, advanced reporting technologies.
2	1	1	2	2	3	3.1.6	Systems Concepts, Use of IT, Customer Service	develop client relationships, understand and meet need, involving the client at all phases of the life-cycle; review of customer functional requirements; consideration of improved business process; assurance of customer needs into requirements analysis
2	2		1	2		3.1.7	Systems Theory and Quality Concepts	system components, relationships, flows, concepts and application of events and measurement, customer expectations, quality concepts; boundaries, open systems, closed systems, controlled systems; effectiveness, measuring system performance, efficiency
			1	1		3.1.8	CMMI and Quality Models	quality culture, goals; developing written standards, templates; process metrics development process improvement through assessment, lessons learned

			2	2	2	3.1.9	Systems Engineering Techniques	scope development, requirements determination, system design, detailed design and specifications, Enterprise Architecture, System architecture, information architecture, make or buy, RFP/Bid Process verification and requirements tracing, validation planning and test case development, unit testing, integration, system testing, system certification, system acceptance, installation and operation of the system, post-implementation audit; ensuring security designs, secure configuration management; agency evaluation and validation of requirements; ensuring customer training and incorporation of installation teams
		2	3	4		3.1.10	End-User Systems	individual software: word processing, spreadsheets, database, presentation, outlining, email clients, statistical packages; work-group software; enterprise software: functional support systems (e.g. PI), enterprise configuration
	1	1	1	1	3	3.1.11	Enterprise Information Systems in Support of Business Functions	Systems that support multiple enterprise functions (e.g. SAP); Electronic Medical Record Systems for physician-groups, and for hospitals; Cloud solutions for individual and organizational support; TPS, DPS, MIS, EIS, Expert System
				2		3.1.12	Emerging Technology	Bleeding edge technologies; testing and adoption of new technologies; cost benefit of new technologies
2	1	2	2	2		3.1.13	Systems Roles in Organizations	operations, tactical, strategic
	1			2		3.1.14	Organizational Models	Hierarchical, Flow Models, Matrix
1		1		2		3.1.15	Metrics and Improvement	Development metrics, quality metrics, metrics in support of 6-Sigma or CMMI, customer satisfaction; Learning Cycles (Understand the problem, plan, act, measure/reflect and learn and repeat the cycle), Lessons Learned (what was supposed to happen, what happened, what was learned, what should be done, communicate the observations)
2	3					3.1.16	Hardware selection, acquisition, and installation for project	Determination of capacity for process, storage devices, and communication systems; consideration of alternative hardware; bid preparation, bid evaluation, and final system selection; hardware installation and testing; system deployment and initial operation.
		1	1	1		3.1.17	Facilities Management	Physical facility construction, access control, fire protection, prevention of flooding; power management (public utilities, generators--fuel storage, testing, battery management--lightening protection), air conditioning, fire prevention systems, physical security, protection from weather
2		1	1			3.1.18	Maintenance Programming	Fault detection and isolation, code correction, code testing, module testing, program testing; code, module, system documentation
			1			3.1.19	Decision Structure	structured, unstructured decisions, decisions under uncertainty, heuristics, expert systems
	1		1			3.1.20	Decision Tools	application results, idea generation, Delphi, nominal group, risk analysis, cost benefit analysis
	2	2				3.1.21	Structured development	process flows, data flows, data stores, process logic, database design, program specifications and design
						3.1.22	Object Oriented Development	UML; class diagrams, swim lane, use case, sequence diagram, design patterns
	1	1				3.1.23	Screen Design	menus, input forms, output forms and reports, linkage of screen modules, navigation

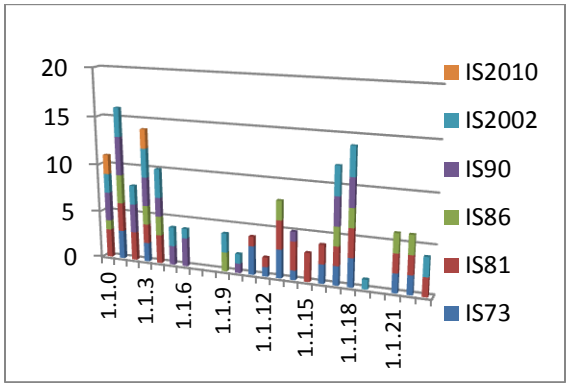
		1				3.1.24	Frameworks and Libraries	object libraries, source libraries, language extensions
2		1				3.1.25	Reports Development	simple lists, control break--group by--reports, error reports, exception reports, graphics reports, audit reports
						3.1.26	Develop Audit Control Reports	Document new accounts with public information: names, addresses, organizations, items, events
		1				3.1.27	Develop cash audits	deposits, batches, accounting variable controls, accounting distributions
						3.1.28	Audit analysis of separation of function	establish roles of staff, validate transactions, validate personal functioning
						3.1.29	Audit risk and disaster recovery strategies	determine risks, verify adequacy of mitigations; audit failure processes, replication, and failover mechanisms; audit backup strategy and physical results
						3.20 Project Management		
2	1	2	2	3	2	3.2.1	Project Goal Setting and Planning	establish project goals consistent with organizational goals as well as re-engineering initiatives; project plan and scope statements: cost, schedule and performance; project initiation, project charter
1	1	2	1	1	2	3.2.2	Monitor and Direct Resources and Activities, Team Leading	specify, gather, deploy, monitor and direct resources and activities, team charter, RACI charts, project team building, team assessment
2	2	2	2	2	2	3.2.3	Coordinate Life Cycle Scheduling and Planning	life cycle coordination, consultant management, schedule management, use of project planning; reporting; documentation
1				1	2	3.2.4	Apply concepts of continuous improvement	apply concepts of continuous quality improvement, providing reliable, cost-effective solutions that satisfy formal standards for performance, capacity, reliability, security, and safety; concept of standard practice--IEEE; ISO 9000;CMMI, 6 Sigma, Federal, state and local quality initiatives
2	2	1	2	2	3	3.2.5	Project Scheduling and Tracking	planning, scheduling and milestones; selection of process model; organizational issues; work breakdown structures; staffing; cost estimation, cost/benefit resources allocation, reviews, measurement, feedback, communication, ensuring quality, use project management software (PERT and Gantt Charts)
	1	1	1	1	2	3.2.6	Project Communications	Formal, informal, nonverbal communications; media selection: hard copy, phone, email, meetings, web conference. Individual, group communication. Communication planning and management: notifications-rules / responsibilities, When to communicate what to whom; issue log and management; communication of project goals, and progress with management
				1	2	3.2.7	Risk Management and Mitigation	Risk determination-root cause analysis, risk management: risk probability, Risk impact; probability / impact matrix and risk mitigation strategies— Avoidance, control, assumption, transfer. Risk register

ISSN: 2167-1435
v29 n1967

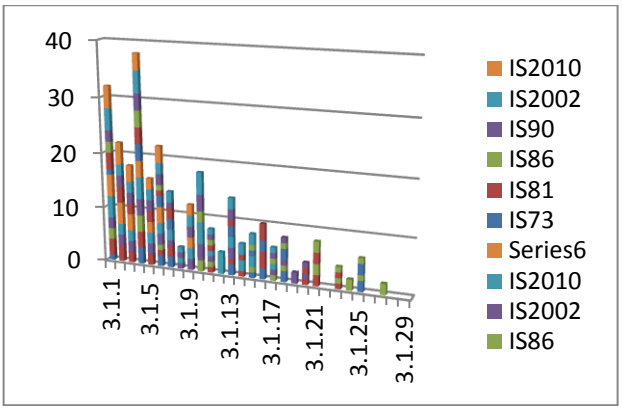
2	1	1	1	2	2	3.2.8	Project Change Control	Configuration Management, Security configuration management; Project change control Board, Requirements Change process, approvals, impact on scope, schedule and cost, work project completion and acceptance, scope creep.
1	1	1	1	2		3.2.9	Change Process	introduction of change, planning for change, acceptance, resistance and its prevention; negotiation and conflict resolution strategies, use of clear standards
				1		3.2.10	Project Close-down	managing the close-down activities; development of close-down reports

ISSN: 2167-1435
v29 n1967

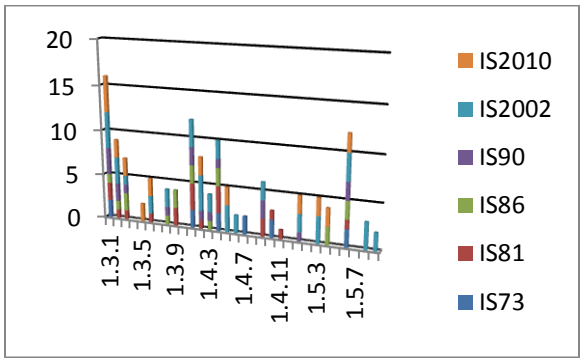
Appendix 3. Graphical representation of Skill Depths Achieved for Indicated Model Curricula



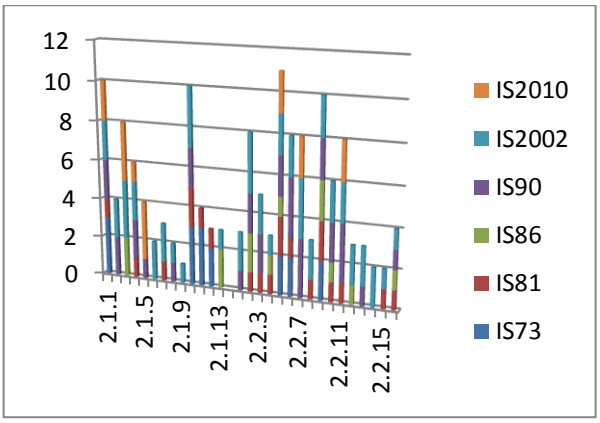
Software Development (1.1.0 – 1.1.24)



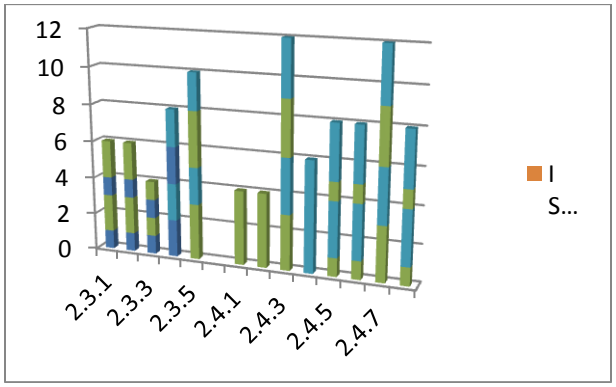
Organizational Systems Development (3.1.1 -3.1.29)



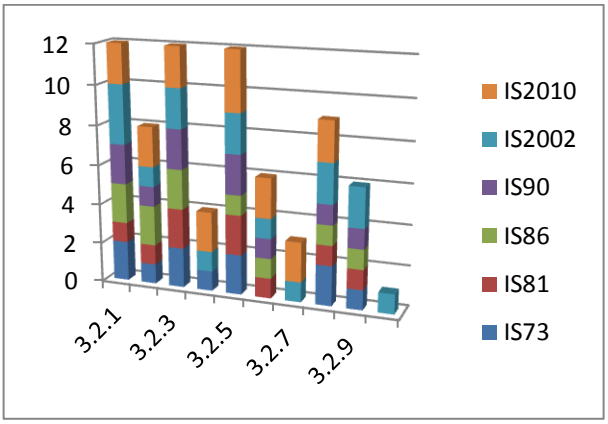
Database (1.3.1 – 1.3.9) Systems Integration (1.4.1 -1.4.11) Information Assurance &Security (1.5.1 -1.5.9)



Business Fundamentals (2.1.1 – 2.1.13)
Individual Skills (2.2.1 – 2.2.16)



Social Implications of Technology (2.3.1 – 2.3.5) Personal Computer (2.4.1 – 2.4.8)



Project Management (3.2.1 – 3.2.10)

ISSN: 2167-1435
v29 n1967

Table 3. Skills Appropriate To Various Curriculum Models

A. 21 Skills relatively common to all models

73	81	86	90	02	10	Skills (current as of 2012)	
2	3	1	3	2	2	1.1.0	Low level data structures
2	2	2	3	3	2	1.1.3	Algorithmic Design, Data, Object and File Structures
2	2	1	3	4	4	1.3.1	Modeling and design, construction, schema tools, DB systems
	1		1	4	2	1.4.2	Networking (Lan/Wan) and Telecommunications
2	1	2	2	3	2	1.5.6	Privacy Impact
3	1	2	2	2	2	2.1.1	Learning Business Process and Environment
				2	2	2.1.6	Enterprise Information Systems and Business Intelligence
2	2	1	2	2	2	2.2.5	Teams-team building, vision / mission development, Synergy building and problem solving; leadership
1	3	2	2	4	4	3.1.1	Strategic Utilization of Information Technology
	3		2	2	4	3.1.2	IT Planning
	2		2	2	3	3.1.3	IT and Organizational Systems
3	3	3	3	4	3	3.1.4	Information Systems Analysis and Design
	2	2	2	2	2	3.1.5	Decision Making
2	1	1	2	2	3	3.1.6	Systems Concepts, Use of IT, Customer Service
	1	1	1	1	3	3.1.11	Enterprise Information Systems Supporting Business Functions
2	1	2	2	3	2	3.2.1	Project Goal Setting and Planning
1	1	2	1	1	2	3.2.2	Monitor and Direct Resources and Activities, Team Leading
2	2	2	2	2	2	3.2.3	Coordinate Life Cycle Scheduling and Planning
2	2	1	2	2	3	3.2.5	Project Scheduling and Tracking
	1	1	1	1	2	3.2.6	Project Communications
2	1	1	1	2	2	3.2.8	Project Change Control

B. 14 Skills relatively common to later curriculum

73	81	86	90	02	10	Skills (current as of 2012)	
	1			2	2	1.3.6	Data Quality: dimensions, assessment, improvement
				3	2	1.4.5	LAN/WAN Design and Management
			1	2	2	1.5.1	Information Assurance Model
				3	2	1.5.3	Security Operations
		2			2	1.5.4	Security Policy
		2		3	3	2.1.3	Business Problems and Appropriate Technical solutions, end-user solutions
	1		2	2	1	2.1.4	Business Law
			1		3	2.1.5	Disaster Recovery
				1	1	2.1.9	IT Standards
	1	1	2	2	2	2.2.10	Collaboration support by IT
	1		3	2	2	2.2.11	Impact of IT on Society
			3	3	2	2.2.7	Ethics-theory/concepts, setting an ethical example
			2	2	2	3.1.9	Systems Engineering Techniques
				1	2	3.2.7	Risk Management and Mitigation

C. 53 Skills relatively common to later curricula (dropped by IS2010)

73	81	86	90	02	10	Skills (current as of 2012)	
			1	1		1.1.10	Code Generators
2	2	2	3	3		1.1.17	Testing

ISSN: 2167-1435
v29 n1967

3	3	2	3	3	1.1.18	Procedural Languages
				1	1.1.19	Object Oriented Languages
	3		3	2	1.1.2	Application Development-requirements, specs, developing, HCI considerations
	2			2	1.1.23	Information Systems
			2	2	1.1.5	Client Server Software Development
			3	1	1.1.6	HCI Principles and Paradigms
		2		2	1.1.9	Prototype
				3	1.2.1	Web page Development--HTML, page editors, tools
				2	1.2.2	Web programming-thin client, ASP, ASPX, ODBC, CGI, E-commerce, web services, scripting
				2	1.2.3	Web Systems Development Tools
	1	1	2	3	1.3.2	Triggers, Stored Procedures, Audit Controls: Design / Development
	1	2	1	1	1.3.3	Administration: security, safety, backup, repairs, replicating
		1	1	2	1.3.8	Data sources and advanced types
2	3	2	2	3	1.4.1	Computer Systems Hardware
		1	1	2	1.4.3	Operating Systems Management-multi platforms/protocols, Win/Unix/Linux/VM
2	3	2	1	2	1.4.4	Computer Systems Software-OS fundamentals, resource mgt concepts
				2	1.4.6	Systems Configuration, Operation, Administration
	2		2	2	1.4.9	End-user interface
				3	1.5.8	Information Systems Email Management
				2	1.5.9	Information Technology Security Principles
		2		1	2.1.13	Information Center Service
			2	2	2.1.2	Accounting, Distribution, supply chain management, Finance, HR, Marketing, Production, payroll, inventory processing
	1			2	2.1.7	Modes of Business
			1	1	2.1.8	Regulations
			1	2	2.2.1	Learning to learn
		1		2	2.2.12	IT Career Paths
			1	2	2.2.13	HCI Principles: underpinnings
				2	2.2.14	Individual behavior
	1			1	2.2.15	Cognition
	1	1	1	1	2.2.16	Develop Consultant Characteristics
	1	2	2	3	2.2.2	Professionalism-self directed, leadership, time management, certification, conferences
	1		2	2	2.2.3	Personal Skills-encouraging, listening, being Organized, principles of motivation
	1	1		1	2.2.4	Professionalism-committing to and completing work
2	1		3	2	2.2.6	Communication-oral, written, multimedia, empathetic listening
	1			2	2.2.8	Critical Thinking
2				2	2.3.4	IT effects on Individuals
		3		2	2.3.5	PC Impact
		2			2.4.1	History
		2			2.4.2	Work station
		3		3	2.4.3	Personal productivity
				3	2.4.4	Internet access
		1		3	2.4.5	E-mail
		1		3	2.4.6	Business software
		3		3	2.4.7	Spread sheets
		1		3	2.4.8	Database
		2	3	4	3.1.10	End-User Systems
				2	3.1.12	Emerging Technology
		1	1	1	3.1.17	Facilities Management
			1	1	3.1.8	CMMI and Quality Models
				1	3.2.10	Project Close-down

ISSN: 2167-1435
v29 n1967

1			1		3.2.4	Apply concepts of continuous improvement

D. 11 Skills relatively common to earlier & later curricula (dropped by IS2010)

73	81	86	90	02	10	Skills (current as of 2012)	
3	3	3	4	3		1.1.1	Programming-principles, objects, algorithms, modules, testing
	3	2	2	3		1.1.4	Problem Solving-identify problems, systems concepts, creativity
	2	2				1.3.9	Data Models
3	2	2	2	3		2.1.10	IT Support for Business Functions
2	2	2	2	2		2.2.9	Mathematical Fundamentals
2	2		1	2		3.1.07	Systems Theory and Quality Concepts
2	1	2	2	2		3.1.13	Systems Roles in Organizations
	1			2		3.1.14	Organizational Models
1		1		2		3.1.15	Metrics and Improvement
			1			3.1.19	Decision Structure
1	1	1	1	2		3.2.9	Change Process

E. 24 Skills relatively common to earlier curricula (dropped in later models)

73	81	86	90	02	10	Skills (current as of 2012)	
3	1					1.1.11	Storage Management
1	1					1.1.12	Multiprogramming and Multiprocessing
3	3	2				1.1.13	File Systems
1	3		1			1.1.14	Machine Structures
	3					1.1.15	Computer Operations
2	2					1.1.16	Systems of Programs
2	2	2				1.1.21	Input Devices
2	2	2				1.1.22	Output Devices
2						1.4.07	Inter-systems Communications
2	1					1.4.10	Communication system hardware
	1					1.4.11	Communication system organization
3	1					2.1.11	Operational Analysis
2	1					2.1.12	Managing the IS Function
1		2				2.3.1	Historical perspectives
1		2				2.3.2	The computer industry
1		1				2.3.3	Job displacement
2	3					3.1.16	Hardware selection, acquisition, and installation for project
2		1	1			3.1.18	Maintenance Programming
	1		1			3.1.20	Decision Tools
	2	2				3.1.21	Structured development
	1	1				3.1.23	Screen Design
		1				3.1.24	Frameworks and Libraries
2		1				3.1.25	Reports Development
		1				3.1.27	Develop cash audits

F. 2 Skills added uniquely in IS2010

73	81	86	90	02	10	Skills (current as of 2012)

ISSN: 2167-1435
v29 n1967

1	1.3.4	Metadata: architectures, systems, and administration
2	1.3.5	Data Warehouse: design, conversions, reporting

G. 13 Skills added based on NICE specifications (2012) but not in any curriculum model

G	1.1.20	Logic Programming
G	1.1.7	Digital Media
G	1.1.8	Software Security
G	1.2.4	Web Security and Vulnerability
G	1.3.7	Database Security
G	1.4.8	Data mapping and exchange
G	1.5.2	Security Mechanisms
G	1.5.5	Security Attacks
G	1.5.7	Information Assurance Systems
G	3.1.22	Object Oriented Development
G	3.1.26	Develop Audit Control Reports
G	3.1.28	Audit analysis of separation of function
G	3.1.29	Audit risk and disaster recovery strategies