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Information Systems Education Journal

Establishing the Basis for a CIS (Computer Information Systems) Undergraduate Program: On Seeking the Body of Knowledge

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Abstract

The evolution of computing education spans a spectrum from *computer science (CS)* grounded in the theory of computing, to *information systems (IS)*, grounded in the organizational application of data processing. This paper reports on a project focusing on a particular slice of that spectrum commonly labeled as *computer information systems (CIS)* and reflected in undergraduate academic programs designed to prepare graduates for professions as software developers building systems in government, commercial and not-for-profit enterprises. These programs with varying titles number in the hundreds. This project is an effort to determine if a common knowledge footprint characterizes CIS. If so, an eventual goal would be to describe the proportions of those essential knowledge components and propose guidelines specifically for effective undergraduate CIS curricula. Professional computing societies (ACM, IEEE, AITP (formerly DPMA), etc.) over the past fifty years have sponsored curriculum guidelines for various slices of education that in aggregate offer a compendium of knowledge areas in computing. This paper describes a project to determine the subset of that compendium pertinent to CIS. The project began by surveying experienced academic curriculum designers self-identified with the CIS perspective. The pilot survey results reported herein indicate that many essential knowledge areas of CIS are shared with published IS curricular guidelines but, design and implementation of database systems, software development and project management are distinctive in CIS. The next project phase launches a revised survey suitable for a general audience of computing academics. The intention is to triangulate the perspectives of a widely varied population of computing academics to further crystalize the distinctiveness of CIS as a well-formed closely related discipline of IS with a core of necessary knowledge and skills – then to develop curricular guidelines for undergraduate CIS education.

Keywords: CIS, computer information systems, model curriculum, body of knowledge.

1. INTRODUCTION

This paper explores a proposition that a band within the spectrum of computing disciplines exists which is known as Computer Information Systems. However, this evolving branch of Information Systems (IS) exists largely through self-identification. While Computer Information Systems (CIS) has been somewhat validated in the literature as a "strain" of a discipline known as Information Systems (IS), it is a casual association of self-selection (Shackleford, et al. 2005). IS's interdisciplinary nature explains the numerous and varied attempts to describe its essence and purpose as an academic discipline (Alter, 1998; Checkland & Howell, 1997; Davis & Olson, 1984; Orlikowski & Iacono, 2001; Palwak, 1981). Likewise the breadth of issues and aspects constituent reference disciplines attributable to IS is a challenge to any widespread or consistent adoption of curriculum guidelines for IS programs.

This paper aims to answer these undergraduate curriculum questions:

a) Does CIS reflect a distinct body of knowledge that constitutes an academic discipline?
b) What are the nature, characteristics, aims, goals, expectations, and assurances of CIS?
c) As young as the scientific discipline computing is, what place does CIS hold within it, if any?

In search of answers to the above questions, we first briefly review the origins of computing to highlight its continuing evolution and diversification. We review a brief history of computing curricula and attempts along the way to structure academic curricula to support the evolving education and training of computing professionals: universal connectivity, ubiquitous computing and pervasive organizational dependence on information systems. The remainder of the paper sets the stage for a process our fundamental question might be answered: is there "such a thing" as the Computer Information Systems discipline?

We base the rationale for this exposition upon the extant models of curricula that offer a variety of perspectives to choose from (IS2002, CC2005, IS2010). With CC2005 as a seminal foundation, we attempt to reconcile among the various Knowledge Areas from the Bodies of Knowledge endorsed by computing professional societies over the past fifty years. We propose that compendium of computing knowledge areas and skills (CKS) as the superset, the starting point, from which a subset may be identified to characterize CIS. Towards this end, we enlist the input from a small advisory group experienced in curriculum development. In an extensive survey instrument, each advisor rated each item in the CKS for the desired depth of knowledge, learning outcome orientation (theory, principle, innovation vs. application, deployment, configuration [CC2005]), area of computing practice (organizational, application, software systems, infrastructure, architecture [CC2005]), and finally, the raters' confidence in assessing personal competence in evaluating the KA. The preliminary results are presented with a discussion of limitations and future plans to organize a process that results in a model curriculum for Computer Information Systems.

2. HISTORY OF COMPUTING

Since the mid to late 1950's computers have evolved from museum curiosities into devices that have changed almost all aspects of life and commerce of the world forever. It has not been a single step, rather one of evolution of many technologies. Initial machines such as the IBM 650 were housed in a good-sized room and consumed many kilowatts per hour, many tons of air conditioning, had very small memories, required punched-card input and output and could service at most one person with a small problem. As technology replaced vacuum tubes with transistors; then with simple integrated circuits and eventually with very complex integrated circuits, much changed. Processing speed, memory size, speed of throughput, and machine instruction complexity increased by many orders of magnitude – Moore's Law. Storage media capacity, reliability and speed have had similar rates of growth. Methods of input, output, and inter device communication have advanced exponentially in both speed and diversity. All these technologic changes, yet costs decreased exponentially.

The computer is truly a dazzling piece of electro-mechanical capability. But, it will do nothing until it's told precisely – what to do. Early computers were expensive, few and far between; and rather limited serving only a single user or purpose at a time. By the end of the sixties mini-computers became less expensive, more accessible and increasingly capable. By the mid-seventies multiuser machines allowed "time-shared services" by means of terminals connected by modems to the computer.

In the early nineteen eighties, a major revolution occurred; in 1983 the IBM PC became Time Magazine's "Man of the Year". The expanding role of computing in commerce and government resulted in growing demand for computing professionals and academic programs to educate them. The proliferation of microprocessors ushered in personal computers and another burst of demand for computing education. As communications technologies (telephony, digital signaling, satellite and optical transmission) matured and expanded, connectively took the lead in computing's advancement (e.g. the Internet effectively brought all the points on the globe within reach).

With every advance in computing the need for software and systems developers has grown almost in the reverse relationship to the shrinkage of size, cost, and time to compute described in Moore's Law. But, Moore's Law has not held for productivity or cost/effectiveness of software and systems development practice. This fact motivates this project's concern for the CIS curricular perspective and it potential for addressing the reported shortfall in productivity and cost/effectiveness that appear widespread in the computing industry today.

3. HISTORY OF CURRICULUM

The Association for Computing Machinery (ACM), Data Processing Management Association (DPMA) – now the Association for Information Professionals (AITP) – and Institute of Electrical and Electronics Engineers (IEEE) have consistently supported the advancement of computing professional education. These organizations, along with newer organizations, including the Association for Information Systems (AIS) have sponsored a series of curriculum models that guide and shape the curricula that train and educate computing professionals. Prompted by the introduction and advancement of computers in the late 1950's, and with their availability in the 1960's, model curricula developed to guide programs and faculty. Each model curriculum specifies (to some degree) a focused perspective of professional competency including learning outcomes and the means (courses) for achieving them. Some curricular designs favored flexibility with alternative - but closely related – paths, while others were more prescriptive.

During the late 1960's, as computing and its applications diversified, it became apparent that at least two distinct flavors of computing had emerged. The ACM and IEEE first focused primarily on computer science, the first model curriculum being Computer Science 1968, reflecting its core scientific interests to answer questions related to "what can be computed?" Subsequently, a second group also emerged, focused on how computing could best be utilized for commercial or governmental purposes. The first working product of this "other" flavor of computing - IS model curricula (Ashenhurst, 1972; Couger, 1973, and Nunnamaker, 1982).

In the research on IS curricula that followed DPMA (1981; 1986) and IS'90 (Longenecker and Feinstein, 1991), as many as 126 names for IS programs were identified. These programs were housed in academic divisions, colleges and departments with at least 10 different designations according to Peterson's Guide and the DPMA mailing list. This diversity of labeling and situating IS education persists as a direct consequence of its inter-disciplinary nature.

Over the years, collegiate IS programs often adopted either the DPMA (now known as AITP) or ACM guidelines, or a mixture of both. Also, within the past 15 years, some programs have achieved ABET accreditation, which also has some influence on the curriculum adopted by that program. Regardless when surveying those programs, their faculty indicated much the same technical expectations for their graduates regardless of the academic division's label, or the guidelines they espoused. Aligning with a particular model's guidelines is better explained as a case of program marketing rather than an endorsement of a model curriculum's philosophy.

4. INITIAL COVERAGE OF CURRICULUM

Computing machinery vendors developed and sold systems and application software along with their machines while supplying organizational end-user training as well. Computer vendors also supplied computers so that interested faculty could learn to use the hardware, and perhaps promote the software to students taking classes. Early computing education supported discipline-specific computing applications in the sciences, mathematics or statistics. Programs focused specifically on computing theory evolved in the computer science programs in the mid-sixties along with the establishment of doctoral programs in computing. Computer-related education began to find a way into virtually every academic discipline as computing became an important research tool.

During this period of time, IS programs emphasized operating systems and system software as a platform for sophisticated application systems. (The reader who would like to review the detail of these skills migration is referred to the Appendix material of Longenecker, et al 2012.)

5. POST 1990 CURRICULUM

The post 1990 model curricula began to reflect diversification within the "spectrum" of the computing discipline such that an emergence of several computing disciplines had arisen. For instance, the CC2005 report refers to Information Technology as a new sub-discipline of computing quite distinct from Computer Engineering, Computer Science and Software Engineering programs. Curiously, it was also around this time that society had adopted the label "IT" for any of the endeavors of computing although "IT" is a clear misnomer as an umbrella term in light of description of IT in CC2005. IT programs were distinguished by a focus largely on infrastructure: "off the shelf" hardware and software installation and configuration. Whereas, IS's focus evolved toward creating and extending systems while closely aligning systems with business models and strategies to support the business's end-users, partners and clients including top-management. IS'95, IS97, and IS2002 model curricula all emphasize these core distinguishing aspects of IS as it "sits" among the other computing disciplines.

IT's focus appears from a current vantage point and also as described in CC2005 is planning, installing, configuring, testing and managing infrastructure: networks, operating systems, virtualization servers and server farms; and most recently supporting organizational information processing and security concerns. One could propose that IT should consider IS as a critically-important customer. Figure 1 suggests this relationship.

CC2005 provides a well-reasoned framework for mapping the computing landscape of computing professionals' knowledge, skills and responsibilities. Nearly a decade later, we should consider whether that landscape is evolving and whether the spectrum of computing disciplines should be refined, refocused and/or reconstituted. That is, just as IT emerged as a recognized and independent computing discipline, what other aspects within the computing problem space have changed such that other disciplines have evolved, or new disciplines have emerged? This paper argues that the Information Systems discipline has evolved.

<table>
<tr><td colspan="2">Organizational End-User</td></tr>
<tr><td colspan="2">CIO or CTO</td></tr>
<tr><td>Information Systems</td><td>IT Help Desk</td></tr>
<tr><td colspan="2">Information Technology Management</td></tr>
<tr><td colspan="2">Virtual and Physical Systems</td></tr>
<tr><td colspan="2">The Internet and Private Networks</td></tr>
</table>

Figure 1. Relationships of IS, IT, End-Users and the Help Desk to Physical Systems. The CTO/CIO has ultimate authority for hardware and networks through IT.

6. WHY CIS AS A DISCIPLINE IS WORTH THE EFFORT TO DEFINE

In seeking answers to the central question in this paper, has information systems evolved such that Computer Information Systems has arisen as a distinct variant of Information systems, we explore the following propositions:

(P1) *Computer Information Systems is a discernible sub-discipline of computing closely aligned but distinct from IS.*

Although not designating CIS as specifically a sub-discipline, CC2005 does describe a community of programs with a distinctive emphasis on information systems development and software construction. If our first proposition can be explored in a manner that is empirically testable and confirmable, it is reasonable to pursue a curriculum guideline to both describe and promote effective undergraduate education to prepare professionals to pursue CIS as a discipline.

One rationale for exploring the question of CIS as a discipline is the critical centrality of software and application systems in the super-discipline of computing. Although systems building was a core (perhaps the first) goal of IS undergraduate education in its earliest incarnations, the burgeoning catalog of business, organizational, and sociological topics that vie for attention in IS programs has gradually diminished or displaced system building as a core focus in many programs. Indeed the most recent curriculum guidelines for undergraduate IS education, IS2010, does not list the rudimentary knowledge and skills for programming and software development as required learning. This is a clear indication of the challenge in IS program design to allow room for the burgeoning topic catalog within a limited credit hour, four-year undergraduate degree (Waguespack 2012; Babb & Waguespack, 2014).

This leads to a second proposition:

(P2) The undergraduate computing programs that label themselves CIS consistently outline the set of professional knowledge and skills that defines the essential labor competencies to support the age of big data, mobile apps, and ubiquitous computing.

There is no question that innovation relies on availability of systems builders for the information systems that support their evolving products and services. More than ever, governments are turning to information system capabilities to address social and civic challenges in managing resources and public services. Taking nothing away from the value of IS education, there is a distinct and palpable need for undergraduate degree programs to serve the exploding demand for computing professionals who can create, build and rebuild the information processing engines that support the world's economies.

If the project described herein can empirically ground our second proposition, this outcome will support the effort to develop curriculum guidelines for undergraduate degree(s) in CIS. Experiences in our institutions show that programs that can attest to following published guidelines have a greater prospect for establishment, growth and sustainment in colleges and universities. The mantel of guideline compliance supports recruiting of students, faculty, and philanthropic support. And the collegiality that a community of programs and their faculty can develop advances pedagogy and research that advances the discipline.

7. SKILLS TO MEET NEEDS

At this point in our process, we have not attempted to complete a skills analysis, even though a curriculum must be specified by its skills. We suspect that the fundamental skills would be similar to Colvin (2008), Landry (2001) and Haigood (2001), these are the underpinnings of IS 2002. Skills are not a list of topics, rather they are a list of what the graduate of a program must be able to do as an effective practitioner in the discipline. All curricula must identify these skills based on discussions with employers. Once it becomes clear what skills would seem to satisfy the body of knowledge, courses can be proposed as a means of grouping the skills, and course outcomes can be prepared. These concepts are depicted in Figure 2.

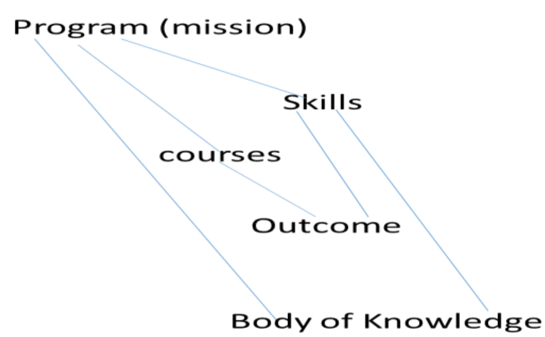

Figure 2 shows the relationships between the entities of the figure: Program has a body of knowledge; program also has courses specified by the course outcomes which outcomes are necessary to provide time on task to achieve the skills which satisfy the coverage of the body of knowledge.

8. THE EFFECT OF ACCREDITATION ON THE DISCIPLINE

From the beginning, Information Systems laid its "anchor" in the port called the "College of Business;" and for many good reasons. Among the facts of life of setting up your interdisciplinary "shop" in a College of Business is that Colleges of Business will typically attain AACSB (Association to Advance Collegiate Schools of Business) accreditation. If we consider that ABET provides a similar program-level accreditation for IS programs in the manner that AACSB provides college-level accreditation, it is important that we consider how these two "cultures" mix (Babb & Abdullat, 2014). While there are many cases where each accreditation co-exist, AACSB will always be the dominant culture and that dominance imposes two serious limitations to computing programs: 1) AACSB would prefer an 8 course limit on the number of courses in a program, and 2) AACSB would prefer no sequences of courses greater than 2 courses. It is clearly difficult to expose the number of topics relevant to IS with this time limitation, and worse yet it is most likely impossible to reach the applications level of knowledge (Bloom, 1956) necessary for practitioners. However, in a "have your cake and eat it too" sense, if Information Systems (and its variants) wish to persist in the college of business, some accommodation or work-around is needed. While ABET-accredited programs have that work-around "built in" by way of its own specific and reliable requirements, very few IS programs are ABET accredited, perhaps largely due to this AACSB-dominance of the college of business culture (Babb & Abdullat, 2014).

9. IS 2002 WORK-AROUND

One work-around is in the nature of the IS 2002 model curriculum, which can be said to offer a more generous approach: 1) a 10-course minimum course count was established; 2) courses were viewed as containers of knowledge specifications—while only a single course was suggested for programming, it was very clear that more class time would be required; and 3) a set of prerequisite recommendations was given either in the curriculum, in general studies, or even in high-school. All ABET- accredited schools have clearly followed this model whether in a business school or not (Feinstein, Longenecker, and Shrestha, 2013). However, the complaint from some quarters is that IS 2002 is too fully and inflexibly specified. However, rather than make additional opportunities available as IS 2010 suggests, the obvious solution is to increase the number of offered courses. We do not as of this writing have an immediate answer. Certainly a coupled master program is one alternative that could be explored.

10. GUIDANCE FROM CC2005

A significant problem of working on a "Computer Information Systems" degree model curriculum is that the underlying discipline does not really exist. The team working on this study made the decision to call the discipline "Information Systems" and then to provide a single model curriculum for our field. To be sure that this new model had an involved professional society, the DPMA believed this as appropriate and funded efforts to promote the model curriculum report at that time. Also, the ACM had published its ACM'72 document with the name Information Systems. The discipline name took hold and as evident with the following publications: IS'95, IS'97, IS2002 sponsored jointly by the AITP (formerly DPMA), the ACM, and the AIS. In pursuit of our research questions, we began with the approach for discipline definition as outlined by the CC2005 task force. First, CC2005 present a sketch of the spectrum and breadth of computing disciplines (albeit in broad strokes), and, specifically, the report is grounded by defining and/or referencing bodies of knowledge appropriate to each discipline. Thus, we take the approach that the body of knowledge of the discipline is its "kernel:" it's central taxonomy, epistemology, and perhaps ontology upon which "knowing" the discipline is founded.

11. HUNT FOR THE CIS BODY OF KNOWLEDGE

Parameters and Picture

With CC2005 as a guide we used a small panel of experts, combined with a very comprehensive survey instrument, to collect and evaluative input regarding a collection of Knowledge Areas (KA) from the various bodies of knowledge that could arguably define the "boundaries" of the CIS discipline. Moreover, these KAs were culled from the more current model curricula guidelines for the most salient disciplines that seemed to relate to our postulated "CIS" discipline. Thus, for each body of knowledge element to be studied, it was decided to collect each of the following parameters:

1. Cognitive depth of knowledge, an integer value with the meaning shown in appendix 2 which ranged from 0 meaning "no knowledge required" to 5 a very high level of professional. Most faculty who work with indicator would be very surprised to find many at level 4—application knowledge. As faculty we seem not to have been able to get our students to do even this well. A

specification below 2 most likely indicates that although considerable time will have been spent, most all of this knowledge will be lost within days of the last exam. Perhaps we should set our expectations higher on that which we really care about: Our students might not make computer jeopardy players, yet they may have become exceptional problem solvers. This parameter will become the z or height off the paper axis. Please note that in CC2005 the parameter is represented by a "dot".

2. Emphasis is a parameter with values between +50 and -50 which describes highly practical (+50) to highly theoretical (-50). This parameter will be the x or horizontal axis.

3. Organizational relevance is a parameter between 1 and 5. Possible values of the parameter are specified as shown in the graph below. Please note, the parameter may take on multiple values.

4. Rater confidence is a value between 0 and 99% and gives the rater's confidence in make the estimates for parameters 1, 2, and 3. The value is contained in tables, but is not plotted.

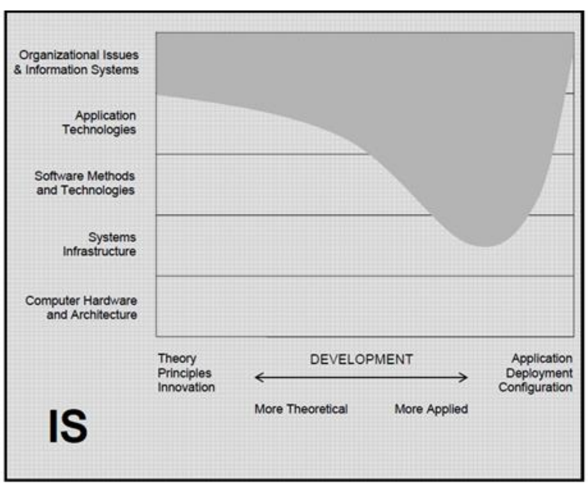

Figure 3. A "definition of IS" according to the three parameters herein used by CC2005. Each program should be different.

Our intention was to begin to empirically define, test, and validate the "problem space" of CIS in a manner that had been notionally compiled in by a respected team of experts in CC2005. Figure 3 (from CC2005) depicts the area that Information Systems "claims" within the problem space of computing and we generally agree that it appears to be correct. However, we feel that Computer Information Systems continues to reflect Figure 3 while recent model curricula (IS 2010) have begun to paint a different picture of Information Systems that seems to "retreat" more towards the "Organizational Issues and Information Systems" end of the y-axis in Figure 3.

Our initial work then was to solicit a team of invited experts to help test the viability of this approach as an "entry point" into exploring what CIS might look like and ultimately answer the questions posed in this paper: does CIS exist? What does it look like?

Body of Knowledge Candidates

All recent ACM model curricula contain a list of knowledge areas (KA) and sub-areas known as knowledge units (KU). These KA's were the basis for the graphics shown above. In other words, all KA's were considered for potential inclusion in the graphic. Therefore, our KA list was comprised of all KA's included in the ACM website showing all model curricula. Our list included KA's from IS'90, IS'95, IS'97, IS2002, and IS2010. Our list is current through CSC 2013. It also contains the graduate SE (Software Engineering) curriculum, but does not include the systems engineering material. It includes a 2014 minimum NICE specification which includes a minimal coverage of IA.

We sorted the list alphabetically, and did remove exact duplicates, but left material that might be different. We did not attempt to resolve hierarchically structured material that could be managed in a second or later pass.

Appointment of Expert Advisory Group

We solicited a group of experts (see Appendix 1) as a way to preliminarily validate a body of knowledge for CIS and provide expert feedback on this new candidate program. We chose individuals with a strong and consistent background of excellence in computing education. The characteristics of this 20-member expert team include:

- Significant ABET experience
- AACSB Schools
- EDSIG (AITP) Fellows
- Chairs / Deans
- National curriculum participants
- Professor / University Professor
- Editors/Associate Editors
- Publishers
- Conference Leaders

All members of the Expert Advisory Group were emailed and then called. All attempted the survey and 16 completed the entire survey instrument. The results of that effort are visible in the appendix material of this document.

12. ANALYSIS OF PRELIMINARY DATA

From an analysis of the depth of knowledge required (e.g. expectations are greater than 3.5), several groups of knowledge clearly are revealed as being the most important to this curriculum (see appendix 3, 4, and 5 material):

- Database
- Information Systems Development (Business Requirements)
- Systems Design
- Software Requirements, Programming (including web)
- Project Management based on Leadership, Team, and Interpersonal skills

The relevance of multiple sources of KA's can be seen by inspection in Appendix 5. Appendix 4 and 5 show the KA's assigned to each category as identified in Appendix 3. Finally, Appendix 6 provides a mechanism for comparison of IS curricula as well as a way to clearly see the differences between the existing IS curricula and the new CIS model

While networking, operating systems, and security are important, it is becoming clear that Information Technology groups will have to take the responsibility to fulfill such requirements.

13. CONCLUSION

The results of the survey indicate that the body of knowledge reported would be a worthwhile adventure. Although we all have experience in curriculum development, we never started without a clear picture of the prize, the definition of CIS. We all have been impressed with the scholarship of that document as well as its practicality.

We were very pleased with the active willingness of our Executive Advisory Team to respond strongly and with a very short lead time. The team responded with remarkable consistence. Characteristic of their leadership ability they were able to focus on key ideas that did not just fall off the turnip truck. Rather, they bring a new focus for our consideration.

Future research will be to adjust the data gathering instrument, to cull the list slightly, and get the material out to as wide a group as possible for response.

Also, we will be identifying some necessary projects and will be asking for help. Those announcements and requests for help will be built into our next data collection effort, and we sincerely hope you will answer the call.

13. ACKNOWLEDGEMENTS

Professor Heikki Topi of Bentley has become a mentor to us. We are deeply appreciative. He has provided warm yet most detailed critique enabling this team to perform much better and at a higher level.

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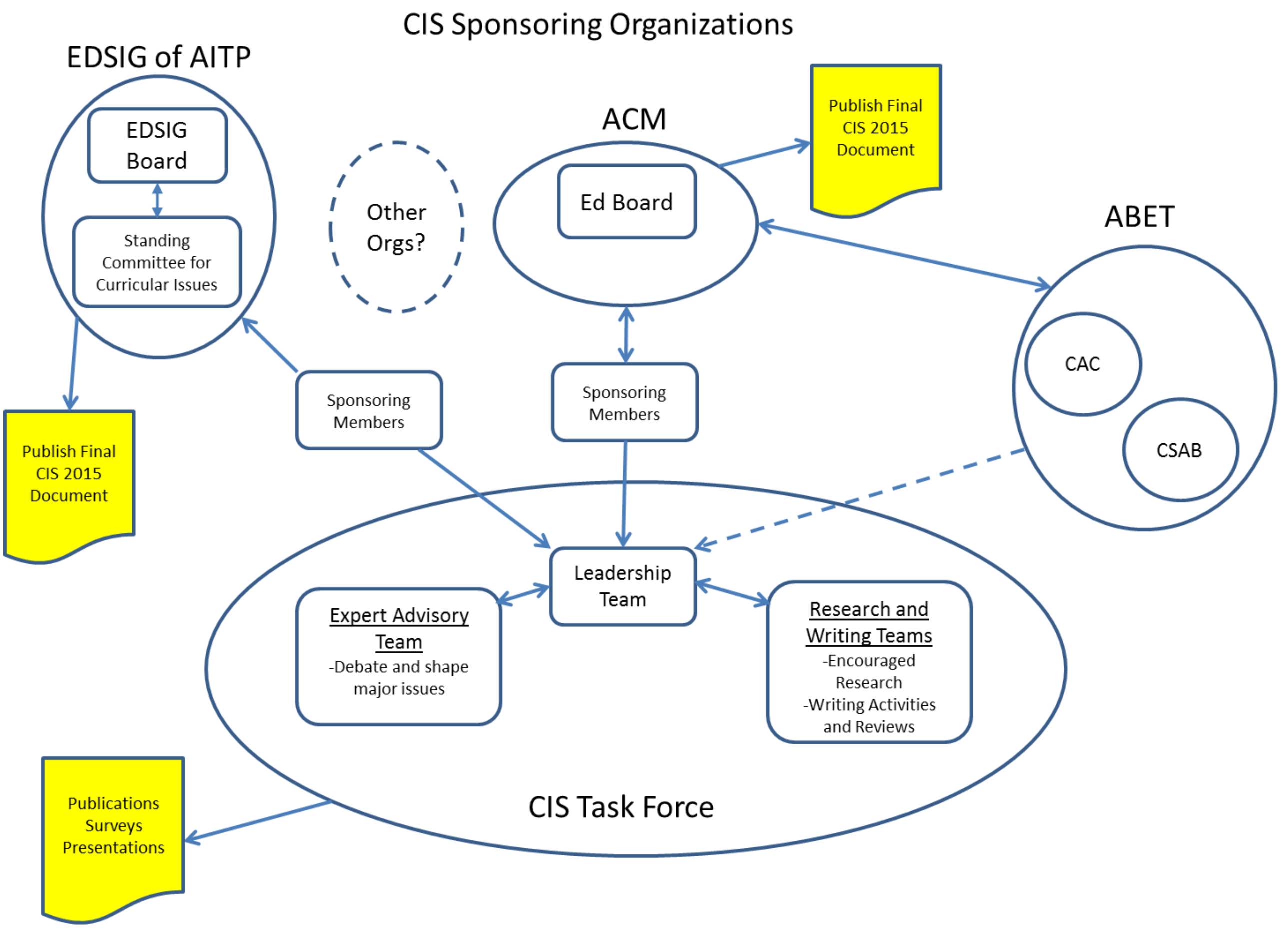
Appendix 1: Expert Advisory Team

Name	Affiliation
Bart Longenecker	University of South Alabama
Bruce Saulnier	Quinnipiac University
Bruce White	Quinnipiac University
Cameron Lawrence	University of Montana
Cheryl Aasheim	Georgia Southern University
Chuck Woratschek	Robert Morris University
David Feinstein	University of South Alabama
Gayle Yaverbaum	Penn State University
Harold Pardue	University of S. Alabama
Heikki Topi	Bentley University
Jeff Landry	University of South Alabama
Jeffry Babb	West Texas A&M University
Jerry Wagner	California State Polytechnic University
John Turchek	Robert Morris University
Jon Clark	Colorado State University
Karthikeyan Umapathy	University North Florida
Les Waguespack	Bentley University
Paul Leidig	Grand Valley State University
Ronald Kizior	Loyola University
Scott Hunsinger	Appalachian State University
Tom Janicki	University NC Wilmington
William Tastle	Ithaca College



Note: Operation of the CIS Task Force began informally as discussions over the period of a year with David Feinstein and Heikki Topi along with Bart Longenecker. Jeff Babb and Bart invited Les Waguespack to join the discussions because of the closeness of Les and Heikki. Then, Les worked with the AITP-EDSIG Board for formal recognition of the effort. EDSIG formed a Committee for Curricular Affairs appointing Les as Chair, along with Jeff Babb. Internally to the Task Force, Tom Janicki joined the group. The five members operate as Co-chairs of the CIS Force. The task force has in turn invited very well-known members of the community to form the "Expert Advisory Team" The task force plans to this advisory team as a sounding board to verify approaches. The first face-face meeting of the entire task force will occur at ISECON 2014. Members of ISECON will be invited to the meeting.

Note: The relationship with the ACM is proposed. Other groups may be asked to join.

Appendix 2: Introduction for Expert Advisory Team (Included within Survey Instrument)

We are writing to you as the Leadership Team for Curriculum; we are working with both AITP-EDSIG and the ACM. We are writing to you as a computing professional to become part of our Advisory Team. Your first job will be to help vet the attached survey to establish the body of knowledge for the closely related disciplines identified in CC2005.

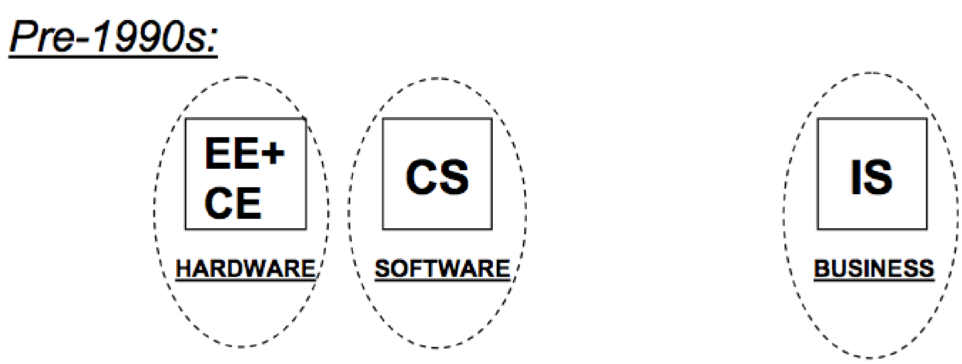
Over the past fifty years computing has evolved, as have computing curricula. Now, there is new hardware and software as well as many new opportunities and risks with systems 1000's of times more powerful and diverse. Most of us readily recognize curriculum in CS, IS, SE. IT, and CE which were identified in a 2005 document entitled: "Computing Curricula 2005--The Overview Report, covering undergraduate degree programs in Computer Engineering, Computer Science, Information Systems, Information Technology, Software Engineering". There are new initiatives in IA (information assurance), as well as significant change expressed in the observables in the ACM model curricula. However, are there potentially more disciplines (or prominent sub-disciplines)?

We feel that our first major task is to confirm the need for a more technically focused Information Systems (IS) Undergraduate degree. CC2005 identifies CIS as a "more technical form" of IS. We support IS 2010, and view this work as an "extension" of that work. However, it is time to study formally changes that may have occurred to the Body of Knowledge, and to expectations of the computing industry who we would like to hire our graduates.

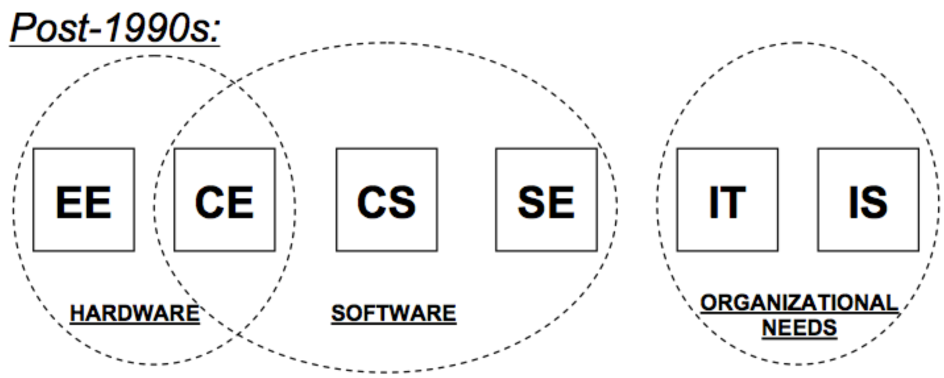
Following our joint effort we plan to release the work product to a wide group of computing academics. We would like to determine if the original five disciplines identified in CC2005 are relevant at the undergraduate level. We would like to know if there are discrete areas in information systems: general information systems, management information systems, and computer information systems. Is there a need for information assurance to be a separate degree program or be included within existing programs?

Therefore, if our focus will most likely be developing of a CIS program, we will be interested in establishing the characteristics of an undergraduate curriculum in computing that best prepares students to design, develop and implement secure information systems.

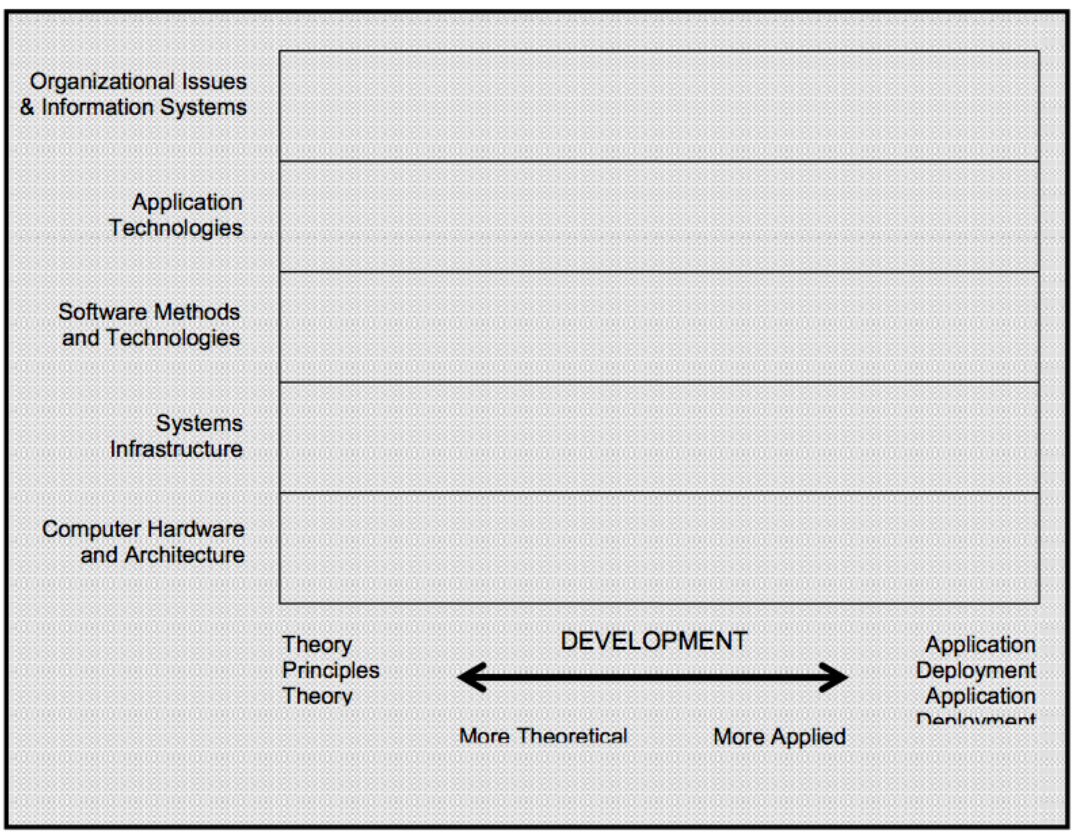
In 2005 a joint computing task force of computing societies (ACM, AIS, and IEEE-CS) portrayed the range of academic computing programs spanning computer hardware, software and organizational needs in the following diagram.



We wish to see how the computing education landscape may have changed since then. This survey duplicates the knowledge areas/skills published in curricular guidelines since 1997 into this survey to study how the clusters of knowledge areas may have evolved into the focus areas of computing education today.



The Joint Task Force for Computing Curricula 2005 developed a conceptual model to illustrate the commonalities and differences among computing disciplines. The model was designed to consider how each computing discipline occupies the problem space of computing. The model was design to reflect the disciplines as they existed at the time (2004/2005). The model was also intended to focus on what students in each of the disciplines typically do after graduation, not on all of the topics a student might study within a curriculum. The model follows:



In the Joint Task Force for Computing Curricula 2005 "Problem Space of Computing" Model, the horizontal range runs from Theory, Principles, and Innovation on the left, to Application, Deployment, and Configuration on the right. The vertical range runs from Computer Hardware and Architecture at the bottom, to Organizational Issues and Information Systems at the top.

The model was designed such that both the horizontal and vertical dimensions are considered together. The structure of this survey instrument is designed to provide a contemporary "picture" of what this problem space looks like today in the estimation and opinion of experts, educators, and practitioners. Whereas the Joint Task Force for Computing Curricula 2005 used this model to create informal illustrations used to communicate the task force's subjective interpretation of the various disciplines, this survey is an initial foray to examine this model from a more quantitative foundation. This information will be used for preliminary purposes to establish a baseline picture in the problem space of computing in order to inform subsequent steps to more clearly define what the computing discipline spectrum may look like today.

We have prepared a list of survey topics derived directly from the body of knowledge areas predominantly from the ACM curricula which we believe to be the Body of Knowledge area for computing. (Please see attachment "Knowledge Areas".)

As a member of our Advisory Team, we are asking you to answer this survey from the perspective of your discipline. We will ask you to identify yourself from a provided list if disciplines. If you are from another discipline, then enter your discipline and describe it. After you have answered the survey we will be looking to see your analysis as an academic professional. How can we improve this work product?

Then (considering the next 3 – 5 years), for each knowledge survey element presented please inform us at what depth of knowledge instruction should be specified with respect to requirements of your discipline. This is a very important first step, and will enable curriculum designers to write behavioral objectives. These objectives will enable a model curriculum and detailed course planning. Please remember that everything cannot be achieved in an undergraduate curriculum (10-12 courses of 36/semester hours -> 360 hours total). The higher the specification level, the more time will be required to learn the material. Most previous committees have found that the highest level specification is very difficult for undergraduates to achieve. The following table gives further insight into the depth of knowledge levels:

Depth of Knowledge	Meaning of Depth
0 – No Knowledge Required	No objectives will be planned for this item
1- Awareness	Learners have the ability to recognize this element, but can do nothing with the information. This process is automatic. It can be enhanced through repetition.
2 – Literacy / Strong Knowledge	Learners can differentiate among elements (red pen, black pen, felt tip, quill) and with guided practice can answer simple questions about the elements. Still nothing useful can be done with this level of knowledge.
3 – Concept / Use Skill	It is time for learners to be prompted to "DO" something with knowledge. As learners have increased cognitive burden with multiple elements, it can not be ignored that this is a prompted process of items barely learned at level 2.
4 – Application Ability	Learners at this level will have spent 3-10 times the effort associated with levels 1-3. Initial stages of application ability will enable solution of selection of simple elements to create a desired solution. However, considerable repetition will be necessary to marginally secure this ability. Without the repetition the ability will be rapidly lost. If the learning process involves a level of excitement, the learning will be enhanced.
5 - Advanced	This level consists of analysis, synthesis and evaluation based on Bloom's specifications. Solving a problem is an "ability", not this level of development of new knowledge.

Appendix 3: Data from Expert Advisory Team (Sorted by Body of Knowledge KA's Having a Level of 3.5 or Greater are Highlighting with Color Showing Groups)

KA	Knowledge Areas Sorted by Expert Expected Depth of knowledge	Depth 0-5	Emphasis theory -50 practice +50	Expert Confidence
A22	Database	4.3	28	97%
B03	Data Retrieval and / Manipulation with Database Languages	4.0	26	93%
A23	Analysis and Specification / of System Requirements	4.0	19	90%
A19	Analysis of Business / Requirements	3.9	20	94%
A21	Information Systems Design /	3.9	21	93%
C01	Programming / Fundamentals	3.8	32	94%
A07	Web Systems and / Technologies	3.8	32	92%
A15	Approaches to Systems / Development	3.7	24	96%
G08	Project Plan, Scope, and / Initiation	3.7	21	90%
D14	Systems Analysis & / Design	3.6	23	92%
B05	Data and Information / Modeling at Conceptual and logical Levels	3.5	17	90%
C09	Software / Requirements	3.5	18	93%
A24	Team and Interpersonal / Skills	3.5	20	94%
G07	Leading Project / Teams	3.5	21	91%
B01	Database Systems and / Distributed Databases	3.4	18	86%
C15	Software / Design	3.4	20	90%
A06	Information Technology / Fundamentals	3.4	23	91%
D09	Systems Development / Concepts and Methodologies	3.3	15	91%
C05	Human Computer / Interaction	3.3	17	92%
C16	Software Development / Fundamentals	3.3	25	92%
B12	Data Integrity and / Quality	3.2	19	91%
A20	Information and Business / Analysis	3.2	15	90%
D11	Systems Implementation and / Testing Strategies	3.2	16	89%
C06	Module Design and / Construction	3.2	18	91%
C19	Software / Testing	3.2	21	91%
G10	Project Execution & / Control	3.2	20	87%
A01	Impact of Information / Systems on Organizational Structure and / Processes	3.1	15	91%
D06	System Deployment and / Implementation	3.1	17	89%
B07	Physical Database / Implementation / Data Definition Language	3.0	16	92%
A13	Business Intelligence and / Decision Support	3.0	14	90%
M03	Basic Scripting/ / Programming	3.0	25	92%
B04	Teams and Interpersonal / Skills	2.9	15	89%
M01	Basic Data / Analysis	2.9	21	86%
G12	Project / Quality	2.9	8	82%
C13	Security and Privacy, / Vulnerabilities, Risks, Mitigation	2.9	10	78%
B08	Stored Procedure / Implementation	2.8	20	85%
B10	Data and Database / Administration	2.8	18	88%
A03	Identification of / Opportunities for IT enabled Organizational / Change	2.8	10	92%
A16	Different Approaches to / Implementing Information Systems	2.8	15	91%
C02	Programming / Languages	2.8	14	92%
C17	Software / Construction	2.8	30	89%
G06	IS Project Strategy and / Management	2.8	8	85%
G03	Establishing Project / Communication	2.8	13	88%
G09	Work Break-down / Structure	2.8	18	90%
G13	Project / Closure	2.8	13	84%
E04	Networks and / Communications	2.8	15	81%
H02	Probability and / Statistics--Basic probability theory, random variables and / probability distributions, estimation theo...	2.8	8	82%

B11-	Data Management and / Transaction Processing	2.7	22	90%
A17	Business Process Design and / Management	2.7	15	89%
A26	Computer / Networks	2.7	21	89%
H01-	Math and Statistics for / IT	2.7	18	87%
D15	User / Experience	2.6	16	89%
G11-	Project / Standards	2.6	11	83%
A02	Individual and / Organizational Knowledge Work Capabilities	2.6	14	89%
C04-	Integrative Programming and / Technologies	2.6	18	78%
B13-	Security attacks and / mitigations	2.6	15	84%
B06-	Scripting	2.5	25	91%
A09	Enterprise / Architecture	2.5	4	79%
D07	System Verification and / Validation	2.5	12	86%
A25	Configuration and Change / Management	2.5	12	85%
C03-	Programming / Environments	2.5	16	87%
C07-	Software Engineering / Process	2.5	15	89%
C18-	Software / Quality	2.5	11	88%
C20-	Software / Maintenance	2.5	17	89%
D05	System Integration and / Architecture	2.5	13	83%
F02-	Information Assurance and / Security	2.4	3	78%
C11-	Algorithms and Data / Structures	2.3	12	86%
G01	Professional Issues in / Information Systems	2.3	6	85%
E07-	Organizational and / Management Concepts	2.3	-6	83%
M06	Cyber Defense, threats, / attacks, Incidents, incident management	2.3	7	76%
M02	Databases: Database / operations, injection attacks	2.2	19	73%
B02-	Basic File Processing / Concepts	2.2	12	88%
F03-	Managing the Information / Systems Function	2.2	-3	70%
F06-	Information Systems / Sourcing and Acquisition	2.2	9	72%
F05-	Information Systems / Planning	2.2	8	83%
F07-	Information Systems / Strategy	2.2	4	76%
G05	Managing the Process of / Change	2.2	-1	76%
D01-	Theory and Development of / Systems	2.2	3	86%
D13	Systems Analysis & / Design Philosophies and Approaches	2.2	-1	88%
G04	IT Risk / Management	2.2	4	79%
E08-	Organizational / Behavior	2.2	-10	80%
F01-	Legal and Ethical Aspects / of IS	2.2	1	79%
M10	Policy, Legal, Ethics, and / Compliance	2.2	-3	80%
M11	System Administration: / installation, authentication, access, backups, virtualizations, / updates/patches, logging audit...	2.2	18	75%
A08	Using IT Governance / Frameworks	2.2	2	79%
M7-	IT Systems Components: / workstations, servers, storage, peripherals	2.2	14	84%
A27	Acquiring Information / Technology Resources and Capabilities	2.2	11	79%
M05	Fundamental Security Design / Principles	2.2	7	81%
D04	System Operation, Administration and / Maintenance	2.2	8	79%
G02	IS Leadership and / Empowerment	2.1	6	76%
B09-	Reporting Services, / ETL	2.0	15	77%

M04	IA Fundamentals: / Vulnerabilities, Attacks, Mitigation	2.0	6	80%
E05-	Operating / Systems	2.0	10	74%
D02	Strategic / Alignment	1.9	0	81%
D08	System Verification and / Validation Enabling	1.9	10	81%
E02-	High level System Design / Issues	1.9	-4	74%
E12-	Policies and / Compliance	1.9	-3	69%
C14	Social Issues and / Professional Practice	1.9	1	89%
A10	Architecture and / Organization	1.9	-2	79%
M08	Network Concepts, / Technology and Protocols, Vulnerabilities, Defense: firewalls, / vpn, dmz, monitoring, tools	1.9	11	76%
C08	Software Engineering / Management	1.8	2	82%
A05	General Organization Theory /	1.8	-10	81%
A12	Decision Theory /	1.8	-7	88%
F09-	Financing and Evaluating / the Performance of Information Technology / Investments	1.8	5	69%
A11	Computer Architecture and / Organization	1.8	9	83%
M09	Operating Systems Concepts, / security issues	1.8	8	81%
E09-	Parallel and Distributed / Computing	1.8	9	80%
C10	Algorithms and Complexity /	1.7	-7	90%
A04	General Systems Theory and / Quality	1.7	-5	87%
D03	Improving Alignment / Maturity	1.2	-4	71%

Appendix 4: Data form Expert Advisory Team (Grouped from the Highest Level Body of Knowledge Categories of Appendix 3)

KA		Depth 0-5	Emphasis Avg	Expert Confidence	
A22-	Database	4.3	28	97%	database
B03-I	Data Retrieval and / Manipulation with Database Languages	4.0	26	93%	
B05-I	Data and Information / Modeling at Conceptual and logical Levels	3.5	17	90%	
B06-I	Scripting	2.5	25	91%	
B01-I	Database Systems and / Distributed Databases	3.4	18	86%	
B07-I	Physical Database / Implementation / Data Definition Language	3.0	16	92%	
B08-I	Stored Procedure / Implementation	2.8	20	85%	
M02-	Databases: Database / operations, injection attacks	2.2	19	73%	
B12-I	Data Integrity and / Quality	3.2	19	91%	
B09-I	Reporting Services, / ETL	2.0	15	77%	
A13-	Business Intelligence and / Decision Support	3.0	14	90%	
B10-I	Data and Database / Administration	2.8	18	88%	
B11-I	Data Management and / Transaction Processing	2.7	22	90%	
B02-I	Basic File Processing / Concepts	2.2	12	88%	
A03-	Identification of / Opportunities for IT enabled Organizational / Change	2.8	10	92%	system development
A16-	Different Approaches to / Implementing Information Systems	2.8	15	91%	
F03-I	Managing the Information / Systems Function	2.2	-3	70%	
F06-I	Information Systems / Sourcing and Acquisition	2.2	9	72%	
A15-	Approaches to Systems / Development	3.7	24	96%	
F05-I	Information Systems / Planning	2.2	8	83%	
G02-	IS Leadership and / Empowerment	2.1	6	76%	
A01-	Impact of Information / Systems on Organizational Structure and / Processes	3.1	15	91%	
D02-	Strategic / Alignment	1.9	0	81%	
D03-	Improving Alignment / Maturity	1.2	-4	71%	
D08-	System Verification and / Validation Enabling	1.9	10	81%	
E02-I	High level System Design / Issues	1.9	-4	74%	
F07-I	Information Systems / Strategy	2.2	4	76%	
G05-	Managing the Process of / Change	2.2	-1	76%	
D01-	Theory and Development of / Systems	2.2	3	86%	
D13-	Systems Analysis & / Design Philosophies and Approaches	2.2	-1	88%	
A23-	Analysis and Specification / of System Requirements	4.0	19	90%	
A19-	Analysis of Business / Requirements	3.9	20	94%	
A20-	Information and Business / Analysis	3.2	15	90%	
D09-	Systems Development / Concepts and Methodologies	3.3	15	91%	
D06-	System Deployment and / Implementation	3.1	17	89%	

A21-	Information Systems Design /	3.9	21	93%	system design
D14-	Systems Analysis & / Design	3.6	23	92%	
B04-I	Teams and Interpersonal / Skills	2.9	15	89%	
D15-	User / Experience	2.6	16	89%	
A09-	Enterprise / Architecture	2.5	4	79%	
A17-	Business Process Design and / Management	2.7	15	89%	
D07-	System Verification and / Validation	2.5	12	86%	
D11-	Systems Implementation and / Testing Strategies	3.2	16	89%	
A25-	Configuration and Change / Management	2.5	12	85%	
E12-I	Policies and / Compliance	1.9	-3	69%	
C01-I	Programming / Fundamentals	3.8	32	94%	progarmming
C02-I	Programming / Languages	2.8	14	92%	
C03-I	Programming / Environments	2.5	16	87%	
M01-	Basic Data / Analysis	2.9	21	86%	
M03-	Basic Scripting/ / Programming	3.0	25	92%	
A07-	Web Systems and / Technologies	3.8	32	92%	
C05-I	Human Computer / Interaction	3.3	17	92%	
C06-I	Module Design and / Construction	3.2	18	91%	
C11-I	Algorithms and Data / Structures	2.3	12	86%	
C10-I	Algorithms and Complexity /	1.7	-7	90%	
C07-I	Software Engineering / Process	2.5	15	89%	
C16-I	Software Development / Fundamentals	3.3	25	92%	
C08-I	Software Engineering / Management	1.8	2	82%	
C09-I	Software / Requirements	3.5	18	93%	
C15-I	Software / Design	3.4	20	90%	
C17-I	Software / Construction	2.8	30	89%	
C18-I	Software / Quality	2.5	11	88%	
C19-I	Software / Testing	3.2	21	91%	
C20-I	Software / Maintenance	2.5	17	89%	
G06-	IS Project Strategy and / Management	2.8	8	85%	project management
A24-	Team and Interpersonal / Skills	3.5	20	94%	
G07-	Leading Project / Teams	3.5	21	91%	
G08-	Project Plan, Scope, and / Initiation	3.7	21	90%	
G03-	Establishing Project / Communication	2.8	13	88%	
G09-	Work Break-down / Structure	2.8	18	90%	
G10-	Project Execution & / Control	3.2	20	87%	
G11-	Project / Standards	2.6	11	83%	
G12-	Project / Quality	2.9	8	82%	
G04-	IT Risk / Management	2.2	4	79%	
G13-	Project / Closure	2.8	13	84%	

A04-	General Systems Theory and / Quality	1.7	-5	87%	Management of CIS
A05-	General Organization Theory /	1.8	-10	81%	
A12-	Decision Theory /	1.8	-7	88%	
E08-I	Organizational / Behavior	2.2	-10	80%	
F01-I	Legal and Ethical Aspects / of IS	2.2	1	79%	
C14-I	Social Issues and / Professional Practice	1.9	1	89%	
A02-	Individual and / Organizational Knowledge Work Capabilities	2.6	14	89%	
F09-I	Financing and Evaluating / the Performance of Information Technology / Investments	1.8	5	69%	
G01-	Professional Issues in / Information Systems	2.3	6	85%	
M10-	Policy, Legal, Ethics, and / Compliance	2.2	-3	80%	
M11-	System Administration: / installation, authentication, access, backups, virtualizations, / updates/patches, logging audit...	2.2	18	75%	
A08-	Using IT Governance / Frameworks	2.2	2	79%	
E07-I	Organizational and / Management Concepts	2.3	-6	83%	
M7-D	IT Systems Components: / workstations, servers, storage, peripherals	2.2	14	84%	
A27-	Acquiring Information / Technology Resources and Capabilities	2.2	11	79%	
D05-	System Integration and / Architecture	2.5	13	83%	
C04-I	Integrative Programming and / Technologies	2.6	18	78%	
M04-	IA Fundamentals: / Vulnerabilities, Attacks, Mitigation	2.0	6	80%	
M06-	Cyber Defense, threats, / attacks, Incidents, incident management	2.3	7	76%	
F02-I	Information Assurance and / Security	2.4	3	78%	
B13-I	Security attacks and / mitigations	2.6	15	84%	
C13-I	Security and Privacy, / Vulnerabilities, Risks, Mitigation	2.9	10	78%	
M05-	Fundamental Security Design / Principles	2.2	7	81%	
A06-	Information Technology / Fundamentals	3.4	23	91%	IT Components
A11-	Computer Architecture and / Organization	1.8	9	83%	
A10-	Architecture and / Organization	1.9	-2	79%	
D04-	System Operation, Administration and / Maintenance	2.2	8	79%	
M08-	Network Concepts, / Technology and Protocols, Vulnerabilities, Defense: firewalls, / vpn, dmz, monitoring, tools	1.9	11	76%	
E04-I	Networks and / Communications	2.8	15	81%	
A26-	Computer / Networks	2.7	21	89%	
E05-I	Operating / Systems	2.0	10	74%	
M09-	Operating Systems Concepts, / security issues	1.8	8	81%	
E09-I	Parallel and Distributed / Computing	1.8	9	80%	
H01-	Math and Statistics for / IT	2.7	18	87%	Other Courses
H02-	Probability and / Statistics--Basic probability theory, random variables and / probability distributions, estimation theo...	2.8	8	82%	

Appendix 5: Knowledge Areas ordered by Classification, by Source (curriculum model)

Source	Classification	Survey	KA Description	Depth	Emphasis	Conf
IS2002	Database	A22	Database	4.3	28	97%
IS2010	Database	B02	Basic File Processing / Concepts	2.2	12	88%
IS2010	Database	A13	Business Intelligence and / Decision Support	3.0	14	90%
IS2010	Database	B10	Data and Database / Administration	2.8	18	88%
IS2010	Database	B05	Data and Information / Modeling at Conceptual and logical Levels	3.5	17	90%
IS2010	Database	B12	Data Integrity and / Quality	3.2	19	91%
IS2010	Database	B11	Data Management and / Transaction Processing	2.7	22	90%
IS2010	Database	B03	Data Retrieval and / Manipulation with Database Languages	4.0	26	93%
IS2010	Database	B01	Database Systems and / Distributed Databases	3.4	18	86%
IS2010	Database	B07	Physical Database / Implementation / Data Definition Language	3.0	16	92%
new	Database	B09	Reporting Services, ETL	2.0	15	77%
new	Database	B08	Stored Procedure Implementation	2.8	20	85%
NSA2014	Database	M02	Databases: Database operations, injection attacks	2.2	19	73%
NSA2014	Database	B06	Scripting	2.5	25	91%

IS2002	Sys Devel	A15	Approaches to Systems / Development	3.7	24	96%
IS2002	Sys Devel	A20	Information and Business / Analysis	3.2	15	90%
IS2002	Sys Devel	G02	IS Leadership and / Empowerment	2.1	6	76%
IS2002	Sys Devel	G05	Managing the Process of / Change	2.2	-1	76%
IS2002	Sys Devel	D09	Systems Development / Concepts and Methodologies	3.3	15	91%
IS2010	Sys Devel	A23	Analysis and Specification / of System Requirements	4.0	19	90%
IS2010	Sys Devel	A19	Analysis of Business / Requirements	3.9	20	94%
IS2010	Sys Devel	A16	Different Approaches to / Implementing Information Systems	2.8	15	91%
IS2010	Sys Devel	E02	High level System Design / Issues	1.9	-4	74%
IS2010	Sys Devel	A03	Identification of / Opportunities for IT enabled Organizational / Change	2.8	10	92%
IS2010	Sys Devel	A01	Impact of Information / Systems on Organizational Structure and / Processes	3.1	15	91%
IS2010	Sys Devel	D03	Improving Alignment / Maturity	1.2	-4	71%
IS2010	Sys Devel	F05	Information Systems / Planning	2.2	8	83%
IS2010	Sys Devel	F06	Information Systems / Sourcing and Acquisition	2.2	9	72%
IS2010	Sys Devel	F07	Information Systems / Strategy	2.2	4	76%
IS2010	Sys Devel	F03	Managing the Information / Systems Function	2.2	-3	70%
IS2010	Sys Devel	D02	Strategic / Alignment	1.9	0	81%
IS2010	Sys Devel	D06	System Deployment and / Implementation	3.1	17	89%
IS2010	Sys Devel	D08	System Verification and / Validation Enabling	1.9	10	81%
IS2010	Sys Devel	D13	Systems Analysis & / Design Philosophies and Approaches	2.2	-1	88%
IS2010	Sys Devel	D01	Theory and Development of / Systems	2.2	3	86%

IS2002	Sys Design	A21	Information Systems Design /	3.9	21	93%
IS2002	Sys Design	D11	Systems Implementation and / Testing Strategies	3.2	16	89%
IS2002	Sys Design	B04	Teams and Interpersonal / Skills	2.9	15	89%
IS2010	Sys Design	A17	Business Process Design and / Management	2.7	15	89%
IS2010	Sys Design	A25	Configuration and Change / Management	2.5	12	85%
IS2010	Sys Design	A09	Enterprise / Architecture	2.5	4	79%
IS2010	Sys Design	E12	Policies and / Compliance	1.9	-3	69%
IS2010	Sys Design	D07	System Verification and / Validation	2.5	12	86%
IS2010	Sys Design	D14	Systems Analysis & / Design	3.6	23	92%
IS2010	Sys Design	D15	User / Experience	2.6	16	89%

CS2013	Programming	C10	Algorithms and Complexity /	1.7	-7	90%
CS2013	Programming	C02	Programming / Languages	2.8	14	92%
CS2013	Programming	C16	Software Development / Fundamentals	3.3	25	92%
IS2002	Programming	C11	Algorithms and Data / Structures	2.3	12	86%
IT2008	Programming	C05	Human Computer / Interaction	3.3	17	92%
IT2008	Programming	A07	Web Systems and / Technologies	3.8	32	92%
NSA2014	Programming	M01	Basic Data / Analysis	2.9	21	86%
NSA2014	Programming	M03	Basic Scripting/ / Programming	3.0	25	92%
NSA2014	Programming	C03	Programming / Environments	2.5	16	87%
SwE2009	Programming	C06	Module Design and / Construction	3.2	18	91%
SwE2009	Programming	C01	Programming / Fundamentals	3.8	32	94%
SwE2009	Programming	C17	Software / Construction	2.8	30	89%
SwE2009	Programming	C15	Software / Design	3.4	20	90%
SwE2009	Programming	C20	Software / Maintenance	2.5	17	89%
SwE2009	Programming	C18	Software / Quality	2.5	11	88%
SwE2009	Programming	C09	Software / Requirements	3.5	18	93%
SwE2009	Programming	C19	Software / Testing	3.2	21	91%
SwE2009	Programming	C08	Software Engineering / Management	1.8	2	82%
SwE2009	Programming	C07	Software Engineering / Process	2.5	15	89%

IS2002	Proj Mgmt	G06	IS Project Strategy and / Management	2.8	8	85%
IS2002	Proj Mgmt	A24	Team and Interpersonal / Skills	3.5	20	94%
IS2002	Proj Mgmt	G09	Work Break-down / Structure	2.8	18	90%
IS2010	Proj Mgmt	G03	Establishing Project / Communication	2.8	13	88%
IS2010	Proj Mgmt	G04	IT Risk / Management	2.2	4	79%
IS2010	Proj Mgmt	G07	Leading Project / Teams	3.5	21	91%
IS2010	Proj Mgmt	G13	Project / Closure	2.8	13	84%
IS2010	Proj Mgmt	G12	Project / Quality	2.9	8	82%
IS2010	Proj Mgmt	G11	Project / Standards	2.6	11	83%
IS2010	Proj Mgmt	G10	Project Execution & / Control	3.2	20	87%
IS2010	Proj Mgmt	G08	Project Plan, Scope, and / Initiation	3.7	21	90%

CE2004	IT Components	A26	Computer Networks	2.7	21	89%
CE2004	IT Components	A11	Computer Architecture and / Organization	1.8	9	83%
CS2013	IT Components	A10	Architecture and / Organization	1.9	-2	79%
CS2013	IT Components	E09	Parallel and Distributed Computing	1.8	9	80%
IS2002	IT Components	D04	System Operation, Administration and / Maintenance	2.2	8	79%
IT2008	IT Components	A06	Information Technology / Fundamentals	3.4	23	91%
NSA2014	IT Components	M08	Network Concepts, Technology and Protocols, Vulnerabilities, Defense: firewalls, vpn, dmz, monitoring, tools	1.9	11	76%
NSA2014	IT Components	M09	Operating Systems Concepts, security issues	1.8	8	81%
SwE2009	IT Components	E04	Networks and Communications	2.8	15	81%
SwE2009	IT Components	E05	Operating / Systems	2.0	10	74%

IS2002	Mgmt of CIS	A12	Decision Theory /	1.8	-7	88%
IS2002	Mgmt of CIS	A05	General Organization Theory /	1.8	-10	81%
IS2002	Mgmt of CIS	A04	General Systems Theory and Quality	1.7	-5	87%
IS2002	Mgmt of CIS	F01	Legal and Ethical Aspects / of IS	2.2	1	79%
IS2002	Mgmt of CIS	E08	Organizational / Behavior	2.2	-10	80%
IS2010	Mgmt of CIS	A27	Acquiring Information / Technology Resources and Capabilities	2.2	11	79%
IS2010	Mgmt of CIS	F09	Financing and Evaluating / the Performance of Information Technology / Investments	1.8	5	69%
IS2010	Mgmt of CIS	G01	Professional Issues in Information Systems	2.3	6	85%
IS2010	Mgmt of CIS	C13	Security and Privacy, Vulnerabilities, Risks, Mitigation	2.9	10	78%
IS2010	Mgmt of CIS	C14	Social Issues and / Professional Practice	1.9	1	89%
IS2010	Mgmt of CIS	D05	System Integration and / Architecture	2.5	13	83%
IS2010	Mgmt of CIS	A08	Using IT Governance / Frameworks	2.2	2	79%
IT2008	Mgmt of CIS	F02	Information Assurance and / Security	2.4	3	78%
IT2008	Mgmt of CIS	C04	Integrative Programming and / Technologies	2.6	18	78%
new	Mgmt of CIS	A02	Individual and Organizational Knowledge Work Capabilities	2.6	14	89%
new	Mgmt of CIS	E07	Organizational and Management Concepts	2.3	-6	83%
NSA2014	Mgmt of CIS	M06	Cyber Defense, threats, / attacks, Incidents, incident management	2.3	7	76%
NSA2014	Mgmt of CIS	M05	Fundamental Security Design Principles	2.2	7	81%
NSA2014	Mgmt of CIS	M04	IA Fundamentals: Vulnerabilities, Attacks, Mitigation	2.0	6	80%
NSA2014	Mgmt of CIS	M07	IT Systems Components: / workstations, servers, storage, peripherals	2.2	14	84%
NSA2014	Mgmt of CIS	M10	Policy, Legal, Ethics, and Compliance	2.2	-3	80%
NSA2014	Mgmt of CIS	B13	Security attacks and mitigations	2.6	15	84%
NSA2014	Mgmt of CIS	M11	System Administration: / installation, authentication, access, backups, virtualizations, / updates/patches, logging audit...	2.2	18	75%

IT2008	Math	H01	Math and Statistics for IT	2.7	18	87%
IT2008	Math	H02	Probability and Statistics--Basic probability theory, random variables and probability distributions, estimation theo...	2.8	8	82%

Appendix 6: Distribution of Survey Items and Impact

									Totals		
# of KA's in Model	27	73	17	13	18	18	4	11	181		
# of KA's used in survey	19	47	12	7	5	2	4	11	107		
	70%	64%	71%	54%	28%	11%	100%	100%	59%		
Models	IS2002	IS2010	SW	IT	CS	CE	new	NSA	Totals		
KA's used from *Model Used on Survey*											
Database	1	9	0	0	0	0	2	2	14	13%	
Systems Dev elopment	5	16	0	0	0	0	0	0	21	20%	
Systems Design	3	7	0	0	0	0	0	0	10	9%	
Programming	1	0	10	1	3	0	0	3	18	17%	
Project Management	3	8	0	0	0	0	0	0	11	10%	
IT Components	1	0	2	1	2	2	0	0	8	7%	
Management of CIS	5	7	0	3	0	0	2	6	23	21%	
Math	0	0	0	2	0	0	0	0	2	2%	
Sum	19	47	12	7	5	2	4	11	107	100%	
Relative impact of Model: (100 * #of Survey KA's) / Total #of Model KA's)							hrs/course =			35	courses to build CIS
Database	4	12								16	0.5
Systems Dev elopment	19	22								40	1.2
Systems Design	11	10								21	0.6
Programming	4		59	8	17					87	2.5
Project Management	11	11								22	0.6
IT Components	4		12	8	11	11				45	1.3
Management of CIS	19	10		23						51	1.5
Math				15						15	0.4
Totals	70	64	71	54	28	11				298	8.5

Note: The columns "new" and "NSA" are partial specifications and are not complete model curricula. For the complete models, the number of KA's in the model are variable. Thus, the numbers of KA's in each column is normalized to 100 for comparison. The totals add up to the number of items used in the survey. To shorten the survey, items were deleted which were duplicated, or which were felt not to be relevant for an IS type curriculum. The culling process was done from an alphabetically ordered list of KA's where the sources of the KA's were not shown. Interestingly, the numbers of KA's from both the IS 2002 model and IS 2010 are very similar except for programming wherein SW (Software Engineering), CS, IT, and CE contributed significantly to the total KA's. Under a lot of assumptions, if the KA's could be taught with the efficiency indicated in 298 hours, only 8.5 courses would be needed. Some caution is indicated: the 59 score for SE represents approximately 60% of the total time for and SW degree…