Information Systems and Computer Science Model Curricula: A Comparative Look

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ABSTRACT

Computer science and information systems are interrelated disciplines that both cover the technical and functional aspects of computing. They are fields of study in high demand by students and employers. Yet, many colleges do not have the resources to offer multiple computing departments. So, professional organizations have developed model curriculums to help define the knowledge necessary for information technology majors. This paper provides a discussion of model IS and CS curricula. It is hoped that IT departments will be able to develop an information technology curriculum, which suits their student's needs.

INTRODUCTION

Computer science, information systems, and management information systems are in high demand. Industry needs the graduates. The shortage of qualified information technology specialist is well known. Students want an information technology education to be able to fill the demand.

The demand for information technology (IT) workers will not decrease in the near future. It is fueled by the decrease in physical size of IT hardware, the decrease in price of information technology hardware and software, and the increase in performance, reliability, and flexibility. These affordability factors have caused IT to become critical to business operations and personal daily activities. This demand is not limited to the United States, the raising world wide demand is pushing the shortage to a global problem [Freeman 1999, Watson 1999].

All organizations today depend on information technology. Computers and information systems are essential to business and government. The information itself is a resource similar to finances, personnel, material, and equipment, which must be managed. To effectively management information requires technical knowledge of hardware, software, and information production, distribution, and integration. Therefore, the information technologist requires both technical and organizational knowledge [Davis 1997, IRMA 1999, Freeman 1999].

WHAT IS INFORMATION TECHNOLOGY

Information technology involves the "design, development, implementation, support or management of computer-based information systems, particularly software applications and computer hardware [ITAA 1997]." An IT worker is someone who performs at least one of those activities as 50% of their job. IT workers can be further classified into one of four categories: conceptualizers developers, modifiers, and supporters [Freeman 1999].

Conceptualizers are workers involved with the conception of the basic nature of an IT system or part of an IT system. Developers are people who specify, design, construct, and test IT. The workers who modify information technology work with existing hardware or software. Finally, there are those who support the existing systems by delivering, installing, operating, maintaining, or repairing. Undergraduate institutions should emphasize preparing students to work as developers, modifiers, or supporters or for further education to become conceptualizers.

IT is not a homogeneous field, it has many different and diverse academic and professional origins. IT uses as reference disciplines mathematics, management and engineering [Denning 1998, Freeman 1999, Myers 1999, Watson 1999]. Depending on the interests of academic faculty the IT major originated from one of three reference disciplines. In business, computers were first used in accounting departments to track accounts receivable and accounts payable. This quickly led to university business departments investigating computing as it applied to management control and accounting. Mathematicians found the algorithmic and logical nature of programs to be a resurrection of these fields of mathematics. Mathematics departments began investigations into the theoretical aspects of software. Electrical engineering is of course necessary to construct the hardware components of the computer. From the academic perspective, computing may have originated in the business department focusing on information systems, the mathematics department focusing on software, or in electrical engineering as computer engineering. IT is now an umbrella-term for the fields of computer engineering, computer science, software engineering, information systems, and management information systems.

INFORMATION TECHNOLOGY DEPARTMENTS

The rise of IT and the variation of business and technical emphasis has lead to many program names. Even with different schools calling programs by different names, most IT programs teach students the following areas: develop hardware or software, maintain information systems in organizations, and provide information services [Denning 1999, Freeman 1999].

To help schools and departments develop appropriately structured curriculums professional organizations, particularly the Association of Computing Machinery (ACM), in conjunction with the Computing Society of the Institute of Electrical and Electronic Engineers (IEEE-CS); the Information Resources Management Association (IRMA) in conjunction with the Data Administration Management Association (DAMA); and the Association for Information Systems (AIS), in conjunction with the ACM and the Association of Information Technology Professionals (AITP) have developed model curricula. Model curricula have also been developed by other organizations, in particular the Information Systems-Centric Curriculum (ISCC) committee. This paper provides a comparison of model curricula. From these models, computing departments should be able to develop an IT curriculum, which

suits their particular needs.

TOPICS COVERED IN INFORMATION TECHNOLOGY

Information Technology consists of various technical topics, which the curriculum models address. Topics range from a theoretical understanding of computing through the design of practical applications. These topics collectively represent the body of IT technical knowledge expected of bachelor's degree IT graduates.

1. Use of Software Tools - Practice and theory in the use of software development tools to construct small decision-making systems.
2. Overview of IS - A survey of information systems specifically their business application and effect on society.
3. Operating Systems - Control mechanisms for the execution of computer programs in an environment of multiple resources.
4. Architecture - Computer organization for the implementation of processors, memory, communications, and software interfaces.
5. Programming, Languages, Algorithms and Data Structures - Design and construction of application programs using computer languages.
6. Networking - Hardware and software data communication concepts and the design, development, and management of computer networks.
7. Systems Analysis and Design - The analysis and specification of requirements and the design and development of the system.
8. Database and Information Retrieval - The modeling and implementation of databases.
9. Project Management - Planning and management of complex software development projects.
10. Artificial Intelligence, Robotics, and Decision Support - Design, development, and management of systems that support decisions.
11. Ethics - A survey of the legal and moral issues of computer and system usage.
12. Internship or Design Project- An opportunity to apply classroom knowledge in a professional setting.

These topics were derived from a collective analysis of the curriculum models. Each of the model's courses was then assigned to the topic most closely matching the course. This provides for a comparison of courses across models as shown in Table 1.

The table does not discuss the depth of knowledge or imply equivalence between the courses. It only shows the coverage by course of the topics. For example, the Systems Analysis and Design topic has one course from ACM's CS, and the IRMA/DAMA models and two courses from the IS '97, and ISCC '99 models. All of these courses discuss elements of requirements analysis and systems design.

It is possible that topics in a model are covered in courses of the model but not specifically identified as such a course. For example, the ethics of computing in the IS '97 and IRMA/DAMA models may be discussed in Overview of IS courses, whereas, the ISCC '99 model has two specific half-courses.

INFORMATION RESOURCES MANAGEMENT MODEL

Information Systems (IS) is the combining of business and computer science. As a discipline it is composed of two parts: information management and systems development. The acquisition, deployment, and management of information technology resources and services are studied in the information management portion. The development and evolution of technology infrastructures is the focus of the systems development portion [Davis 1997].

The Information Resources Management Association's (IRMA) IRMA/DAMA 2000 model has a business approach to IS. Taking a top down approach to IS education this model stresses learning general principles before specific implementation details. Specifically, programming is left to the third course after the concept of information as a resource is well understood.

Central to the IRMA/DAMA curriculum is the recognition of information as the major organizational asset. This preparation for an IT profession revolves around the application of IT to business problems. Effective verbal and written communication, time management, leadership, and delegation of authority skills are stressed in this program.

The proposed curriculum consists of 10 courses of which the student must complete 7, 6 required and 1 elective selected from the remaining five [IRMA 1999]. The traditional application programming, systems programming, and computer hardware is de-emphasized. How information is used in decision-making and how information effects the various components of a business are the basis of the courses. The elective courses provide management refinement and specialization [IRMA 1999]. See Figure 1 and Table 1.

Table 1 Comparison of Courses to Topics *(electives in Italics)*

Topic	IRMA/DAMA 2000[1]	AIS '97	ISCC '99	ACM-CS[6]
Software Tools		IS'97.P0 Knowledge Work Software Tool Kit[3,4] IS'97.2 Personal Productivity with IS Technology[3,4]		
Overview of IS	IRM1 - IRM Principles[2] IRM2 - Information Systems Technology *IRM8 - Global Information Management* *IRM10 – Selected Topics in IRM*	IS'97.1 Fundamentals of IS[3,4] IS'97.3 Information Systems Theory and Practice[4]	ISCC-11 Information Systems in Enterprises ISCC-44 Dynamics of Change	
Architecture		IS'97.4 Information Technology Hardware and Software		CS 201 Introduction to Computer Systems CS 301 Computer Organization and Assembly Language CS 306 Architecture
Operating Systems				CS 302 Software Systems CS 305 Operating Systems
Programming, Languages, Algorithms and Data Structures	IRM3 - Algorithm Concepts and Information Management	IS'97.5 Programming, Data and Object Structures[4]	ISCC-21& Information Systems Architecture I ISCC-31 Information Systems Architecture II	CS 101 Intro to Computing I CS 102 Intro to Computing II CS 202 Analysis and Design of Algorithms CS 304 Programming Lang
Networking	*IRM7 - Communication Technology and Information Management*	IS'97.6 Networks and Telecommunications	ISCC-43 Telecommunications and Networking Issues/Methods ISCC-51 Distributed Systems	
Systems Analysis and Design	IRM6 - IRM Design and Implementation	IS'97.7 Analysis and Logical Design of an IS[4] IS'97.9 Physical Design and Implementation with a Programming Environment	ISCC-42 Human Computer Interaction and Methods ISCC-53 Comprehensive Enterprise Information Systems Engineering	CS 303 Software Engineering
Database and Information Retrieval	IRM5 - Data Resource Structures and Administration	IS'97.8 Physical Design and Implementation with DBMS	ISCC-41 Information Databases and Transaction Processing	
Project Management		IS'97.10 Project Management and Practice		
Artificial Intelligence, Robotics, Decision Support	IRM4 – Data Warehousing, Data Mining, and DSS *IRM9 - Executive Information Systems Management*		ISCC-45 Applications of AI in Enterprise Systems	
Ethics			ISCC-22 Ethics I[5] ISCC-52 Ethics II[5]	
Internship or			ISCC-61 Comprehensive	CS Design Elective

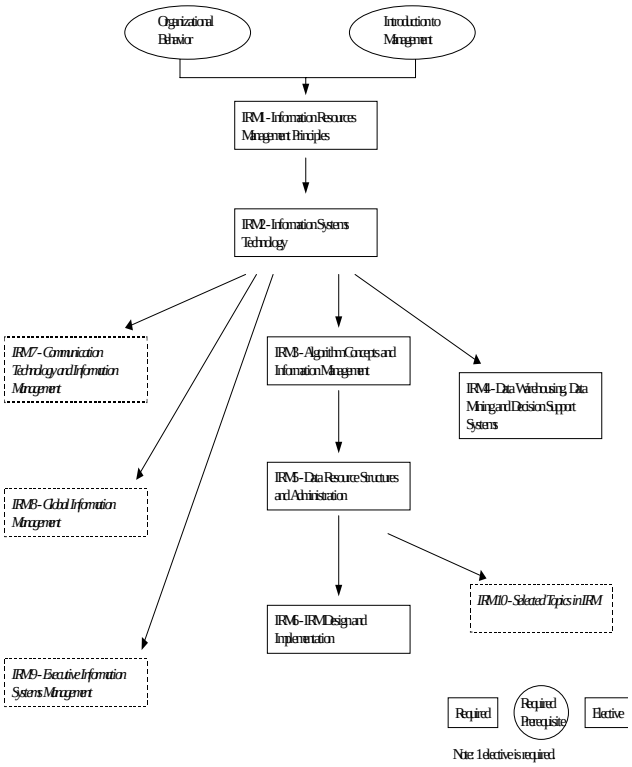

Figure 1 Information Resource Management Model

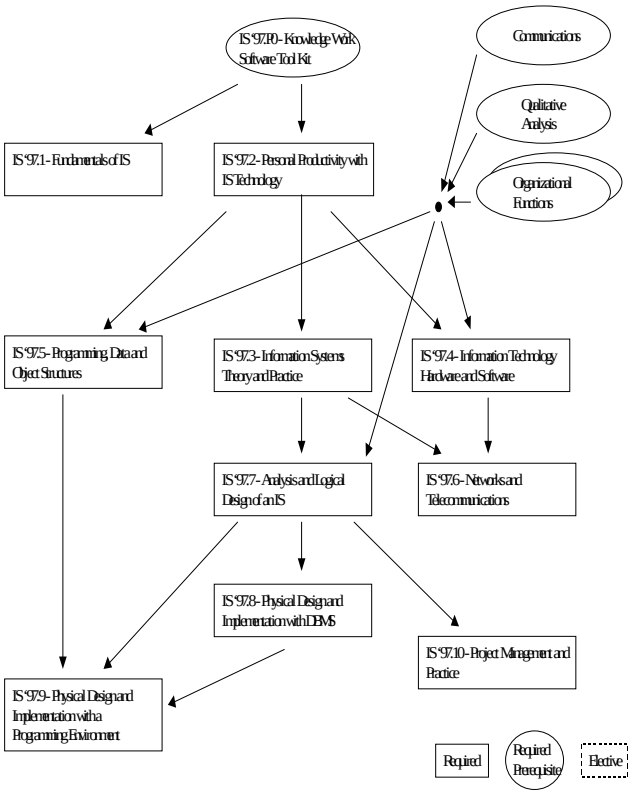

Figure 2 Information Systems '97 Model

INFORMATION SYSTEMS '97 MODEL

The Association for Information Systems (AIS) Model Curriculum for Information Systems, IS' 97, provides for the technical aspects in information systems as well as a foundation in business processes. The AIS's model comes from a body of knowledge developed "from surveys of practitioners and academics" [Davis 1997].

This model is strong in fundamental computing and information systems knowledge. The curriculum is divided into three components. The first level stresses the development of small office and personal systems, the effective use of organizational systems, and the identification of a quality system. The second part specializes in the technology; courses in the hardware and the software of information technology, software programming, and systems analysis and design. Emphasizing teamwork in systems design, development, and project management is the final portion [Davis 1997]. This three level structure allows students to leave the program and still have obtained an organized body of knowledge, and perhaps a minor, in information systems.

The curriculum is divided into ten required courses and one prerequisite (IS'97.P0). The prerequisite course provides students basic knowledge in office applications. There are no specified technical electives.

Because IS professionals need to be able to communicate within a business organization effectively, courses in communications, quantitative and qualitative analysis, and organizational functions are necessary. Courses outside of IT are also necessary to provide technical background and breadth in business functions. Therefore, non-technical required, but not specified, courses include courses in communications, mathematics, and business functions. [Davis 1997]. See Figure 2 and Table 1.

INFORMATION SYSTEMS-CENTRIC CURRICULUM '99

A collaborative Academe/Industry Task Force has developed a third model known as the Information Systems-Centric Curriculum '99 (ISCC '99). It is heavy in ethics and practical skills. The authors are seeking the endorsement of the AIS, the ACM, and the IEEE [Lidtke 1999].

This curriculum looks at information as an enterprise asset, which must be managed. The management is accomplished through large-scale, complex information systems. It is the building of complex systems that takes precedence in this curriculum. This is an engineering development approach to information systems. However, it does not exclude interpersonal skills, which are necessary in the teamwork environment of systems development.

The key components of the ISCC'99 curriculum are the close relationship with industry and education through teamwork. By using innovative pedagogical techniques such as teaming, just-in-time learning, and guy by the side, the courses place students into an active learning role. The last course is a project that comes from an industrial sponsor of the program.

The curriculum consists of 11 full courses and 2 half courses as well as 4 required foundation courses. The model also contains 4 technical electives and identifies a number of non-technical courses to bring in business aspects such as economics, project management, and business functions. The model encourages students to include in their studies courses that require interpersonal, systemic thinking, and problem solving skills [Lidtke 1999]. See Figure 3 and Table 1.

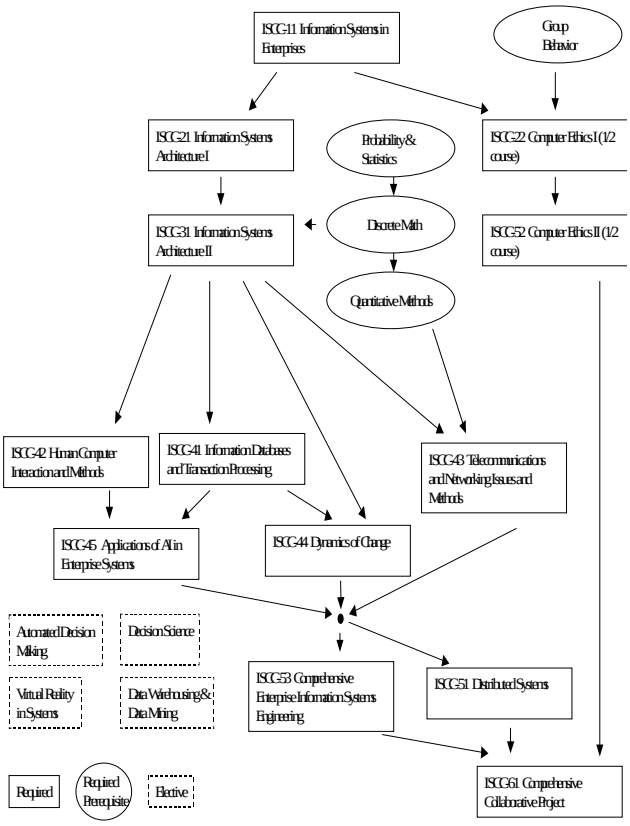

Figure 3 Information Systems-Centric Model

COMPUTER SCIENCE

In 1991, the ACM and IEEE-CS published computing curricula models for computer science [Tucker 1991]. The method used was to divide the material considered important in computing into concepts known as knowledge units.

The recombination of knowledge units allows creation of multiple courses and curriculums from the same body of knowledge. The ACM/IEEE-CS task force created 12 different curricula. All the curricula have a heavy programming emphasis. We will consider here only the Computer Science program meeting the accreditation requirements of ABET and CSAC [Tucker 1991]. Engineering programs in the United States are accredited by the Accreditation Board of Engineering and Technology (ABET). The nationally recognized accreditation organization for computer science is the Computer Science Accreditation Commission (CSAC)

Mathematics plays a strong part in all the curricula, but most of the courses are not specified. None of the programs has a requirement for business courses. However, there is recognition for the need for humanities, the social sciences, and communication skills.

The curriculum consists of 16 courses: 10 required, 6 concentration electives and a design elective. The required concentration may be in software engineering, multiprocessing, knowledge-based systems, or a similar area. The program is capped with a design course [Tucker 1991]. See Figure 4 and Table 1.

SIMILARITIES AND DIFFERENCES

The CS model begins with programming courses in a higher order language. The inverted curricula proposed by the IRMA, AIS, and ISCC present at least one course that establishes a foundation in information technology before focusing on the more narrow aspects of IT. The introductory course serves two purposes. First, it provides an introduction to the field for potential majors. Second, it serves as an overview to the field for other majors. It provides the non-major with an understanding of IT and acts as a gateway for majors and minors [Freeman 1999].

Most new students do not know the difference between the computing fields and typically start in computer science. With the introductory course as programming, there are high attrition rates; and it becomes a rite of passage course [Freeman1999, Shaekelford 1994]. This can present a problem with switching majors from computer science to information systems. These students have already completed courses, specifically programming, which come latter in the IS curricula. These transfer problems need to be worked out between the programs at individual schools.

The four models represent a continuum of the reference disciplines from business to mathematics (Figure 5). IRMA/DAMA provides a business management approach to IT education. This model treats information as a business resource, which needs efficient and effective management. To manage the information it is necessary to manage the production and storage tools (hardware and software) and to understand the business needs.

The AIS model provides for both the business and technical aspects of IT. The structure recognizes that some IT knowledge is important to everyone. Course sequences are provided for all college students and IS minors as well as IS majors. The building nature of these sequences allows students to start slowly and continue or switch majors without loss of effort.

The ISCC '99 model is oriented toward large-scale system design and implementation. This model stresses the need for teamwork in problem identification and solution. The focus is on the construction of the tools necessary for information management.

The ACM computer science model has no business component. The courses focus on programming and the architecture of the computer. The approach is the most theoretical. Programming related courses comprise nearly a third of the computer science implementation. Architecture and operating systems comprise another third. The final third are electives in an area of concentration.

The IRMA/DAMA, ISCC, and ACM models contain elective courses. The ACM model in computer science requires that the electives form a technical area of concentration. The AIS model recommends additional courses in business to complete the curriculum. Each model also requires prerequisite work in mathematics.

The standard college education is based on an eight-semester sequence of courses. The courses provide for a general education and specialization in one particular field - the major. The courses in the major are generally interleaved with the general education re-

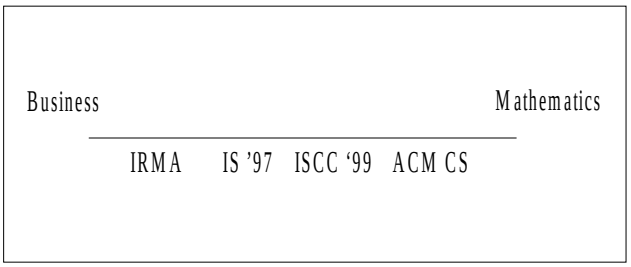

Figure 4 Business Mathematics Continuum

	Required Courses	Required Prerequisites	Specified Electives	Minimum Semesters to Complete
IRMA/DAMA 2000	7[1]	1[2]	4	5
AIS - IS '97	10	4[3,4]	—	6[4]
ISCC '99	12[5]	4	4	7
ACM - CS	17[1]	2	7	7

- Includes required electives.
- May be Organizational Behavior or Introduction to Management.
- Specific organizational functional courses are not specified; this table assumes one such course.
- Includes computing prerequisite.
- The two ethics courses (ISCC-21 and ISCC-52) are half courses and counted as one here.

quirements. This allows students an opportunity to explore different fields and select an appropriate major. Therefore, the number of semesters to complete the major courses may be less than eight.

The courses in the major are normally arranged is a hierarchical, prerequisite structure. This provides for increased depth of knowledge as the student's education proceeds. For the curriculum to be do-able, it must fit into the 8-semester time frame.

The IRMA/DAMA model is designed to start in the third year. If the prerequisite business courses are completed in the first two years, the model requires at least five more semesters to complete the required courses. This is a problem because the student has only four semesters left. However, if the IRMA/DAMA program is started in the fourth semester (2nd year) this problem is resolved. Because the model also suggests the first course (IRM 1) be part of all business majors this is not a serious problem.

The IS '97 model is a six semester sequence of courses. This includes one semester for the prerequisite computer literacy course (IS'97.P0). It is expected many new students will come to college with these computer literacy skills and be able to complete the IS '97 curriculum in five semesters. Plus, this model identified 2 courses for all students and a 5 course minor beyond the prerequisite. With this philosophy there is no loss of effort on changing majors.

The ISCC '97 and ACM CS models, including prerequisite courses, comprise a seven-semester sequence. This leaves little slack for entering the program late without extending beyond four years.

CONCLUSION

All of these models have good points. Most schools will not be able to adapt a model in its entirety. Rather each school needs to assess its educational philosophy and student needs to choose and modify the model best for them. By closely following a model the school's prospective students, student's potential employers, and graduate schools know the type of education received by the graduates. The school administration is assured that the IT department is providing a recognized curriculum, which covers all the central topics of information technology. Although the models differ in emphasis, businesses will need information technologist from each of the models presented here.

Each of these models is under continuous review. IRMA/DAMA updated their model in 2000. AIS expects to update in 2000, as well. The ACM expects to publish a new set of models in early 2001 [ACM 2000]. IRMA/DAMA's most recent draft is available at http://gise.org/IRMA-DAMA-2000.pdf. AIS is currently collecting data and comments over the World Wide Web at http://www.IS2000.org/. The ISCC's Web site http://www.iscc.unomaha.edu includes an opportunity to comment on the model.

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