IS'95: Guideline for Undergraduate IS Curriculum

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Abstract

This paper provides an overview report of the first joint curriculum development effort for undergraduate programs in information systems. The curriculum recommendations are a collaborative effort of the following organizations: ACM, AIS, DPMA, and ICIS. After a summary of the objectives and rationale for the curriculum, the curriculum model is described. Input and output attributes of graduates are delineated. Resource requirements for effective IS programs are then identified. Lastly, there is a proposal for maintaining currency of the curriculum through electronic media.

Keywords: Education, undergraduate curriculum, information systems, system analysis, system design, faculty resources

ISRL Categories: IA01

Introduction

An industry as innovative and progressive as the computer field needs continuous knowledge and skill updating. Concomitantly, university-level information systems curriculum needs constant updating to remain viable. Most IS academic units have mechanisms in effect to maintain currency of curriculum. Then why have professional society curriculum committees?

Curriculum models have proved useful for a variety of reasons. Of course, if an IS academic unit was providing graduates solely to local business and government, it would not need to refer to curriculum models. The input on program contents would be derived from representatives of the local organizations that hire the unit's graduates. Local employment is *not* the objective for all undergraduate majors in information systems, however. Students from most IS programs accept jobs in widely dispersed geographic areas. Therefore, availability of curriculum models enables local academic units to maintain academic programs that are consistent with employment needs across the country.

Professional society curriculum reports serve several other objectives. The foremost is to provide a local academic unit with rationale and leverage to obtain proper resources to support its program. Administration of the local institution may not agree with the number of courses proposed by the IS unit for adequate preparation of IS students. Administration may be unaware of the quality level of computing equipment, software, and laboratories necessary to support a viable IS program. It may be unaware of the specialized classroom technology, or the amount of library resources or lab assistants essential for proper education of IS undergraduates. Finally, administration might not recognize the rapid turnover of knowledge in the field and the need for resources to support constant retooling of faculty. National curriculum reports provide recommendations in these resource areas as well as content for the necessary body of knowledge. These reports provide important leverage for local IS academic units to negotiate with administration for proper levels of support for their program.

This paper summarizes the curriculum recommendations of the joint committee from ACM (Association for Computing Machinery), DPMA (Data Processing Management Association), ICIS (International Conference on Information Systems), and the newly formed academic society, AIS (Association of Information Systems). It is the first collaborative curriculum effort between these organizations. The separate curriculum recommendations prepared previously by ACM and DPMA have confused both academic and practitioner communities. Leverage on the university administration is much more effective through a collaborative curriculum report. IS'95 recommendations have additional leverage because they were not prepared solely by academicians. Representatives from industry participated both in the curriculum development and review process (see the Appendix for an explanation of these processes). Over 1,500 copies of the report were distributed for comment to practitioners who are members of ACM's Special Interest Group in Business Information Technology (SIGBIT), DPMA, and the Society for Information Management (SIM).

This paper covers the following topics: curriculum response to changes in the IS environment, model curriculum, input and output attributes of graduates, and resource recommendations. It also describes the approach recommended for future curriculum updates—via electronic media. The proposed electronic updating approach will not only allow the curriculum to be updated more frequently, but will enable a wider range of participation in the curriculum updating process.

Curriculum Responses to Changes in the IS Environment

Significant changes have occurred in the national IS environment since the last curriculum reports from ACM (Nunamaker, et al., 1982) and DPMA (DPMA, 1991). The trend to move IS functions out to the user community has accelerated.

Regardless of the organization in which they take jobs, a strong demand for IS professionals is forecast by the U.S. Bureau of Labor Statistics to continue through the year 2005 (Bureau of Labor Statistics, 1993). As shown in Table 1, the forecasted increase in demand for systems analysts is 110 percent for the period 1992-2005, averaging over eight percent annually.

Table 1. Fastest Growing Occupations Requiring a College Degree

1992-2005

Computer Engineers and Scientists	112%
Systems Analysts	**110%**
Physical Therapists	88%
Special Education Teachers	74%

The IS field also remains attractive in regard to compensation. Although pay was not rising as fast as in the early growth periods of the industry, 1993 raises exceeded those of all other professions except for engineers (Sullivan-Trainor, 1994). These factors—growth and pay levels—indicate undergraduate degrees in IS will continue to be in strong demand over the next decade.

Nevertheless, in this era of restricted academic budgets, some IS academic departments have been under pressure from peer academic units, citing the decline in the central IS organizations. There is no lessening in demand for IS knowledge and ability in the corporation; to the contrary, the demand is expanding as the functional areas of the firm seek to gain more capability in IS. Many functional areas of the firm are now hiring IS majors for departmental computing activities. There is also a strong demand for IS minors, for students in other disciplines who want IS expertise in order to be able to serve as the liaison to the central IS organization developing applications in their functional area. The third area of expanding need for IS education occurs throughout the various disciplines taught in the university, for students who want more IS knowledge to facilitate career growth in their field. Every discipline is experiencing growth in computer use, and students who are not enriching their IS knowledge are at a career disadvantage.

Therefore, the computer content in curricula has been expanded in almost every discipline within the university. There is a need to delineate both the teaching responsibilities for the various topics and the level at which the topics are taught. A simple representation of this delineation is provided in Figure 1.

The **prerequisite skills level** provides a much more sophisticated personal capability for students than was provided just a few years previously. Basically, six topic areas are covered: electronic mail, spreadsheet processing, database management, presentation graphics, statistical analysis, and external database retrieval (word processing is also included in the toolkit but is typically enforced as a prerequisite). Students obtain a competency base in each of these six areas. Some schools provide the prerequisite skills level of IS education via a course required of all students. Other schools enable students to acquire this competency through laboratories with computer-based tutorial modules and competency tests.

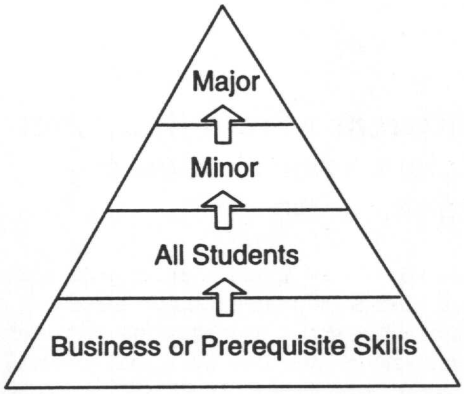


Figure 1. Educational Level for IS Academic Programs

An **"all students" level** of IS education provides the necessary competencies for end users of IS systems. Students obtain advanced instruction and competency in the six foundational areas. They also gain additional IS skills and understanding through use of application packages in their major fields of study, such as accounting, finance, or marketing.

The **minor level** provides competency for functional students who plan to be the ones in the user community who serve as user representatives on teams to develop and enhance major applications such as marketing analysis and cost accounting. These people also acquire expertise for assistance in personal and workgroup computing for other members of their work unit. These students take a subset of the required curriculum for IS majors.

The **major level** prepares students for a career in the IS field. They complete the prior three levels before beginning their specialization. The preparation for the IS major includes project management in a team environment, designing and implementing systems, and integrating solutions into functioning systems.

Information Systems as a Field of Academic Study

Information systems as a field of academic study began in the 1960s, a few years after computers were first used for information processing by organizations. As organizations extended the use of information technology to operational processes, decision support, and competitive strategy, the academic field also grew in scope and depth. As the new organization function emerged to manage information technology, a new academic discipline was developed to provide instruction relative to the concepts and processes of the new function. During the 30-year period of growth and change, different names have been used, and the definition of the field has been enlarged.

Differing names for the academic field

Information systems as a field of academic study uses a number of different names. The variety of labels reflects both the historical development of the field and different ideas about how to characterize it, and the different emphases that were available when programs were begun. In general, the following terms are equivalent and are all incorporated in the term *information systems:*

- Information systems
- Computer information systems
- Information management
- Information technology resources management
- Information resources management
- Management information systems

University degree majors within professional schools usually reflect important organization functions. In the same way that universities have degree programs for organization functions of financial resources management, marketing resources management, and human resource management, a degree program emerged for information technology resources management. Henceforth, the simple term, information systems (IS) will be used to refer to this academic field.

Differing scope

Information systems, as an academic field, encompasses two broad areas: (1) acquisition, deployment, and management of information technology resources and services (the information systems function), and (2) development and evolution of infrastructure and systems for information use in organization processes (systems development).

The information systems function has a broad responsibility to develop, implement, and manage an information infrastructure of information technology (computer and communications), data (both internal and external), and organization-wide systems. It has the responsibility to track new information technology and assist in incorporating it into the organization's strategy, planning, and practices. The function also supports departmental and individual information technology systems.

The activity of creating systems for organization and inter-organization processes involves creative use of information technology for data acquisition, communication, coordination, analysis, and decision support. There are methods, techniques, technology, and methodologies for this activity. Creating systems in organizations includes issues of innovation, quality, human-machine systems, human-machine interfaces, socio-technical design, and change management.

Information technology is pervasive in all organization functions. It is used by accounting, marketing, production, etc. Even though it is pervasive, the need for an information systems function and systems development expertise is not eliminated. Its pervasive use changes the work of the function and the role of systems development methods. The information systems function moves from "doing it all" to supporting innovation, planning and managing information infrastructures, and coordinating information resources. Systems development involves not only organization-wide integrated systems but also support for individual and departmental application development.

Difference From Computer Science and Software Engineering

To some, it may appear that computer science and information systems cover the same domain or that software engineering and information systems are the same with respect to systems development. There are important differences, necessitating a separate information systems degree program. The important differences are in the context of the work to be performed, the types of problems to be solved, the types of systems to be designed and managed, and the way the technology is employed.

The context of information systems is an organization and its systems. The context of computer science is algorithms and system software. In computer science, the emphasis is on the "systematic study of the algorithmic process—the theory, analysis, design, efficiency, implementation, and application—that describes and transforms information. The context of software engineering tends to be large-scale software systems of the type found in command and control systems, military systems, communications systems, and large inter-organizational systems. Although the methods can be applied in smaller systems, the context for the methods is generally tied to the problems of large systems (Glass, 1992).

The nature of work in the information age assumes that students are skilled in the basic knowledgework software toolkit. In addition, all students need to understand the relationship of systems to organizational goals. Also, the information systems academic field provides academic coursework for majors in the two broad areas of the information systems function and systems development.

Attributes of information systems graduates

The graduate of an IS program should be equipped to function in an entry-level position and should have a basis for continued career growth. The desired attributes of IS program graduates are shown in Table 2, as are the specific competencies acquired through the program.

In Table 3 the competencies are broken into specific ability and knowledge objectives of the curriculum.

Prerequisites for the IS Program

All knowledge workers need proficiency in the fundamental tools of personal computing, such as e-mail, spreadsheets, wordprocessing, databases, presentation graphics, statistical analysis, and external database retrieval. In addition, the IS professional needs the skills to design, develop, acquire, and deploy an organization's information technology. To do this, the IS professional must be able to communicate to knowledge workers within and between organizations. Tomorrow's IS professional must also be a creative, innovative, entrepreneurial problem solver, implementor, and change agent.

Table 2. Attributes of Information Systems Program Graduates

Characteristic	Competence to . . .
Communication	exchange information in a professional manner using a variety of tools and techniques
Computer Applications Systems	understand how and where to apply application systems to organizational functions
Information Technology and Tools	understand computer and information technology and its function
Interpersonal Relationships	successfully interact with a diverse population
Management	plan and direct people and projects
Problem Solving	define and interpret complex problems using qualitative and quantitative methods
Systems Development Methodologies	develop or acquire software
Systems Theory and Concepts	view, describe, and define any situation as a system
Professionalism	engage in appropriate behavior consistent with professional standards

Table 3. Representative Abilities and Knowledge for IS Program Graduates

Characteristic	With the Ability to...	Using the Knowledge of...
Communication	• actively listen and express complex ideas in simple terminology • make presentations • write memos, reports, and documentation	• interviewing skills • proper presentation of data • automated tools and techniques
Computer Applications Systems	• apply IS solutions to functional, inter-organizational, operational, managerial, and executive problems and opportunities • describe characteristics of various information systems	• organizational theory, structure, and functions • characteristics and capabilities of systems and technologies
Information Technology and Tools	• describe the functions and components of computers and networks • select and apply software tools for organizational solutions	• computer and networking concepts • programming languages and environments
Interpersonal Relationships	• effectively work with people of diverse backgrounds • effectively work with people at all corporate levels • ability to lead and facilitate teams	• leadership, management, and organizations • small group communications and motivation • cultural diversity
Management	• establish project goals consistent with organizational goals • specify, gather, deploy, monitor, and direct resources and activities • apply concepts of continuous quality improvement	• planning and resource management • leadership, motivation, and team building • measurement and benchmarking
Problem Solving	• recognize the need for the application of analytic methods • formulate creative solutions to simple and complex problems	• collect, summarize, and interpret data • statistical and mathematical methods
Systems Development Methodologies	• select and utilize appropriate methodologies • use tools and techniques to analyze, design, and construct an IS • assess feasibility and risks associated with projects	• systems development life cycle • prototyping, purchasing, and outsourcing • feasibility and risk analysis
Systems Theory and Concepts	• represent organizational processes and data using formal methods • identify interfaces, boundaries, and components of problems	• general systems theory • process, data, logic, and event modeling
Professionalism	• articulate a personal position and respect the opinions of others • adhere to ethical standards • assess organizational and societal impacts of an IS • actively employ current practice and knowledge	• codes of conduct • ethical theory • standards for practice

All IS students should be able to communicate effectively in both a written and spoken language(s), and in both qualitative and quantitative techniques. The IS student must also have the people skills and basic understanding of the functions of an organization and its people to effectively empower its knowledge workers. This requires an introduction to the basic principles of mathematics and the behavioral, social, and natural sciences, as well as a foundational knowledge in the disciplines within business administration. Specific prerequisite topics include:

- Communications
  - Writing and technical writing skills
  - Oral communication
  - Listening skills
- Mathematics and Statistics
  - Calculus/calculus for business
  - Basic statistics
  - Discrete mathematics
- Business Core
  - The cross-functional nature of systems requires knowledge in the areas of marketing, finance, accounting, production, distribution, and human resources
- Other
  - Macro economics
  - Micro economics
  - Internationalization of business

Model Curriculum

Figure 2 depicts the core curriculum areas for the IS body of knowledge. The dotted box indicates the organizational behavior and functional area curriculum, typically acquired in the core curriculum for a degree from a college of business. The other boxes show the core curriculum typically

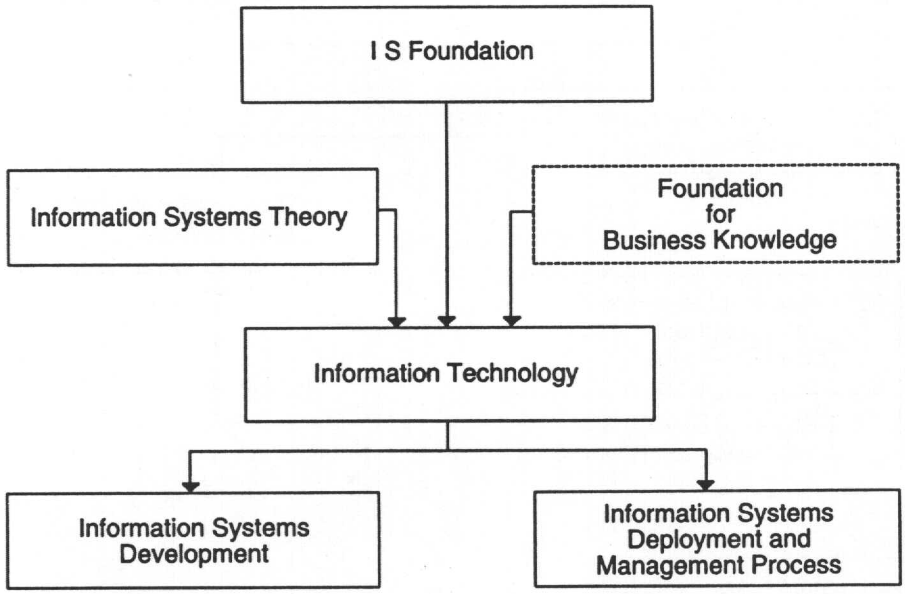
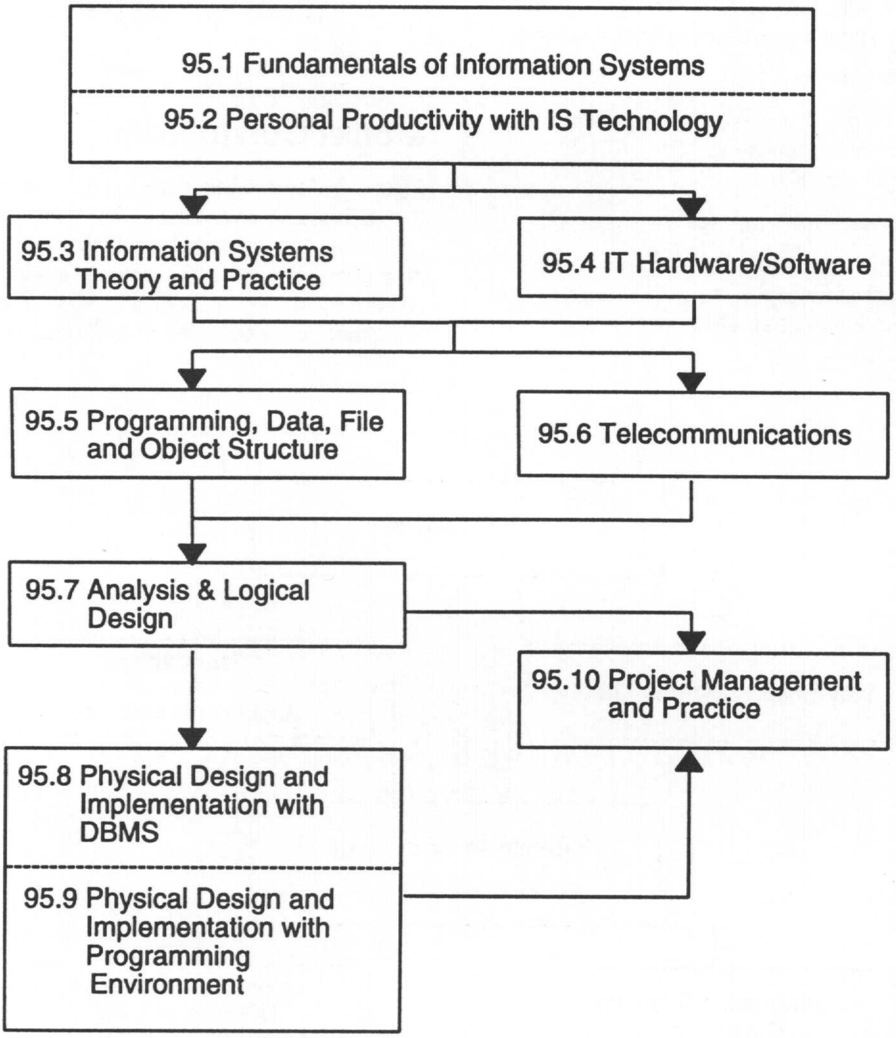


Figure 2. Curriculum Areas for IS Body of Knowledge

acquired from the IS academic unit. The figure also depicts the sequence in which the knowledge is acquired by students of an IS program.

Figure 3 depicts the recommended packaging of learning units for the IS major and their recommended sequence. Eight to 10 courses are needed to operate effectively in the technology-intensive environment of the information systems field. Schools that do not have the resources to support this degree of specialization should concentrate on providing a minor rather than a major in the field. Additional courses would be required for specialization in the field, such as database designer or network designer.



Eight to 10 courses are recommended for the IS major, depending upon an IS unit's limitations for courses/major. For units with an eight-course limitation it is recommended that four courses be combined into two courses (95.1 & 95.2 and 95.8 & 95.9), as shown in the diagram by the dotted line.

Figure 3. Recommended Courses for IS Major

Course descriptions

One hundred twenty-eight learning units have been identified and are defined in the curriculum report. The 10 courses described below consist of the committee's suggestions for packaging learning units into courses. There may be factors contingent upon local conditions that would cause a faculty to package the learning units in other ways.

IS'95.0—Knowledge Work Software Tool Kit

Scope: This curriculum assumes as prerequisites a suite of software tools useful for knowledge workers, such as spreadsheets, databases, presentation graphics, database retrieval, statistics, word processing, and electronic mail. Although identified as a course, this material can be delivered as: self-study modules, modules associated with other courses using the software, or as a full course.

Topics: E-mail, Internet tools, spreadsheets, databases, presentation graphics, external database retrieval, and introduction to statistical analysis.

IS'95.1—Fundamentals of Information Systems

Prerequisite: IS'95.0

Scope: This course provides an introduction to systems concepts, information technology, and application software. It also introduces students to how information is used in organizations and how IT enables improvement in quality and timeliness of information.

Topics: Systems concepts; system components and relationships; cost/value and quality of information; specification, design and reengineering of information systems; application versus system software; procedural versus non-procedural programming languages; database features, functions, architecture; telecommunication systems and applications; and characteristics of IS professionals and IS career paths.

IS'95.2—Personal Productivity With IS Technology

Prerequisite: IS'95.1

Scope: This course enables students to extend their knowledge work and improve their skill in the use of packaged software in order to improve their personal productivity.

Topics: End-user computing support, roles, and functions; evaluating end-user requirements for tailored information needs; feasibility analysis; evaluation criteria for packaged software; database products; information retrieval; accessing internal and public databases; software package acquisition and integration; accessing shared software; workflow systems; groupware; data conversion and manipulation.

IS'95.3—Information Systems Theory and Practice

Prerequisite: IS'95.2

Scope: This course provides an understanding of the decision process and how information is used for decision support in organizations. It covers decision theory and information theory and practice essential for providing viable information to the organization.

Topics: Systems theory and concepts; how information systems relate to organizational systems; decision theory and how it is implemented by IT; level of systems: strategic, tactical, and operational; systems components and relationships; information systems strategies; roles of information technology and roles of people using, developing, and managing systems; IS planning; human-computer interface; implementation and evaluation of systems performance; global aspects of IS; societal and ethical issues related to information systems design and use.

IS'95.4—Information Technology Hardware and Software

Prerequisite: IS'95.2

Scope: This course provides the hardware-software technology background to enable systems development personnel to understand tradeoffs in computer architecture for effective use in the business environment.

Topics: Hardware: CPU architecture, memory, registers, addressing modes, busses, instruction sets, multiprocessors versus single processors; peripheral devices: hard disks, CDs, video display monitors, device controllers, input/output; operating systems functions and types; operating systems modules: processes, process management, memory and file system management; examples of hardware architectures; examples of operating systems; and basic network components, switches, multiplexers, and media.

IS'95.5—Programming, Data, File and Object Structures

Prerequisites: IS'95.3, IS'95.4

Scope: This course provides an understanding of algorithm development, programming, computer concepts, and the design and application of data and file structures. The increasing complexity of applications requires an understanding of the logical and physical structures of both programs and data.

Topics: Data structures and representation: characters, records, files, multimedia; precision of data; information representation, organization and storage; algorithm development; object representation compared to conventional data flow notation; programming control structures; program correctness, verification and validation; and file structures and representation.

IS'95.6—Telecommunications

Prerequisites: IS'95.3, IS'95.4

Scope: The course provides an in-depth knowledge of data communications and networking requirements including telecommunications technologies, hardware, and software. Emphasis is upon the analysis and design of networking applications in business. Management of telecommunications networks, cost-benefit analysis, and evaluation of connectivity options is also covered. Students learn to evaluate, select, and implement different communication options within a business.

Topics: Telecommunication devices, media, systems; network hardware and software; network configuration; network applications; coding of data; cost-benefit analysis; distributed versus centralized systems; architectures, topologies, and protocols; network performance analysis; privacy, security, reliability; installation of networks; monitoring of networks; and management of telecommunications and communications standards.

IS'95.7—Analysis and Logical Design

Prerequisites: IS'95.5, IS'95.6

Scope: This course provides an understanding of the systems development and modification process. It enables students to evaluate and choose a systems development methodology. It emphasizes the factors for effective communication with users and teammembers and all those associated with development and maintenance of the system.

Topics: Lifecycle phases: requirements determination, logical design, physical design, test planning, implementation planning, and performance evaluation; communication, interviewing, presentation skills; group dynamics; risk and feasibility analysis; group-based approaches: JAD, structured walkthroughs, and design and code reviews; prototyping; database design; software quality metrics; application categories; software package evaluation and acquisition; professional code of ethics.

IS'95.8—Physical Design and Implementation With DBMS

Prerequisite: IS'95.7

Scope: The course covers information systems design and implementation within a database management system environment. Students demonstrate their mastery of the design process acquired in earlier courses by designing and constructing a physical system to implement the logical design.

Topics: Data models and modeling techniques; structured and object design approaches; differing models for databases: relational, hierarchical, network, and object oriented; CASE tools; dictionaries, repositories, warehouses; and implementation: coding, testing, installation, and post implementation review.

IS'95.9—Physical Design and Implementation With Programming Environments

Prerequisite: IS'95.8

Scope: This course is designed to follow IS'95.7, Analysis and Logical Design, which addresses the early part of the system life cycle. This course addresses the latter part of the life cycle and is concerned with physical design, programming, testing, and implementation of the system.

Topics: Selection of programming language environment that uses a database; software construction: structured, event driven, and object-oriented application design; testing; software quality assurance; system implementation; user training; system delivery; post implementation review; configuration management; maintenance; and reverse engineering and reengineering.

IS'95.10—Project Management and Practice

Prerequisite: IS'95.7; Co-Requisites: IS'95.8, IS'95.9

Scope: This course covers the factors necessary for successful management of systems development or enhancement projects. Both technical and behavioral aspects of project management are discussed.

Topics: Managing the systems life cycle: requirements determination, logical design, physical design, testing, implementation; system and database integration issues; metrics for project management and systems performance evaluation; managing expectations: superiors, users, team members, and others related to the project; determining skill requirements and staffing the project; cost-effectiveness analysis; reporting and presentation techniques; and effective management of both behavioral and technical aspects of the project.

Competency Levels

Identifying competency levels helps distinguish the differences between the three emphases of the IS curriculum: all students, minor, and major. The competency distinctions are based on the Bloom (1956) taxonomy. The zero (0) level is "no assumed knowledge." The awareness level (1) represents "recall and recognition." For example, at this level an individual could: define, list characteristics of, name components of, list advantages/disadvantages, classify and diagram. The literacy level (2) is represented by a "knowledge of frameworks and contents." For example, at this level an individual could: compare and contrast, perform simple exercises, describe interrelation of object and other objects in the same context. The concept level (3) is "comprehension as exemplified by usage, translation, extrapolation and interpretation of meaning." For example, at this level an individual could: communicate ideas/abstractions, be given a concept and translate and/or extrapolate it into other contexts, perform intermediate level exercises. The detailed understanding level (4) represents "appropriate application on knowledge in a structure or controlled context." For example, at this level and individual could: interface effectively with users/clients, design a computer application, implement and maintain an application.

Table 4 identifies the competency levels for key educational modules in IS'95, as distinguished for the subprograms of all students—minor and major.

Resources Necessary for Effective IS Programs

Appropriate computing, laboratory, classroom, and library resources are essential elements for a successful academic program in information systems. In the rapidly changing technical environment, students must be exposed to a variety of up-to-date hardware and software systems that adequately represent the professional setting in which they will be employed. The faculty must possess the expertise necessary to deliver the curriculum.

Computing

Adequate computing facilities are essential for effective delivery of the IS program. These resources normally involve a blend of computer facilities of

Table 4. Competency Levels for Key Educational Modules, for Each IS Program (On a Scale of 4, where 4 is the highest level of competency)

Educational Modules	Knowledge Competency Levels		
	All Students	Minor	Major
Hardware and Software	2	2	2
End-User Applications	3	4	4
Information Systems Concepts and Functions	2	3	4
Procedural Programming and Other Languages	0	3	4
Algorithmic Design	0	3	4
File Techniques	0	3	4
Utilities: Code Generators, Report Writers	0	2	4
Groups and Teams	2	3	4
Data Structures	0	3	4
Database	1	2	3
Data Communications and Networks	1	2	3
Operating Systems	1	2	3
Systems Integration	0	2	3
Information Systems Analysis, Design, and Implementation	1	2	4
Management of Information Systems	0	0	3

varying capabilities and complexity. They should include:

- Graphical user interface (GUI) environment
- Desk-top systems
- Local area networks
- Mainframes

Students at different levels in the curriculum have different needs. Substantial resources must be provided to support the service function of teaching basic computing skills (foundation level). More sophisticated resources are necessary for IS minors and majors who are developing skills in computing and IS fundamentals. Specialized laboratories are needed for advanced students where group and individual projects are developed.

Hardware and software is rapidly changing and improving. It is critical that faculty and students have access to facilities that represent the kind of environments that graduates will be expected to use professionally. Therefore, laboratory equipment and software should be kept current. In order to accomplish this, a plan should exist to upgrade and/or replace equipment in a timely manner. An appropriate rule of thumb is to replace equipment in a three-year cycle or approximately one third each year.

Software development tools should be available to create GUI client/server-based applications. Among the categories of tools that should be included are:

- Visual (graphic) programming languages
- Gaphic database systems
- Graphical design tools

Knowledge of at least one development language with graphical or object-oriented capabilities is a fundamental requirement. Some experience with advanced computer-aided systems engineering (CASE) development tools is essential.

Systems should be networked with convenient access to Internet and Internet tools. In order to extend the educational experience beyond the classroom, faculty and students should be encouraged to develop dialogues through e-mail.

Laboratories

Programs in information systems require adequate hardware and software for structured, open/public, and specialized laboratories. Students must have an opportunity to use learning materials in both structured and unstructured laboratories.

It is important to provide the opportunity for the students to work together on team-oriented projects. The group skills developed in this mode are critical to the successful IS professional. Groupware is needed to support effective group activity.

All laboratories must have adequate technical support in terms of professional staff to provide for installation and maintenance of the equipment. The staff should be proficient in both the hardware and software applications. Complete documentation must also be available. The different types of laboratories are described in more detail below.

Structured Laboratories

A structured laboratory is a closed, scheduled, supervised experience in which students complete specified exercises. Supervision is provided by an instructor who is qualified to provide necessary support and feedback to the students. These exercises are designed to reinforce and complement the lecture material.

Open/Public Laboratories

It is also important that students have ample time to complete exercises that are not part of the structured assignments. It is not necessary to have separate facilities for this purpose, but adequate unscheduled time must be available in the labs.

Specialized Laboratories

Specialized laboratory facilities are necessary to support up-to-date IS programs. Special facilities include the following:

Systems Development Focus—to provide access to and evaluation of the latest systems development tools and platforms. Examples include CASE tools, higher-level languages, and database management systems. These facilities may be used for upper-division project and design assignments.

Data Communication Focus—to provide hands-on experimentation with and evaluation of local and wide-area network hardware, software, and applications. Examples include LAN network software and hardware, access to mainframe communication facilities, cross-platform linkage capability, and access to assorted communication-based applications such as Internet.

Advanced Technology Focus—to provide hands-on experimentation with and evaluation of applications that require special hardware and software. Examples include group and executive support systems and multimedia systems.

Network and Remote Access

It is highly desirable for both students and faculty to have remote access to the campus systems through personal computers and networks. This has the advantage of reducing capital expenditure for the program and providing more convenient access for the individual.

Classrooms

Suitable classroom facilities, equipped with appropriate information technology teaching resources, should be provided. A computing system with multimedia facilities is necessary for demonstrating the development, implementation, and application of information technology. Classrooms should also have access to networks.

Library

Library support is an important part of any academic program. It is even more important for disciplines with fast turnover of knowledge such as the IS field. Libraries should include access to appropriate journals, proceedings, monograms, and reference books. Access to online databases is also important. Fundamental to these holdings are the publications of the professional societies including the ACM and DPMA. Online access to library systems should be available through a campus network for both students and faculty. Faculty should support the professional library staff in the review and procurement of materials.

Faculty resources

The strength of the information systems program lies with its faculty. Both educational and practical experience of IS faculty are needed. There must be enough faculty to provide course offerings that allow the students to complete the program in a timely manner. The interest and qualifications of the faculty must be sufficient not only to teach the courses but also to plan and modify the courses and curriculum. Faculty members must remain current in the discipline.

The number of full-time faculty needed by the program is influenced by such factors as the number of students in the program, the number of required courses, the number of service and elective courses offered, and the teaching load of the faculty. Typically, a program should have a minimum of four full-time faculty with primary commitment to the information systems program. This minimum would help meet the teaching needs of the program and would provide depth and breadth of faculty expertise. Additional faculty would be needed to teach the service courses, providing foundation-level knowledge across the campus.

The professional competence of the faculty should span a range of interest in information systems including: computer systems concepts, information systems concepts, data management, telecommunications and networks, systems development and design, and policy.

All faculty members must remain current in their profession and should regularly contribute to the discipline. Given the rapidly changing technology, it is particularly critical that faculty members have sufficient time for professional development and scholarly activities. Resources should be provided for faculty to regularly attend conferences, workshops, and seminars. The program is enhanced significantly when faculty acquire practical experience in the professional world through activities such as consulting, sabbatical leaves, and industrial exchange programs.

Joint Majors

Another example of expanded demand for IS coursework is the joint major of IS and another field. It was not listed separately among the three programs previously mentioned because the students take the same courses as an IS major, along with the full set of courses required for their second field, such as marketing or finance. An intermediate level between the minor and double major is also possible. An example is accounting, where the five-year undergraduate degree programs are specifying an expanded knowledge set in information systems. The following is an excerpt from "Education Requirements for Entry into the Accounting Profession" (AICPA, 1988):

> The widespread use of computer and telecommunications technology makes an understanding of the technologies and their application and limitations essential. Students should be familiar with the functions and interrelationships of hardware components, and with the capabilities and applications of software. File structures, data storage and retrieval, networking and telecommunications are relevant concepts. The internal controls that ensure accuracy, integrity and confidentiality of information should be examined. Most importantly, the CPA should know how and if the system provides information to management that is relevant, reliable, timely, and readily accessible. This requires that students be aware of the management processes and the importance of information to effective management (p. 22).

Updating the Curriculum Through Electronic Media

The curriculum updating cycle has been too slow to meet the needs of academia and industry. Both the committee procedural process and the publication of results process have been inefficient and time consuming. The IS'95 task force recommends a new updating procedure and publication approach using e-mail. Development of this system requires work beyond the scope of the 1995 curriculum recommendations, and proposals are being prepared to funding agencies to support this effort. It is recommended that there be a coordinating agency, with inputs solicited on a continuing basis from both academia and industry sources. The coordinating agency would assimilate this material for future curriculum model recommendations. In this manner, curriculum guidelines would be updated annually and be immediately available to all individuals or groups who access the curriculum database via Internet.

Internationalization of the Curriculum

IS'95 contains content on the global aspects of IS and included European and Asian reviewers. However, the model undergraduate courses were designed to fit the general pattern of university degree programs in the United States and Canada. These programs are based on assumptions about student preparation from secondary education and broadly accepted principles about the portion of the degree program that can be devoted to a single field of study (e.g., AACSB accreditation requirements).

University education in other countries will share many of these assumptions and concepts; however, there may be different knowledge and skill levels for students entering the degree program. In some countries the undergraduate degree program can achieve significant depth; in others, the requirement for liberal education restricts the number of courses for the major. In some countries the role of university education is defined as specific training for a position; in others, university degrees are very broad—specific skills are expected to be acquired on the job.

IS'95 serves as a reference model for undergraduate curriculum in information systems and provides a framework for discussions of curriculum for any country. Since the report codifies many principles related to information systems as an academic discipline and field of study, it establishes a starting point for IS curriculum development activity in any country. Such referential use occurred previously with both the ACM and DPMA curriculum recommendations.

Technical Committee 8 (information systems) of the International Federation for Information Processing (IFIP) is reviewing the curriculum recommendations to evaluate the implications of curriculum for different countries. The results of the review will be published in a monograph and will describe the applicability of the curriculum for different international settings.

Principal Differences for IS'95 Compared to Prior Reports

The details of the body of knowledge, learning units, and models courses contain significant differences from prior curricula recommendations. While the expanded and updated body of knowledge is a given for curriculum revisions, IS'95 has a number of additional features, summarized in Table 5.

Acquiring the Full IS'95 Report

This paper has provided a summary of the full curriculum report (Couger, et al., 1995). The complete report contains the detailed body of knowledge that makes up the IS curriculum, with Bloom taxonomy levels for each topic. The body of knowledge elements are mapped to educational modules, then to courses. The course descriptions include: catalog description, course goals, explanation and expectations, and behavioral objectives. At the front of the report is an executive summary for each of the

Table 5. IS'95

	New or Expanded Feature	Example
1.	Improved course design	Even though a model course structure is provided, the report includes learning units that can be packaged to meet local needs more effectively.
2.	Better integration of technical topics	For example, telecom is not confined to a single course but is covered in a variety of learning units.
3.	More balance between topics	New behavioral topics such as creativity and empowerment were added, providing more balance between behavioral and technical topics.
4.	More global orientation	Additional topics were added, such as effect of IS on organizational structures, ethical and societal issues, as well as inclusion in more learning units.
5.	Delineated resource requirements, for better planning and leverage with the administration	Specific lab requirements, minimal faculty levels, hardware and software, library resources, general and special classroom requirements.
6.	Broadened quality emphasis	Integrated across learning units, as well as expanded coverage such as quality standards and continuous improvement topics.
7.	Improved process for updating	Decision to provide an electronic updating process via Internet curriculum.

following constituencies: deans, IS department chairs, IS faculty, IS practitioner, and IS students. There are also comparisons with other curricula (such as IEEE) and a description of the curriculum development and review process.

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Appendix

Curriculum Development Process

In December of 1992 an ad hoc committee was formed at ICIS to work on future needs of the IS academic community. Several subcommittees were formed. One was established to develop an undergraduate IS curriculum model. The subcommittee chair contacted the educational committees of DPMA and ACM to obtain agreement for a collaborative effort for the curriculum update. The chairs of these three organizations agreed to become co-chairs of the curriculum update project. They were: Dan Couger (AIS, ICIS), Gordon Davis and John Gorgone (ACM), and David Feinstein and Herbert Longenecker (DPMA). The co-chairs managed the process primarily by e-mail, with periodic meetings as described below.

The first joint meeting was held in Chicago in March 1994, with representatives from the three groups, as well as participants from industry. The joint task force was comprised of 25 people. IS programs housed in colleges of business as well as other organizational units of the university were represented. Both AACSB-accredited and non-accredited institutions were represented, including both public and private institutions, located in a variety of circumstances, from metropolitan to townships, in the U.S. and Canada. Industry representation came from manufacturing, finance, and marketing companies. The principal task was to combine and update the bodies of knowledge from the previous curricula of ACM and DPMA.

The next meeting was held in June 1994, at the University of Baltimore. Milt Jenkins was host and co-facilitated the meeting using the school's electronic GDSS facility. The process produced the attributes of information systems graduates (Table 2) and representative abilities and knowledge for IS program graduates (Table 3). Using the body of knowledge, 128 learning units were derived, each with its defined goal. Then 208 objectives were defined to meet those goals. From that base, courses were developed to logically "house" the learning units, goals, and objectives. The following sections of the curriculum were then developed: educational levels for IS academic programs (Figure 1), core curriculum areas for the body of knowledge (Figure 2), recommended courses for the IS major (Figure 3), competency levels for key educational modules (Table 4), and prerequisites.

The draft report was prepared and presented for comment at the meetings of ISECON (October 1994), DSI (November 1994), IAIM (December 1994), ICIS (December 1994), and ACM (February 1995). At ISECON, workgroups were formed to review the various sections of the curriculum. Included were people from Puerto Rico, The Netherlands, Japan, and Sweden. At DSI, the presentation was followed by small group discussions of each section of the curriculum report. At the other meetings, comments received from the presentations were recorded for post-meeting evaluation. A summary of the report was printed in *Data Base* and distributed to all 2500 members of ACM's SIGBIT (special interest group on business information technology). Over 1000 copies were also distributed at ICIS. The responding comments were highly supportive of the draft document.

Next, the draft report was printed and distributed to 1500 IS practitioners and executives who are members of DPMA and SIM. Several other organizations became "Cooperating Organizations," providing formal review and comment on the draft report: IAIM (International Academy for Information Management), INFORMS (formerly ORSA/TIMS), and IFIP (TC8). Senior consultants such as Peter Denning, Jim McKenney, and Jim Emery were selected to provide comment as well. The report was also published on Internet for widespread review and comment.

After review of the comments, the final report is expected to be published in November 1995. A procedure for maintaining the curriculum electronically on Internet will be developed in the Spring of 1996.