

Curriculum Modification Reflects the Growth of Computer Systems Technology

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Abstract—Computer System Technology is an enormously vibrant field that emerged at the end of the last century as our society experienced a fundamental change from an industrial society to an “information society.” This in turn demands changes to the curriculum of Computer Systems degree programs at colleges and universities so that the programs provide their graduates with the skills and knowledge to take on appropriate professional positions in Computer Systems Technology and grow into leadership positions or pursue research or graduate studies in the field.

This paper presents an effort taken at the Computer Systems Technology department of the New York City College of Technology that led to a thorough study of industry changes, students’ interest and modification of curriculum for Bachelor degree of Technology. The new curriculum aims to prepare students not only fundamentals of computer systems with critical thinking and problem solving skills, but also an in-depth training in one of four tracks: Database, Networking and Security, IT Operation and Software Development.

Index Terms— Curriculum Development, Computer Systems Technology, Database, Networking and Security, IT Operations, Software Development.

I. INTRODUCTION

A. Emergence of Information Technology as a discipline

The past four decades have seen the computing field expand dramatically, from a small group of academics mostly in mathematics and electrical engineering, to a full academic discipline known as computer science, to even more computer-related disciplines in the last decade. From its inception just half a century ago, computing has become the defining technology of our age, changing how we live and work. Computers are integral to modern culture and are a primary engine behind much of the world’s economic and social changes.

The technical changes that have driven the recent expansion of computing have direct implications on the engineering

education curriculum [6]. The curriculum must be flexible as there are a large number of careers that graduates from IT programs enter [8]. Those careers show an enormous diversity and the knowledge base and skill sets required for each consequently vary widely as well. The curriculum should therefore be designed in a way that gives an institution considerable freedom in tailoring the curriculum to the needs of its students and other institutional stakeholders. For this purpose, we recommend core outcomes that must be met, and provide examples of advanced learning outcomes for additional depth in each unit of each knowledge area. The design of Information Technology curricula must take those changing technologies into account [4][5][7].

In spite of the complexity of curriculum development, the process can be examined by asking seven basic questions:

1. What is the purpose of the curriculum?
2. What are the objectives of the curriculum?
3. How are the learning experiences to be selected and organized?
4. What are the objectives of the course?
5. What resources are to be employed, and how are time and space to be used [9][10]?
6. What is the design of the learning activities [7][11][12]?
7. How is the curriculum to be evaluated?

The curriculum must reflect those aspects that set Information Technology [9] apart from other computing disciplines. The integration of different technologies and the integration of technologies into organizations are fundamental to Information Technology [1]. An IT graduate must therefore acquire a skill set that enables him or her to successfully perform integrative tasks, including user advocacy skills, the ability to address information assurance and security concerns, the ability to manage complexity through abstraction, extensive capabilities for problem solving across a range of integrated information and communication technologies, adaptability, outstanding interpersonal skills, high ethical standards, and professional responsibility [2][3].

This paper presents decisions of the Computer Systems Technology department on curriculum modification based on the industry requirements and student interests as discussed in student survey questionnaire in Section V.

II. OVERVIEW NEW YORK CITY COLLEGE OF TECHNOLOGY (CITY TECH)

The Computer Systems Technology (CST) department offers two degree programs, AAS in Computer Information Systems (CIS) and BTECH in Computer Systems (CIB). The CIB curriculum includes 60 credits from the CIS program and additional 60 credits (34 credits in the major and 26 credits in business and liberal arts).

The CST department revamped the CIS curriculum in 2009 to reflect rapid changes in the IT industry. The new CIS program provides fundamental knowledge and practical skills in the field of computer systems. It prepares students for entry-level jobs in computer programming, database, networking and IT support.

While the CIS curriculum is designed to build the foundations in computer systems, the CIB program is meant to provide students with opportunities to specialize in specific areas of concentration in the field of computer systems.

The computer courses offered in the current CIB program are organized in seven modules plus three additional courses with each module consisting of three sequential courses focusing on one specific area of computer systems. Students are required to complete three of the seven modules. The modular curriculum was innovative at the time of its inception, and has served our students well in past years. The Computer Systems Technology department has been modifying the curriculum by adding new modules, and by upgrading content and tools in existing courses.

III. CURRICULUM DESCRIPTION

The CIB curriculum is as shown below:

AAS Degree 60 Credits

Business and Liberal Art 26 Credits

Major requirement 34 credits distributed as follow:

CST4800 Project Management	3
CST4801 Special Topics	1
Workplace Component	
CST 4900 Internship or	
CST 4905 Information Systems Project	3

Students must complete all courses in any three of the following seven modules for 27 credits:

Programming Design and UNIX

CST 3513 Object-Oriented Programming in Java	3
CST 3613 Advanced Object-Oriented Programming	3
CST 4713 Application Architecture Using Java	3

Object-Oriented Systems Analysis and Design

CST 3506 Object-Oriented Systems Analysis	3
CST 3606 Object-Oriented Systems Design	3
CST 4706 Design of OO Distributed Systems	3

Local Area Network

CST 3507 Advanced Single-LAN Concepts	3
CST 3607 Introduction to LAN Connectivity	3
CST 4707 LAN-Internet Connection	3

Client/Server Technology

CST 3508 Design of Graphic User Interfaces	3
CST 3608 Distributed Application Processing	3
CST 4708 Client/Server Technologies	3

Database Systems Design

CST 3504 Design of Microcomputer Databases	3
CST 3604 Design of Distributed Databases	3
CST 4704 Data Warehousing	3

Internet Computing

CST 3519 XML Data Representation	3
CST 3619 Web Services Architecture	3
CST 4709 Installing and Maintaining Web Servers	3

Information Security

CST 3510 Computer Security	3
CST 3610 Network Security Fundamentals	3
CST 4710 Advanced Security Technologies	3

A. Concerns raised about the Current Curriculum:

1. Topics in the different modules are no longer independent and are more interrelated

The topics in each module are no longer independent. For example, students taking the three courses in the Networking module will not be best prepared for network administration jobs if they do not take a network security course. Students taking the Information Security module should have a comprehensive understanding of network infrastructure to fully explore and understand security issues. Computer programming is growing beyond the development of standalone applications that run on a single desktop computer. Students will need to learn how to write applications that run on the web, across different networks, and on mobile devices, etc.

In the current database module students learn database design, distributed databases and data warehousing. However, databases are widely used by software applications across computer networks and the Internet. Database security has also become a very important issue. The application and database security topics are not covered in the current database module.

2. Three courses in one module may not be sufficient to cover the necessary topics in a specific areas of technology undergoing a rapid growth

Computer systems technology evolves and changes rapidly. For example, for students who take the programming module, the three current courses are not sufficient to prepare them for an application developer job, or to pursue a graduate degree. With the rapid

evolutions of software technology, a developer not only should have a solid understanding of object-oriented concepts, but also should grasp other programming skills such as database connectivity, internet programming, mobile device programming and game programming.

The area of Networking has changed tremendously. Virtualization technology is becoming more common today as enterprises attempt to improve flexibility, availability, resource utilization, and cost saving. Applications are now being virtualized, allowing enterprises to exceed the performance of physical servers at a lower cost. Topics of computer security have also become an essential component of network administration.

3. Students might not select the best three modules to meet their goals.

Each student enrolled in the CIB program is assigned a faculty member as mentor/advisor and CST faculty members diligently provide the best advice based on their understanding of the student's interest. The above problems might not be critical when students properly elect the three modules to combine the skill set that will prepare them to achieve their goals. However, many students choose the three modules based on a limited knowledge of the modules, their personal schedules and their perception of the level of difficulty of the modules, sometimes without considering the required synergy between the three modules. As a result, their choices may not properly prepare them for the demanding workforce.

4. The module structure limits the expansion of topics to cover new developments in technology.

Each area of computer systems is facing challenges and changes. It is not possible to expand each module to allow us to introduce new technology developments in addition to the fundamental concepts. For example, Game programming has been around for a long time, but we could not add it to our current modular structure. Virtualization and Cloud computing are current trends in the IT industry that we found difficult to add the current modular structure.

IV. THE MODIFIED CURRICULUM OF BACHELOR DEGREE PROGRAM IN COMPUTER SYSTEMS (CIB)

After the CST department went through more than a year of self-study of the existing curriculum, research in current industry technologies, and several meetings with CST industry advisory board, a major curriculum modification was proposed and approved by the university and took effect in Fall 2013. The proposal is a re-organization of the modular structure curriculum into four tracks: Database, Networking and Security, IT operation, and Software Development. Each track

includes 7-8 required courses and 1-2 elective courses. The proposal includes 8 new courses, 3 major modifications to existing courses and 10 minor modifications to existing courses. Some of the courses in the proposed curriculum required no changes. Each track covers a wide range of knowledge and skills in the respective area. In addition to the common required Business and Liberal Art courses, students will elect one track to study so that they will gain thorough knowledge and skills which will prepare them well to enter the workforce in the computer systems industry courses. The requirement for B.Tech degree in Computer Systems is described as:

AAS Degree 60 Credits

Business and Liberal Arts 26 Credits

Universal Requirement for all CIB students

Course Code and Title	Credits
CST4800 Project Management	3
CST4801 Special Topics	1
CST4900 Internship or CST4905 Project	3
Total	7

The above 93 credits are not changed.

Instead of electing three modules to complete a total of 27 credits, students ought to elect one of the following four tracks to complete:

1. Database

List of Courses:

Course Code and Title	Credits
CST3504 Database Design	3
CST3606 Object Oriented System Analysis & Design	3
CST3604 Quality Database Implementation	3
CST3613 Application Development with Databases	3
CST4704 Data Warehousing	3
CST4714 Database Administration	3
CST4724 Data On The Web	3
Two Electives**	6
Total	27

The Database track covers the design of databases including single and distributed databases, database performance, database administration, programming applications, Business

intelligence including data warehousing, the Semantic web and special topics in current database usage.

Databases have been in existence since the early 1960s and continue to be widely used in current environments. They are an integral part of any IT system today and are evident in almost every domain including financial, health, business, academics and the Web. Database knowledge and expertise is essential in completing a Bachelor of Technology degree. Students who choose to become immersed in the database domain must gain expertise in the effective design and integration of databases and the key issues surrounding these functions. The Database curriculum will prepare students to meet this challenge by providing them with the various knowledge and skills needed to succeed in the database domain. Knowledge coupled with hands-on classroom lab experience will be provided to students allowing them to understand essential concepts while experiencing simulated “real life” scenarios. A comprehensive understanding of the database domain includes an understanding of: analysis, design, performance, security, administration, programming, integration, and semantics. Each course in the database curriculum addresses these key issues and provides students with the in depth understanding needed to successfully implement, integrate and support databases in any domain.

2. Networking and Security

List of Courses:

Course Code and Title	Credits
CST2405 or CST2415 System Administration	3
CST3507 Advanced Single-LAN Concepts	3
CST3607 Interconnectivity	3
CST3610 Network Security Fundamentals	3
CST4707 The LAN-Internet Connection	3
CST4710 Advanced Security Technologies	3
CST4715 Advanced Topics in System Admin	3
CST3523 Task Automation in System Admin	3
One Elective**	3
Total	27

The Networking and Security track covers aspects of all types of networks including LANs and WANs, the Internet, and mobile networks, security considerations and principles in various domains (network, database, programming, physical and system administration). The goal is to prepare students to work in network administration, security administration, system operations, and technical support.

3. IT Operation

List of Courses:

Course Code and Title	Credits
CST2405 or CST2415 System Administration	3
CST3507 Advanced Single-LAN Concepts	3
CST3610 Network Security Fundamentals	3
CST3605 Virtualization	3
CST3615 Enterprise Applications	3
CST4700 IT Service Management	3
CST4714 Database administration	3
CST4709 Installing and Maintaining Web Servers	3
One Elective**	3
Total	27

The IT Operation track was designed with reflection of the current changes in the IT operations, administration, and management fields. The IT field has been undergoing drastic changes and with that comes the need to revamp our program to better prepare students for IT careers. While for many years, the focus in IT infrastructures was on decentralization, today, the focus is shifting to centralization and consolidation with new technologies. In this track, our students will be trained not only in traditional systems administrations (both Windows and UNIX), but also in virtualization technologies that are currently reshaping the IT field. As more companies adopt virtualization in order to improve flexibility, availability, resource utilization, and cost saving, our students (having been exposed to all the major virtualization technologies in the market today) will be in a good position to serve those environments. With the theoretical knowledge, and strong hands-on skills developed, our students will be able to distinguish themselves in this ever changing field.

Students will be exposed to popular enterprise applications that they will most likely use in the workplace. Students will install, configure, and maintain Microsoft Exchange, Enterprise Content Management Systems, Enterprise Resource Planning Systems, Customer Relationship managements, as well as Cloud Computing. In this track, students will not only be exposed to the technical side of these applications, but also to how they can serve the organization and help it succeed and prosper.

Because IT in most organizations is a service component, students in this track will be exposed to IT Service Management which addresses IT not from a traditional technology-centered approach but instead from a customer-centered approach. In this track students will focuses on mature and well developed processes such as problem

management, change management, configuration management, capacity planning, performance management, etc. that allows the IT function to better serve the organization.

4. Software Development

List of Courses:

Course Code and Title	Credits
CST3513 Object-Oriented Programming	3
CST3519 Advanced Client Technology	3
CST3613 Application Development with Databases	3
CST3606 Object-Oriented Systems Analysis and Design	3
CST4708 .NET Framework	3
*CST2301 Mobile Device Programming	3
CST4713 Dynamic Web Development	3
Two Electives**	6
Total	27

Software Development is an essential part of computer applications and widely used in current environments. Application developers are widely employed by various domains, including engineering, finance, health, business, etc. Students who choose to become software developers in today's environment, must gain solid understanding of object-oriented concepts, system analysis and software methodologies as well as gain expertise in programming with database, web based programming and mobile device programming. To prepare well-rounded students with background in the various programming areas, this track provides the fundamental object-oriented concepts and software methodologies, as well as the skills widely needed in current industries by programmers (application developers) including Java technology, open source technology, Microsoft.Net framework, Internet Web based programming, Mobile device programming, and Game programming.

V. STUDENT SURVEY

In order to make such a major change to the curriculum, we first had a student survey to find out what areas were interesting from the students perspective. We based our decisions of the modified curriculum on the responses to the questions in the student survey which were as follows:

Which track would you choose?

- Database
- IT Management

- Networking and Security
- Software Development

7. If you choose the Database track, please check your courses of interest

- Semantic Web Databases Design and Retrieval
- Application Development with Database
- Database Administration

8. If you choose IT Operation track, please check your courses of interest

- Virtualization
- IT Service Management
- Enterprise Applications

9. If you choose Networking and Security track, please check your courses of interest

- Computer Forensics
- Task Automation in System Admin
- Advanced System Administration

10. If you choose Software Development track, please check your courses of interest.

- Game Programming
- Software Development Methodology
- Data Structure
- Application Development with Database

VI. CONCLUSION

There is no single formula for success in designing a Computer Systems Technology curriculum. Although we believe that the recommendations of this paper and the specific strategic suggestions in this paper will prove useful to a wide variety of institutions, every Information Technology program must adapt those recommendations and strategies to match the characteristics of the particular institution. It is, moreover, important to evaluate and modify curricular programs on a regular basis to keep up with the rapid changes in the field. The Information Technology curricula in place today are the product of many years of experimentation and refinement by Information Technology educators in their own institutions. The curricula of the future will depend just as much on the creativity that follows in the wake of this report to build even better Information Technology programs for undergraduates throughout the world.

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