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LOYOLA UNIVERSITY CHICAGO

THE EMERGENCE OF COMPUTER SCIENCE INSTRUCTIONAL UNITS IN AMERICAN COLLEGES AND UNIVERSITIES (1950--1975): A HISTORY

A DISSERTATION SUBMITTED TO
THE FACULTY OF THE GRADUATE SCHOOL
IN CANDIDACY FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY

DEPARTMENT OF EDUCATIONAL LEADERSHIP AND POLICY STUDIES

BY
SUSAN E. CONNERS

CHICAGO, ILLINOIS
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PREFACE

Computer science has evolved as a new discipline in the latter half of this century. Yet, the impact of this new discipline is seen in many facets of the modern world. In today's information age, computer science has influenced scientific advancements, the way business is conducted, and the methods used to communicate with people around the world. The emergence of this new discipline into the realm of higher education created spirited conflicts over the tenets of the new discipline. Each academic discipline considered its interpretation of the purpose of computer science as correct. These debates have continued over time and have generated a variety of "academic computer programs."

The purpose and scope of this dissertation is to investigate the origins and development of academic computer science units in American higher education and examine the intent and structure of their curricula. Specifically the study examines selected undergraduate and graduate curricula that developed from 1950 to 1975. This dissertation examines several of the earliest academic units formed and the issues surrounding their formation. These academic computer science units often evolved from other disciplines, computing centers, or combinations of academic disciplines. The debates over

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the purpose of computer science were continual and contentious. These debates resulted in computer science units forming at institutions with very different purposes and curricula.

For the purpose of this dissertation, a curriculum refers to the course content and structure of the courses in the program. Course content and prerequisites often varied from one institution to another depending upon the purpose of the program and the faculty that taught the courses. Program requirements to complete a degree in computer science were often not consistent among higher education institutions. This study examines some of the variety of courses and programs that existed among the early computer science programs.

An academic unit is defined as a group of faculty and students with a common mission -- the study of computers. The actual titles of the units varied but they shared a common overreaching goal to study computers. The departments formed in various methods, some units were a subset of other departments. Faculties of these new units were often comprised of faculty members from various other disciplines.

This study is an exploration of the connections between a variety of diverse institutions and the new computer science discipline that formed from these early academic roots. While much has been written about the history of hardware and software development and the individual pioneers in the relatively

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new computer science discipline, the history of the academic units was documented primarily based on individual institutions. This study uses a wider lens to examine the patterns of these early academic units as they formed and became computer science units. The successes of these early pioneers resulted in a proliferation of academic computer programs in the following decades. The curricular debates continue as the number and purposes of these programs continue to expand. This dissertation seeks to provide useful information for future curricular decisions by examining the roots of the academic computer science units.

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CHAPTER ONE

INTRODUCTION

Computer technology evolved very rapidly throughout this century and continues to evolve today. University pioneers struggled to define the discipline and their academic computer programs. The visionaries of these early programs foresaw the impact of this new technology on society and embarked on developing programs to train industry professionals and academicians in the new "science." Several pieces of academic computer science history surfaced as documentation was examined. The issues included the availability of hardware; faculty resources; software issues; the timeline of the development of the computing machines, and pioneers (see table 1). These items determined who and what institutions were the pioneers in computer science. The initial development of hardware, the pioneers in this new area and the evolution of these exploits provided an initial framework for the academic units.

Early Computer Hardware

The large research institutions that had government or industry research funding to develop computers were able to get their programs running quickly. The influx of government and industry funding provided the opportunity for research on the first early computers. Machines designed to

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Table 1.Timeline

Year	Hardware	People	Companies
1800s	Burroughs adding machine	Boole Burroughs Watson Bush	
1900-1909		Aiken Atanasoff Stiblitz Hopper Mauchly	Burroughs Adding Machine Company
1910-1919		Norris J. Presper Eckert Bush, Ph.D.	Computing Tabulating-Recording Company
1920-1929	Intergraph Analog computers	Aiken, B.A. Atanasoff, Ph.D. Stiblitz, Ph.D.	IBM
1930-1939	Stiblitz Model I	Hopper, Ph.D. Mauchly, Ph.D. Aiken, Ph.D.	

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Table 1.–continued

Year	Hardware	People	Companies
1940-1949	Harvard Mark I MG Gun Director Atanasoff-Berry Computer ENIAC JONIAC BINAC Transistor	Eckert, M.S.	Engineering Research Associates Rand Corporation Eckert-Mauchly Computer Corp.
1950-1959	EDVAC ILLIAC JOHNIAC UNIVAC TRADIC CDC 1604 IBM 701, 702, 705 Integrated Circuit	Eckert, honorary Ph.D.	Remington Rand Sperry Rand Control Data Corp.
1960-1969	Minicomputer Cray CDC 6600 microprocessor		
1970-1975	LSI chip		

facilitate the weapons industry soon revolutionized business and spawned a new academic discipline. While the history of machines that calculate can be traced back to the early abacus, for the purpose of this study the early analog computers will serve as a starting point.

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During the World Wars, scientists and engineers established a partnership with the military, a partnership that had been growing since the early twentieth century. They contributed by helping to define defense problems, design, and implement defense technology. During World War I, these scientists and engineers worked under military supervision. Every effort was made at war's end to retain the services of these professionals, as the military had grown accustomed to the benefits of their service. However, the scientists and engineers preferred their prewar academic freedom and laboratories and they left the military facilities in large numbers. Yet, they did not wish to give up the support for their research. They sought an alliance with the armed services and defense agency leaders encouraged scientists returning to the civilian sector to maintain organized research programs in defense-related areas. To maintain this partnership with the academicians, the Department of Defense instituted broad research and development activities that included some weapons systems. Over the past five decades, the Department of Defense nurtured the partnership and significantly affected research agendas at universities and in industry. [1]

In the decade of the 1930s, significant advances were made at Harvard, Massachusetts Institute of Technology, and Bell Labs in computer technology. Substantive advances were made in the flexibility and versatility of the analog

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[1] Arthur L. Norberg and Judy E. O'Neill, *Transforming Computer Technology: Information Processing for the Pentagon, 1962-1986* (Baltimore: The Johns Hopkins University Press, 1996), 3.

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computer.[2] While the technologies developed for the war effort contributed significantly to the rise of computers, industry advances were progressing rapidly as well. Digital computers began to make advances as well as the analog computers. The advent long distance service prompted the Bell Laboratory to incorporate their telephone technologies with the construction of digital computers. The first computer ever to use on--off elements to perform arithmetic using telephone relay equipment was proposed by Dr. George R. Stibitz. The Model I was a special purpose computer begun in 1938 and completed in 1940.[3] This digital computer was the forerunner of today's modern digital computers. The use of the on--off elements to perform binary arithmetic remains a legacy from the Bell Laboratories.

During the time period from 1937 to 1945 other efforts were also underway at American higher education institutions. Harvard had secured funding from IBM and undertaken the construction of the largest electromechanical computer made at that point in time. The IBM Automatic Sequence Controlled Calculator was developed from 1937 to 1945 by Howard H. Aiken; it stretched more than 50 feet long and contained more than 760,000 parts. This machine was the Harvard Mark I computer.[4] The primary purpose of this computer was calculating

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[2] Bernard D. Holbrook, *Bell Laboratories and the Computer from the Late 30's to the Middle 60's* (Murray Hill: Bell Laboratories, 1975), 19.

[3] Linda M. Dupont, *An Investigation and Analysis of the Influence of John Von Neumann on Computer Design and Computer Science* (Worcester Polytechnic Institute, 1972) 12.

[4] Bernard D. Holbrook, *Bell Laboratories and the Computer from the Late 30's to the Middle 60's* (Murray Hill: Bell Laboratories, 1975), 34.

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mathematical problems. During this time, computers still functioned as modern pocket calculators and were primarily used for scientific calculations.

The business world soon realized the potential of these machines to streamline their daily activities. However, the advent of the Second World War again saw the focus of the computer as a calculator for military weapons. The need to calculate larger numbers faster fueled the research for a quicker, better computer. University faculties continued to accept the challenge to build better machines. Another important development was the invention of the differential analyzer by Vannevar Bush at Massachusetts Institute of Technology. This machine simulated mechanically the various functions in a differential equation. Analog machines like this were widely used in the Second World War for radar and gun operations.[5] The military dependence on computers provided the funding and incentive for the next hardware breakthrough that arrived -- the vacuum tube. This innovation produced the next generation of computers and allowed them to become smaller, faster, and more economical. After the war, computers became less cost prohibitive to business and computers ceased to be only a military and scientific tool.

World War II made improved computer technology more vital than ever as the need for faster computations kept mounting. Similar problems to those encountered in World War I included the calculation of great quantities of ballistic tables for artillery weapons, a faster electric switch, and the need to replace

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humans with machines that were fast, accurate, and never required intervention. The vacuum tube was the new technology that soon revolutionized computers again.[6]

The production of computers became more streamlined and the development time reduced from years to months. Contracts to produce computers for the military resulted in government, higher education, and industry all sharing a common interest in the computer. The manufacturers of the Mg Gun-Director Project (a weapon that used a computer to calculate trajectories) succeeded in one year's time in building an experimental model. A large-scale program for final development followed and the Mg was ready for Western Electric production by fall of 1942.[7] Working together, the government and industry produced a valuable tool for military use in World War II. Computers saved numerous hours of numerical calculation by hand and were error free unlike their human counterparts. The Mg Gun Director predicted the future course of the target, and determined how an anti-aircraft gun should fire a projectile that would arrive at the same spot. While the analog computer enjoyed success, other academicians pursued digital computers. The Atanasoff-Berry Computer made its appearance in 1942. This computer was an electronic digital computer. John Vincent Atanasoff of Iowa State College and Clifford Berry had

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[5] Donald D. Spencer, *Great Men and Women of Computing* (Ormond Beach: Camelot Publishing Company, 1996), 51.
[6] *Ibid.*, 118-119.
[7] Bernard D. Holbrook, *Bell Laboratories and the Computer from the Late 30's to the Middle 60's* (Murray Hill: Bell Laboratories, 1975), 20.

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completed an electronic vacuum tube computer. The Atanasoff-Berry Computer has been recognized as the first true electronic digital computer.[8] This machine became the prototype for vacuum tube computers.

Howard H. Aiken, a Harvard applied mathematician, shared an interest in mechanical computation with his colleague Professor Theodore Brown. Professor Brown was a consultant to IBM and had foreseen the applications of this machine. The machine was referred to as a mechanical sequential computer. Professor Brown made arrangements for Aiken to present his plans to IBM and they agreed to sponsor Aiken's project. After seven years of work at the IBM facilities, Aiken produced the Mark I machine in 1944.[9]

Engineers, mathematicians, and physicists all collaborated on the early computers. John von Neumann's theories on faster computers inspired the work on the ENIAC Computer, one of the most important contributions to computing, at the University of Pennsylvania's Moore School of Engineering for the U. S. Army's Ordinance Department. John W. Mauchly and J. Presper Eckert used the high-speed capabilities of electronic operation and took advantage of speeds that made relay calculators obsolete. When ENIAC was completed in April 1946, it contained 18,000 vacuum tubes and a battery of fans and blowers to cool the

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[8] Donald D. Spencer, *Great Men and Women of Computing* (Ormond Beach: Camelot Publishing Company, 1996), 79.

[9] Linda M. Dupont, *An Investigation and Analysis of the Influence of John Von Neumann on Computer Design and Computer Science* (Worcester Polytechnic Institute, 1972) 13.

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machine and keep it operational.[10] The ENIAC ushered in the new era of vacuum tube computers. The work at the Moore School of Engineering had produced a significant advance in the ENIAC computer. The latter half of the decade produced a variety of machines that out performed their early predecessors. The next comparable significant advance did not come until transistors replaced the vacuum tube computer.

Academic institutions and the government had also designed computers and incorporated new ideas in hardware and software. In 1946, John von Neumann, Herman Goldstine and Arthur W. Burks collaborated on the design of a computer for Princeton. This machine was called the IAS computer, the von Neumann machine, and JONIAC. It was very similar both in design and function to the EDVAC, the next progression after ENIAC, and was under construction at that time. The IAS computer incorporated many changes based upon advances made both in techniques and materials during the past year.[11]

Academic institutions with government funding were not the only parties that competed with each other in developing computers. International Business Machines, after funding the Mark I computer at Harvard, embarked on independent developments. Thomas Watson ordered his engineers to develop a machine superior to the Mark 1. The new IBM machine was the Selective

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[10] Bernard D. Holbrook, *Bell Laboratories and the Computer from the Late 30's to the Middle 60's* (Murray Hill: Bell Laboratories, 1975), 39-40.

[11] Linda M. Dupont, *An Investigation and Analysis of the Influence of John Von Neumann on Computer Design and Computer Science* (Worcester Polytechnic Institute, 1972) 13.

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Sequence Electronic Calculator (SSEC) completed in 1947. It was far more powerful and flexible than any computing machine previously built.[12] Watson and IBM created an empire that dominated the computer industry twenty years later.

While new advancements were created every year, many of the first computers were still in operation. The original Stibliz machine continued to be reliable and remained in service at 463 West Street until 1949. This machine continuously performed accurate and rapid calculations. This was the first electric computer that performed its arithmetical operations in binary fashion, and the first placed in routine general use.[13] The decade ended with significant advances from the electromechanical computer to the use of vacuum tubes. The advances of the computer had helped to win a war and peaked the interest of business. For some academics, the end of the decade brought the lure of business and was enough to pull them from their academic careers. Among the academicians that departed to form their own business were Eckert and Mauchly. They left the University of Pennsylvania in 1947 and formed their own company, the Eckert-Mauchly Computer Corporation. They developed the Binary Automatic

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[12] Donald D. Spencer, *Great Men and Women of Computing* (Ormond Beach: Camelot Publishing Company, 1996), 118.

[13] Bernard D. Holbrook, *Bell Laboratories and the Computer from the Late 30's to the Middle 60's* (Murray Hill: Bell Laboratories, 1975), 29.

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Computer (BINAC) in 1949, the first computer to be programmed by internally stored instructions (EDVAC would not be completed until 1952).[14]

The focus on hardware soon turned to software and more efficient ways to program computers. The next decade continued to produce rapid advancements in computers that increased their impact on academia. The 1950s brought many changes and swift development of this new tool. In this period, commercial data processing became a profitable enterprise and numerous academic institutions began to develop their own computer systems and programs. By the 1950s, the Bell system was no longer in the general-purpose computer hardware business. They turned their focus to the development of better ways to program digital computers. The stored program concept became a significant improvement in the way people utilized computers. The EDVAC, built at the Moore School, was placed in service in 1950 and was the first computer designed from the beginning as a stored program machine. The flexibility of operation became the key that made future electronic computers applicable to a wide range of problems.[15] Software applications were developed for business and scientific computing.

American higher education as well as international institutions participated in computer developments. By 1952, a number of computers similar to the IAS computer had been started or built including the ORDVAC and the ILLIAC built at

[14] Donald D. Spencer, *Great Men and Women of Computing* (Ormond Beach: Camelot Publishing Company, 1996), 90:91.

[15] Bernard D. Holbrook, *Bell Laboratories and the Computer from the Late 30's to the Middle 60's* (Murray Hill: Bell Laboratories, 1975), 31-40.

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the University of Illinois, the JOHNIAC at the Rand Corporation, the MANIAC at Los Alamos, and the WEIZAC at the Weizman Institute in Israel. The original purpose of most of these early computers was scientific computations. In the early 1950s, they began to be used in business-oriented applications. The first computer to be used for commercial data processing was the UNIVAC. Eckert and Mauchly designed the UNIVAC and the first delivery was on 14 June 1951.[16]

While business and scientific applications increased, the military were still significant users of computer applications. The Korean War again generated new government funding for development of computers for weapons systems and generated the next significant advancement in computers--the transistor. Eventually, the transistor replaced the vacuum tube in the computer. The first general-purpose transistor computer was TRADIC (Transistor Airborne Digital Computer) developed for the Air Force at Bell Laboratories. TRADIC development began in 1951 and was completed in January 1954.[17] In the early 1950s, transistors also brought about faster processing speeds that opened many new opportunities for the computer. In 1954, John von Neumann expressed his pleasure at the rate in which computers and their applications had progressed. The speeds obtainable were much greater than any other machine had ever achieved or even seriously attempted. These new speeds opened entirely new

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[16] Linda M. Dupont, *An Investigation and Analysis of the Influence of John Von Neumann on Computer Design and Computer Science* (Worcester Polytechnic Institute, 1972) 91.

[17] Bernard D. Holbrook, *Bell Laboratories and the Computer from the Late 30's to the Middle 60's* (Murray Hill: Bell Laboratories, 1975), 43.

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avenues for the types of problems that were solved by the use of computers.[18] The development of software for these faster systems was imperative for military and business use. The Titan command system was an example of this type of reprogramming. In 1955, Bell Laboratories began work on the Titan command guidance system. The ground guidance computer, for the first time, was a digital machine. The digital machine had the great advantage of being faster and easier to reprogram than an analog computer.[19] The advances in hardware and software continued to expand computer usage and the demand for skilled employees in this new field.

Thomas Watson's IBM introduced new and better computers throughout the decade of the 1950s. These machines were found in both academic and business environments. In the next decade, this company truly dominated the world of computers. Following the Korean War, IBM released a series of computers beginning with the 701 computer. The 701 was twenty-five times faster than earlier computers and performed 21,000 calculations a second. In December 1954, the IBM 650 computer and the IBM 704 scientific computer were successfully introduced. The years 1955 and 1956 saw the release of the IBM 702 and 705 computers and solidified IBM's position as the leader of the computer industry. Thomas Watson lived long enough to see the introduction of

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[18] Linda M. Dupont, *An Investigation and Analysis of the Influence of John Von Neumann on Computer Design and Computer Science* (Worcester Polytechnic Institute, 1972) 64.

[19] Bernard D. Holbrook, *Bell Laboratories and the Computer from the Late 30's to the Middle 60's* (Murray Hill: Bell Laboratories, 1975), 45.

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the 700 family of computers, IBM's first production computers.[20] As academia entered the 1960s, computers had advanced and expanded; many smaller institutions began to receive the older machines as the government and leading institutions continued to develop newer faster computers. These significant advances in computing were the result of numerous dedicated scholars, time, and efforts.

Pioneers in Computing

The achievements of the early pioneers in computing gave rise to a new industry in computer hardware and software. The previous section of this chapter chronicled the development of significant advances in computer hardware. This section is a similar discussion of the people who achieved those advances. The narrative includes the stories of the son of a farmer, the son of a clergyman, a Vassar graduate, and the son of a wealthy Philadelphia businessman. Each of these scholars and their institutions made a significant contribution to the evolution of computers.

1800s

This discussion of computing pioneers begins in the 1800s with the father of what is now called Boolean algebra. George Boole's binary notation and logic became the basis of modern symbolic logic. This nineteenth-century mathematician introduced a theory of logic that later became very important to the

[20] Donald D. Spencer, *Great Men and Women of Computing* (Ormond Beach: Camelot Publishing Company, 1996), 118-119.

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development of computers. Boolean algebra reduced logic to the two-valued binary notation used in computers. In 1844, he was awarded a medal by the Royal Society for his contributions to mathematics. This Irish scholar argued for an alliance of mathematics and logic that had traditionally been the purview of philosophers. In 1849, Boole was appointed professor of mathematics at Queen's College in Cork, Ireland and remained at the college for the rest of his life. While Boole continued to define and publish his theories, he never profited from them nor knew the impact that his theories would have on the modern world through the computer. In 1854, Boole published *An Investigation of the Laws of Thought* on the mathematical theories of logic and probabilities. In the latter part of the nineteenth century, his 1847 and 1854 publications described his ideas and made him the father of modern symbolic logic called Boolean algebra.[21] George Boole's theories contributed to the accomplishments of future scholars in the next century.

The 1800s also produced William Seward Burroughs, a pioneer in computer hardware. Burroughs invented an early adding machine and became the founder of a company that became a major computer manufacturer. The Burroughs machine initiated an evolution of hardware that became the modern computer. In 1884, Burroughs publicly exhibited his first machine, which led to the first patent issued for a key-set recording and adding machine in 1888.

[21] Natalie D. Voss, "George Boole," in *Jones Telecomunciations and Multimedia Encyclopedia*, [http://www.digitalcentruy.com/encyclo/update/boole.html], 1995.

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Burroughs's basic principle for the machine is still considered to be the soundest ever adopted for the purpose. Burroughs designed his machine to be independent of humans and therefore less prone to errors.[22] The early adding machines provided the foundation for the analog computers that would later do the calculations for the advanced weapons systems in the world wars.

The late nineteenth century also produced Vannevar Bush, one of the influential engineers who advanced the abilities of the analog computer. The son of a clergyman, Bush was born 11 March 1890 in Everett, Massachusetts.[23] Bush later joined the faculty of the Massachusetts Institute of Technology and his research with analog computing significantly advanced the early weapons systems.

In addition to mathematicians and engineers, the latter years of the nineteenth century produced Thomas Watson, one of the most powerful businessmen in computing history. In 1895, Watson began as an employee of National Cash Register (NCR) and four years later, he was promoted to manager in Rochester, New York.[24] Watson, while not an academician, funded significant research at leading universities. After founding International Business Machines, Watson built a commercial market for computers and created many of the machines that gave rise to the modern computer industry.

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[22] Donald D. Spencer, *Great Men and Women of Computing* (Ormond Beach: Camelot Publishing Company, 1996), 25-26.

[23] *Ibid.*, 53

[24] "Watson, Thomas, J., Sr.," *Encyclopaedia Britannica Online*, 1997.

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1900-1909

The dawn of the twentieth century saw the pioneers of the nineteenth century build upon their work and additional scholars joining the research. The decade between 1900 to 1910 witnessed the birth of several future contributors and the growth of two fledging entrepreneurs. In Hoboken, New Jersey, on 8 March 1900, Howard Aiken, a future engineer, was born. Aiken was raised and educated in Indiana prior to his academic career.[25] Aiken later joined the Harvard faculty and produced the Mark I computer.

In 1903, the son of an electrical engineer, John Atanasoff, was born on 4 October 1903 in New York. Atanasoff was later declared the inventor of the first digital computer. His parents introduced him to calculus and physics. Inspired by his problem solving ability, Atanasoff chose a career in theoretical physics.[26] The birth of another significant researcher occured the following year.

George Stibitz of Bell Laboratories was born in Pennsylvania on 30 April 1904 and attended a high school in Ohio that was advanced in science projects.[27] Stibitz produced the first computer to use on/off switches to perform its calculations. The use of these switches caused a significant change in computer design. While Atanasoff and Stibitz were entering the world, the initial efforts of

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[25] Donald D. Spencer, *Great Men and Women of Computing* (Ormond Beach: Camelot Publishing Company, 1996), 73-74.

[26] Hien Chris Do, "John Vincent Atanasoff" [http://ei.cs.vt.edu/history/do_Atanasoff.html] October 1996.

[27] "Computer Pioneer George R. Stibitz, dead at 90" [http://dragon.union.edu/HTMLfiles/stibitz.html] 2 February 1995.

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Burroughs had proven successful and a new company was formed in 1905. The Burroughs Adding Machine Company was the forerunner to the computer manufacturer of the future. This company later became the Burroughs Corporation.[28]

One of the most famous and accomplished women of her era, Grace Hopper, was born in New York City on 9 December 1906. This Vassar graduate became a scholar and worked on the significant advances of computers in her time.[29] Her paternal grandfather had been a Rear Admiral in the U.S. Navy, and her maternal grandfather had been a senior civil engineer. She grew up with an interest in mathematics, and later received her doctorate.

In 1907, another future University of Pennsylvania scholar was born in Cincinnati, Ohio. John Mauchly was born on 30 August 1907 in Cincinnati, Ohio.[30] The son of a Carnegie physicist, he later joined J. Prespert Eckert on the ENIAC project. The same year Thomas Watson continued his rise in business and, at thirty-three years old, was the third most powerful man at NCR. Watson had positioned himself to be a future corporate leader in computers.[31]

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[28] "Burroughs Corporation History" Charles Babbage Institute [http://www.cbi.umn.edu/burhist.htm].

[29] Donald D. Spencer, *Great Men and Women of Computing* (Ormond Beach: Camelot Publishing Company, 1996), 143-144.

[30] "John Mauchly and the Development of the ENIAC Computer" University of Pennsylvannia Special Collections [http://www.library.upenn.edu/special/gallery/mauchly/jwm1.html]

[31] Donald D. Spencer, *Great Men and Women of Computing* (Ormond Beach: Camelot Publishing Company, 1996), 116:117

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The first decade of the 1900s witnessed the birth of several future scholars and the rise of business enterprises whose names later became synonymous with computers. The next decade brought the birth of additional scholars, documented the impact of academic institutions on fledgling researchers, and continued to see the rise of the corporate leaders.

1910-1919

The decade of 1910 to 1919 noted the birth of William Norris in Nebraska on 14 July 1911. While in high school, Norris developed a strong interest in physics.[32] In future years, Norris joined Seymour Cray to form Control Data Corporation. In contrast to the arrival of William Norris on a Nebraska farm, Thomas Watson continued his rise up the corporate ladder and consolidated his power and influence. While at NCR, Watson originated the instruction 'THINK' that he made famous. In 1913, he left NCR to become president of the Computing Tabulating-Recording Company, a punched card equipment manufacturer created by combining three separate companies, including Herman Hollerith's Tabulating Machine Company established in 1896. In 1924, Computing Tabulating Recording Company was renamed International Business Machines (IBM).[33] IBM and Thomas Watson continued to affect the research and growth of computers. While Thomas Watson was rising in the business world, the clergyman's son, Vannevar Bush, completed his bachelor and master's

[32] *Ibid.*, 121-122.

[33] "Watson, Thomas, J., Sr.," *Encyclopaedia Britannica Online*, 1997.

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degrees in electrical engineering and began his academic career teaching at Tufts in 1913. In 1916, he received a doctorate degree jointly from Harvard and the Massachusetts Institute of Technology.[34]

The end of the decade brought the arrival of the second half of the Mauchly and Eckert team. J. Presper Eckert was born on 9 April 1919, and was the only child of prosperous Philadelphia parents. Eckert's childhood was spent traveling the world and meeting famous people. These celebrities were colleagues in John Presper Eckert, Sr.'s World War I bond drive efforts.[35] Eckert and Mauchley's research significantly influenced the efforts to build a better computer in the 1940s. The second decade had seen the arrival of Norris and Eckert, the completion of Vannevar Bush's' education in electrical engineering, and Thomas Watson's continued corporate rise.

1920-1929

The years 1920 to 1929 observed the scholars born in the first decade as they completed their educations and initiated academic careers. Howard Aiken completed his B. A. degree in electrical engineering in 1923 at the University of Wisconsin and then continued his education.[36] John Atanasoff completed his B.S. at University of Florida in 1925, his M.S. at Iowa State in 1926, and his Ph.D.

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[34] Donald D. Spencer, *Great Men and Women of Computing* (Ormond Beach: Camelot Publishing Company, 1996), 53.

[35] *Ibid.*, 88-89.

[36] *Ibid.*, 73-74.

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at the University of Wisconsin in 1930.[37] While the universities varied from person to person, the disciplines studied by these pioneers were predominately mathematics, physics and electrical engineering. During this period, George Stibitz concentrated on experimental physics and mathematics. He received a master's degree from Union College in 1927, and spent the following year making radio propagation measurements for the General Electric Company. He and his partner created a voice-actuated electrical communication link that allowed them to operate their equipment from remote control. The next year Stibitz completed his Ph.D. in mathematical physics at Cornell University.[38]

The year after George Stibitz completed his master's degree, Grace Hopper earned her Bachelor of Arts degree in 1928 at Vassar College.[39] The colleges and universities of this decade produced a number of innovative researchers in what became computer science. While these scholars were completing their educations, Vannevar Bush, born a decade earlier, was already contributing with other faculty at the Massachusetts Institute of Technology to the advancement of computing machines. While teaching, he also was involved with his inventions. One of these inventions was the computing machine for solving differential equations. Its principal components performed the mathematical operation of integration. Bush and others at MIT invented the first continuous

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[37] Hien Chris Do, "John Vincent Atanasoff" [http://ei.cs.vt.edu/history/do_Atanasoff.html] October 1996.

[38] Donald D. Spencer, *Great Men and Women of Computing* (Ormond Beach: Camelot Publishing Company, 1996), 69.

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Intergraph, later called a differential analyzer, during the late 1920s.[40] As this decade ends, the stage was set for many of these pioneers to begin their work with computers. The next decade brought government funding to assist in their research and further military weapons advancement.

1930-1939

Improvements in analog computers, the use of telephone relay equipment in digital computers, and the initiation of the Harvard Mark I project were just some of the advancements from 1930 to 1939. In 1930, George Stibitz joined Bell Telephone Laboratories as a research mathematician. At the end of this decade, this research led to a significant breakthrough in digital computing. This work eventually led him into relay circuit theory and problems.[41] Stibitz maintained a lengthy tenure at the Bell Laboratory while conducting his research.

While Stibitz was joining the Bell Laboratory, John Atanasoff completed his doctorate in 1930 and returned to Iowa State College where he remained until 1945 as a professor in mathematics and physics.[42] There Atanasoff would meet Berry and together they created the Atanasoff Berry Computer. In the same time frame, Grace Hopper completed her masters (1930) and doctoral (1934) degrees in mathematics at Yale University. She returned to Vassar in 1931, becoming,

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[39] *Ibid.*, 143-144.

[40] *Ibid.*, 53

[41] "Computer Pioneer George R. Stibitz, dead at 90" [http://dragon.union.edu/HTMLfiles/stibitz.html] February 1995.

[42] Hien Chris Do, "John Vincent Atanasoff" [http://ei.cs.vt.edu/history/do_Atanasoff.html] October 1996.

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successively, instructor, assistant professor, and associate professor in mathematics.[43] Grace's success led to her later assignment in the Navy in computer research.

In 1932, John Mauchly attended Johns Hopkins University on a scholarship, receiving a doctoral degree in physics in 1932 at the age of 24. The following year he became a professor of physics at Ursinus College. During his eight years at Ursinus, he began a project that led him to the conviction that a high-speed computer was necessary to solve more complex mathematical problems and he began experimenting with equipment he purchased himself.[44] John Mauchly had not yet met his future partner Eckert. It would take almost another decade for the famous team to meet. The same year that Mauchly received his doctorate Norris received a bachelor's degree in electrical engineering at the University of Nebraska. He later took a civil engineering job and in 1934, he joined the Westinghouse Company and sold x-ray machines and other equipment.[45] In the next decade, both Norris and Hopper became involved in computers while serving in the military.

Aiken, while completing his graduate work in 1936, began to research the work of Charles Babbage. He began to ponder the possibility of combining into

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[43] Donald D. Spencer, *Great Men and Women of Computing* (Ormond Beach: Camelot Publishing Company, 1996), 143-144.

[44] "John Mauchly and the Development of the ENIAC Computer" University of Pennsylvannia Special Collections [http://www.library.upenn.edu/special/gallery/mauchly/jwm1.html]

[45] Donald D. Spencer, *Great Men and Women of Computing* (Ormond Beach: Camelot Publishing Company, 1996), 121-122.

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one unit a collection of the calculating machines of the time. Aiken was the general editor and co-author of The Annals of the Computation Laboratory of Harvard University. It was composed of more than twenty-four volumes of mathematical tables, books on switching circuits and symposia proceedings on the theory of switching. [46] These early theories lead Aiken to undertake the creation of the Harvard Mark I computer.

In 1937, John Mauchly was teaching and Eckert graduated from the William Penn Charter School, the oldest private boys' school in the United States. He easily completed his regular courses and took on two years of college math, as well.[47] George Stibitz's Complex Number Calculator was completed in 1939. It added and subtracted three times faster than previous machines and used a checking feature to prevent it from producing incorrect answers. Another feature of this machine was that it could be operated remotely from a teletypewriter terminal. At Bell Laboratories this remote feature was common to their engineers.[48] In the next decade, Stibitz continued to contribute to the evolution of the digital computer.

Howard Aiken completed his doctorate at Harvard and began his association with Thomas Watson and IBM. This alliance produced one of the milestones in computing, the Harvard Mark I computer. He obtained his B. A.

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[46] Ibid., 73:74.

[47] Ibid., 87:88.

[48] "Computer Pioneer George R. Stibitz, dead at 90" [http://dragon.union.edu/HTMLfiles/stibitz.html] February 1995.

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degree in electrical engineering in 1923 at the University of Wisconsin and his Ph.D. in 1939 at Harvard University. In 1939, Howard Aiken, in association with IBM Corporation engineers, constructed a fully automatic calculator using standard business-machine components.[49] As this decade closes, many of the important researchers have completed their formal studies and settled into academic and research careers. The next decade brought the Second World War and the impetus to continue to advance computer research.

1940-1949

As early as 1940, Stibitz was using the telephone lines to transmit data. Appropriately, Stibitz's experiment was with academicians at Dartmouth College and he demonstrated remote data processing to a group of mathematicians at the college. Using a telephone line to his machine at Bell Laboratories, he was able to work the device remotely.[50] The following year, 1941, John Mauchly joined the Moore School of Engineering at the University of Pennsylvania and finally met J. Presper Eckert there.[51] The young Eckert benefited from his association with John Mauchly who was an idea man with tremendously good instincts. He was a conceptualizer, a catalyst, and a pioneer who was the prime mover in securing the contract for the first large-scale electronic digital computer. Mauchly was also

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[49] Donald D. Spencer, *Great Men and Women of Computing* (Ormond Beach: Camelot Publishing Company, 1996), 73:74.

[50] "Computer Pioneer George R. Stibitz, dead at 90" [http://dragon.union.edu/HTMLfiles/stibitz.html] February 1995.

[51] "John Mauchly and the Development of the ENIAC Computer" University of Pennsylvannia Special Collections [http://www.library.upenn.edu/special/gallery/mauchly/jwm1.html]

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a founder and early president of the Association for Computing Machinery.[52] Mauchly and Eckert began their work together on the ENIAC computer at the Moore School of Engineering. In 1941, William Norris became an electrical engineer for the U.S. Navy and after Pearl Harbor accepted a commission in the Naval Reserve. Together with corporate and academic mathematicians he began his future career in computers by working to break the enemy codes.[53] An association of academicians, military, and corporate professionals formed to support the war effort and later forged business partnerships in the computer industry.

In 1942, John Atanasoff and Clifford Berry completed what is now recognized as the first true electronic digital computer using vacuum tubes. Atanasoff's work inspired another famous team to undertake a project that was considered a significant milestone in computer history. While Atanasoff was working on his computer, he met and discussed his project with John W. Mauchly of the University of Pennsylvania. Mauchly devised his own ideas on how to build a better computer from John Atanasoff's ideas.[54]

J. Presper Eckert completed his undergraduate degree in electrical engineering at the University of Pennsylvania's Moore School in 1941, and elected to continue with graduate studies. While working lab instructor at age

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[52] Donald D. Spencer, *Great Men and Women of Computing* (Ormond Beach: Camelot Publishing Company, 1996), 94.

[53] *Ibid.*, 121.

[54] Hien Chris Do, "John Vincent Atanasoff" [http://ei.cs.vt.edu/history/do_Atanasoff.html] October 1996.

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twenty-two, Eckert met the thirty-four-year-old John Mauchly and during an eight-week government-paid defense course in electronics, they decided to-build a computer. At this point in time, history witnessed the formation of the Mauchly and Eckert partnership that continued to impact the computer industry for the rest of their lives. Eckert received his master's degree in electrical engineering two years later. In 1942, the team submitted a proposal to the U.S. Army to build an electronic computer and received a contract from the Army's Ordinance Department to build the machine. Eckert was the only full-time person on the project and served as project manager while Mauchly taught full-time, and consulted with a team of fifty people working on the project. The ENIAC project began in April 1943 and was completed 3 years after it was started. ENIAC, which stood for Electronic Numerical Integrator and Computer, was formally dedicated on 16 February 1946. ENIAC perfectly completed its first problem: a highly secret numerical simulation for the-untested hydrogen bomb. The same problem would have taken existing calculating machines 40 hours to complete but only took ENIAC twenty seconds.[55] ENIAC was the first large-scale general-purpose electronic digital computer designed to compute ballistics for the U.S. Army and performed that function quickly and accurately. The ENIAC was funded by the U.S. Army during World War II and was used for many years to

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[55] Donald D. Spencer, *Great Men and Women of Computing* (Ormond Beach: Camelot Publishing Company, 1996), 88-89.

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perform substantial computing work.[56] Military funding and World War II were responsible for many of the accomplishments in computer research. Without this concentrated effort and outpouring of resources, one can only wonder what the state of modern advancements in computers might be today.

Grace Hopper, like her male colleagues, also chose to use her education and talents to assist the military efforts. When World War II broke out, she followed in her grandfather's steps and joined the U.S. Naval Reserve, as women were not allowed to join the Navy at that time.[57] After graduation from midshipman's school in June 1944, "in one of those serendipitous moments that can change history," the Navy assigned Grace Hopper to the Bureau of Ordinance Computation Project at Harvard University.[58] At Harvard, she worked under Lt. Comdr. Howard Aiken, whose invention, the Mark I, was the first large-scale digital computer, and the world's first fully automatic computer in operation.[59] Hopper was 38 years old when she was introduced to her first computer, the Mark I, and received her first assignment from Aiken to compute the coefficients for the interpolation of the arc tangent.[60] She became adept at writing programs for the Mark I. Her programs were used for ballistic tables for

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[56] *Ibid.*, 79-80.

[57] Robert Slater, *Portraits in Silicon*, (Cambridge: MIT Press, 1987) 219-220.

[58] J. A. N. Lee, "Unforgettable Grace Hopper," *Reader's Digest*, October 1994, 181-185.

[59] Martin Campbell-Kelly and William Aspray, *Computer: a History of the Information Machine* (New York: BasicBooks, 1996) 75.

[60] Charlene W. Billings, *Grace Hopper: Navy Admiral and Computer Pioneer* (Hillside, NJ: Enslow Publishers, 1989) 48.

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naval guns, ship supply schedules, and top-secret calculations that helped in the development of the atomic bomb.[61] Hopper went on to write the Mark I's *Manual of Operation for the Automatic Sequence Controlled Calculator*, one of the "most famous documents in the literature of computers".[62]

When the war ended, Grace Hopper returned to the world of academia. While she was on leave-of-absence from Vassar, she resigned that position and joined the Harvard Faculty as a Research Fellow in Engineering Sciences and Applied Physics at the Computation Laboratory. This laboratory continued the work on the Mark II and Mark III computers for the Navy.[63] The war had started Grace Hopper on the path to her destiny as the author of COBOL, a computer language that is still used today.

After the war, in 1946, teams of specialists continued their alliances for the purpose of computer research. William Norris with other technical specialists founded the Engineering Research Associates company to produce data processing equipment for the Navy. The government supported these alliances hoping to create a continued resource to evolve existing computers.[64] The government encouraged computer research and contributed in initiating numerous companies that formed to continue this research and development.

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[61] J. A. N. Lee, "Unforgettable Grace Hopper," *Reader's Digest*, October 1994, 183.
[62] David Ritchie, *The Computer Pioneers* (New York: Simon & Schuster, 1986) 58.
[63] Donald D. Spencer, *Great Men and Women of Computing* (Ormond Beach: Camelot Publishing Company, 1996) 143-144.
[64] *Ibid.*, 121-122.

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The air force organized the Rand Corporation and the government sought to continue the involvement of academics in defense-related research. The air force, army, and navy encouraged the establishment of electronics laboratories on campuses across the nation through the Joint Services Electronics Program. During World War II, the military services had funded experimental projects to design and construct computers. The navy had supported Howard Aiken at Harvard with the Mark I and II computers, Jay Forrester at the Massachusetts Institute of Technology and the Whirlwind project, and some of the computer projects at Bell Laboratories. The army supported the ENIAC project at University of Pennsylvania and the IBM modifications of machines for ballistic table calculation at the Aberdeen Proving Grounds. The government sponsored a project at the Raytheon Corporation, which became the Raydac computer. The army funded EDVAC at the University of Pennsylvania and the IAS machine at the Institute for Advanced Study in Princeton. These projects influenced later industrial developments in computing. Between 1945 and 1962, the defense community invested significant resources in the further development of computing. These efforts set the context for subsequent investigations to change computing.[65]

A battle over a patent between University of Pennsylvania and the Eckert--Mauchly team resulted in their leaving the University of Pennsylvania to strike out

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[65] Arthur L. Norberg and Judy E. O'Neill, *Transforming Computer Technology: Information Processing for the Pentagon, 1962-1986* (Baltimore: The Johns Hopkins University Press,1996) 68.

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on their own after the war. They left in 1946 to form their own company, the Eckert--Mauchly Computer Corporation and they developed the Binary Automatic Computer (BINAC) in 1949.[66] This was the first computer programmed with internally stored instructions. BINAC was the forerunner to their next computer--Univac I. The Univac I was designed to meet the commercial potential of computers. By the fall of 1949, the Eckert--Mauchly firm was in financial difficulties and a year later the company was sold to Remington Rand. Eckert and Mauchly were able to recruit other talent from their academic colleagues. Grace Hopper joined the company in 1949, the year just before the its collapse. Hopper joined as senior mathematician and remained with the company as a senior programmer when Remington Rand bought it. The new parent company, Remington Rand, eventually evolved into the Unisys Corporation. As the very eventful decade of the 1940s ended, the computer was well on its way to becoming a major influence in the modern world. The 1940s had experienced a world war, the development of the first true electronic digital computers, and formation of professional alliances to advance computer research and development. The computer continued to impact the next decade and evolved at a very rapid pace.

1950-1959

The years 1950 to 1959 produced major advancements in hardware and

[66] "John Mauchly and the Development of the ENIAC Computer" University of Pennsylvannia Special Collections [http://www.library.upenn.edu/special/gallery/mauchly/jwm10.html]

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software. The computer pioneers of earlier decades continued to influence and direct the path of computer advancements. Grace Hopper became one of the most prominent pioneers in computer languages. She pioneered the development of the COBOL compiler and later became influential in the development of COBOL programming language in the 1950s. Her reason for developing the business compiler was to reduce the time required to rewrite programs when a compiler could be developed to do much of the basic work over and over again. Hopper had developed COBOL in a manner suitable for business use. In 1951, Univac I was delivered to the Bureau of the Census. This was the first time the government purchased a computer for something other than military weapons.[67]

Initially Eckert and Mauchly were both employees of Remington Rand but after almost two decades of working together, the team separated in 1959. Eckert became the director of the Univac Division and in 1955, he was named vice-president and director of research. Eckert received an honorary degree of doctor of science in engineering from the University of Pennsylvania for his work in computer research.[68]

William Norris and Engineering Research Associates had grown and became very successful producing the over eighty percent of all American-built

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[67] Donald D. Spencer, *Great Men and Women of Computing* (Ormond Beach: Camelot Publishing Company, 1996) 90-91.

[68] *Ibid.*

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electronic computers.[69] This success led to the merging of Remington Rand and Engineering Research Associates bringing together Hopper, Mauchly, Eckert, and Norris in one company, Sperry Rand.

While Norris and his associates were successful, Thomas Watson and IBM had also found success in the computer industry. IBM's marketing skill challenged the newly formed Sperry Rand Company and caused an internal split. Frustrated because Univac was not able to keep up with IBM, Norris decided to venture out on his own. Norris, Seymour Cray, and seven others left Sperry Rand Corporation to found Control Data Corporation in 1957.[70] The new company Control Data Corporation set out to develop a super computer to challenge IBM's market dominance. The first computer produced by CDC was the CDC 1604 and it reached the market in 1958. CDC 1604 was one of the first fully transistorized computers and the largest scientific computer of its time. Its early success was phenomenal and Control Data could not make them fast enough to keep up with the demand. Control Data continued to pioneer developments in computers and successfully market them.

As early as 1959, Control Data Corporation was working on a desktop model computer and continuing to improve on the speed at which computers executed instructions. When Cray's CDC 6600 appeared in 1963, it was twenty times faster than any other computer and executed an average of over 3 million

[69] *Ibid.*, 121:122.

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instructions per second. William Norris and Seymour Cray had chosen to build scientific computers at Control Data Corporation and succeeded at producing the fastest computers on the market.

1960-1969

Howard Aiken, unlike Eckert and Mauchly, remained in academe and served Harvard for many years. Aiken spent twenty-two years at Harvard and served as a director of its fledgling Computation Laboratory, investigating such fields as automatic language translation, switching theory, and mathematical linguistics. He left Harvard in 1961 and became a distinguished professor of information technology for the University of Miami. While at this institution he helped the University develop a computer science program.[71] When he reflected on the first half of the century, he expressed his concern for the development of the computer; "I hope to God this will be used for the benefit of mankind and not for its detriment."[72]

Evolution of the Computer

The computer continued to evolve after the 1950s and the foundations for tremendous advancements were laid in the computers of the 1940s and 1950s. The first major advancement was from the vacuum tube to the transistor. During the 1950s many vacuum tube computers were built and marketed. Computation

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[70] "Control Data Corporation Chronology", Charles Babbage Institute [http://www.cbi.umn.edu/minn/cdc/cdcchron.htm].

[71] Donald D. Spencer. *Great Men and Women of Computing* (Ormond Beach: Camelot Publishing Company, 1996), 75.

[72] *Ibid.*

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speed was in the range of 1000 to 5000 additions per second. These speeds, while slow compared to contemporary standards, were a tremendous increase over pre-computer days. In 1947, physicists at Bell Laboratories invented the transistor. The transistor performed most of the functions that a vacuum tube performed but much faster. They consumed only a small portion of the energy required by vacuum tubes and created very little heat. This seemed to be the answer for computer designers of the late 1950s and early 1960s who had been fighting the problem of keeping computer rooms cool enough to operate computers properly. From 1958 to 1964, a large number of transistor computers were built and marketed.

The second major advancement was the development of the integrated circuit. An integrated circuit combines all of the capabilities of many transistors and other circuit components into one tiny "chip" of solid material. This development allowed for substantial increases in speed and lower production costs. The lower costs allowed many more businesses and academic institutions to participate in the explosive growth of the computer industry. In 1957 the first integrated circuit was produced and it had a tremendous effect on computer development. A mechanized microphotographic process manufactured this device. The integrated chip made it possible to construct faster computers with larger memories and computers with integrated circuits performed 10 million

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additions per second.[73] The integrated chip also paved the way for the personal computer to dominate the market in the 1980s.

The trend toward smaller and faster was well on its way to dictating the future development of the computer. In 1965, the minicomputer introduced by Digital Equipment Corporation became a very popular concept.[74] Smaller and less expensive than the large computers, the minicomputers were affordable to small businesses. In the early 1970s, Large--Scale Integration circuit chips were used in the production of computers. A computer using LSI chips with 100,000 or more transistors performed the same work as the earlier room-size computers. There were many sizes and types of computers. Thus categories of computers were developed: mainframe, minicomputer, and supercomputer.

The next major advancement was the microprocessor. The microprocessor revolutionized many products and continues to be in widespread use. The rapid increase in speed and decrease in size continues to lower the price of microprocessors and increases the innumerable uses of this product. In 1969, the microprocessor was developed and was a general-purpose computer that was programmed to do numerous tasks, from producing a business report to guiding a space vehicle. Companies in every field rushed to take advantage of the microprocessor's power. Computers you can hold in your hand now replace the huge room size computers of only a few decades ago. The technology

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[73] *Ibid.*

[74] "The Digital Equipment Corporation PDP-8" University of Iowa Department of Computer Science [http://www.cs.uiowa.edu/~jones/pdp8/].

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continued to evolve at an amazing rate and challenged academic institutions to keep pace with it.

Conclusion

The early history of computer hardware illustrated the initial attempts to build a machine that would calculate: first an adding machine then eventually a computer. Numerous scholars contributed to the development of the computer from several different disciplines. These disparate researchers were united in a common effort to win two world wars. The computer played an important role in advancements in military weaponry. The extensive resources allocated to these projects produced significant breakthroughs in computer research in a relatively short period. After the war, the focus turned to academic and business functions of the computer. Academicians became businessmen and formed companies to meet the growing need for computers. These businesses generated a need for qualified people to work in the new industry. Higher education institutions, while continuing to research advancements in computers, began to anticipate the need for programs to create a workforce with computer skills. The next chapter uses this initial explanation of early computer history as the foundation for a discussion of early academic computer initiatives and the controversial issues surrounding the formation of the early computer science units.

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CHAPTER TWO

THE EMERGENCE OF THE COMPUTER AND THE STUDY OF COMPUTER SCIENCE

Universities and academic researchers have always played a part in the development and use of computers. The initial introduction of computers into academic institutions was an exploratory endeavor. The early inventions were mechanically inclined and intended to alleviate tedious repetitious calculations done by hand. Both businessmen and scientists were interested in machines that assisted in the calculating process. Several businessmen realized the potential of investing in calculating machines and provided support for early entrepreneurs. The early inventors included government researchers, entrepreneurs, and academic researchers.

Industry and higher education initially allocated limited resources to the development of calculating devices, but the advent of World War I and World War II escalated the necessity for this type of machine. The government allotted extensive resources and used the combined knowledge of military and academic researchers to expedite the development of computers for the war effort. The widespread resources assigned to the development of computers allowed rapid significant advances to occur in these projects.

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.After World War II, computers became more plentiful and were adapted for business and scientific purposes. The number of computer specialists did not increase as rapidly as the production of the machines. The military, academic, and business communities contemplated the future of this new invention and realized that further advances required a workforce trained in the use of computers. The demand for qualified people exceeded the supply in this new industry. Business and government funding played an important role in promoting early courses. Business assisted universities by donating machines to institutions that offered courses on computers. The early computer courses were often influenced by the hardware that was available.

After an initial period, an attempt to formalize this new specialty began in academic circles. The computer was primarily viewed as a tool used to calculate complex mathematical problems. The computer's place in academia sparked numerous debates as specialists from several disciplines attempted to formalize the study of computers and construct initial courses. The universities soon found themselves trying to define a new discipline and meet the demand for trained computer specialists. The initial efforts were disconnected and resulted in academic computer courses with different objectives, content, and purposes.

Initial Academic Computer Initiatives

The sharing of information and the status of hardware development in the 1950s is the starting point for this chapter. This discussion lays the foundation for the computer to evolve from just a calculating machine to the early attempts at

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creating a thinking machine. These very different views of computers led to the early debates on how computers fit in the academic community and how to determine the objectives, for courses on computers. In the 1950s, the sharing of computing knowledge was cumbersome and often informal. The academic specialists who worked with computers wanted to share data, programs, techniques, and knowledge about computing. They recognized the need to overcome incompatibilities of diverse hardware and software systems.

Computers were expensive, and the largest and most powerful computers of that time had severe limitations in memory size and capability. While large-scale computers were the most expensive overall, the economics of the day favored their use. A computer that worked one thousand times as fast as a previous one did not cost one thousand times more. However, obtaining the economy of large computers required that they be used to their full capacity. Many organizations were not prepared to use these large machines extensively.[75] The shortage of trained specialists and new programs were contributing factors to this problem.

A small number of universities and colleges were engaged in some kind of activity in the computer industry. The purpose of the first schools involved was to explore a new field that seemed exciting. Usually, one person who had a strong interest in the field gave a course in whatever department they were currently

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[75] Arthur L. Norberg and Judy E. O'Neill, *Transforming Computer Technology: Information Processing for the Pentagon, 1962-1986* (Baltimore: The Johns Hopkins University Press, 1996) 76.

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teaching. Several institutions had embarked on a program of building large-scale digital computers--only a few were successful. The ENIAC at University of Pennsylvania and Harvard Mark I computers were examples of successful endeavors. By the decade of the 1950s, machines were more plentiful and institutions were not required to build their own to use a computer.

The rapid and diverse advancements in computers and their usage resulted in producing a divergent group of computer specialists. These computer experts from different disciplines contacted each other informally to stay abreast of developments in all areas. The members of this emerging computer community recognized a pressing need for the dissemination of computer-related information. In order to share software for the similar types of computer systems, the programs were copied onto magnetic tape or cards and then sent through the mail.

There were many different types of hardware and most computers could not use programs written for another computer. Programmers used contacts made with other people at professional conferences to obtain information and share programming techniques. Cooperative organizations were formed around particular types of computers to exchange information and programs and to develop programming standards. In 1955, users of IBM 704 computers formed the organization SHARE, and users of UNIVAC 1103A computers formed the USE group. Many other similar groups formed around specific types of computer hardware and software.

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In the late 1950s, people began to notice applications that had been done with General Problem Solver (an artificial intelligence program that attempted to solve problems logically), Logic theorist, and other similar programs. Researchers were aware of activities that were going on in this fledgling field. The first individuals who explored this discipline knew the history of everything that had been developed. Initially in the computer field, computer scientists knew every computer that existed and they knew the existing body of code. After a period, it was no longer possible to know everybody's code, but they still knew every computer. Early researchers were familiar with what happened with computers but as the numbers of computers increased that close contact with other researchers became more difficult. One example of this diversity in computer programs was the design of electric systems done with artificial intelligence using these techniques. This type of inter-disciplinary programming showed up in papers and became a survey of what was going on. The inter-disciplinary work became more common and this facilitated the dissemination of computer-related information.

The computer profession was typical of disciplines in the way participants informed each other. The communication was primarily by letters, papers, and sometimes drafts of papers. The second major channel of communication was at conferences. This conferencing period occurred right after the war. There was a whole group of interdisciplinary quasi-invitational conferences and very few institutional boundaries, because there was an unbounded belief that, technically speaking, everything was connected to everything else. This was a widespread

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view at the beginning of the post-war period, that all computer-related items were connected.

Conference attendees included physiologists, engineers, physicists, and others connected by an interest in operational mathematics and cybernetics, servo mechanisms and Laplace transforms, the digital computer, and information theory all combined together. Conferences were the superior form of exchanging information. When papers were written, they were distributed on a limited basis, as modern photocopying technology was not yet available.[76] The conferences reflected the diversity of computers despite the common perception that all computer-related items together constituted the computer discipline. The diversity continued to grow and spawned numerous diverse computer courses and eventually diverse academic computer programs.[77]

Later, as the pressure for information in these fields grew, courses were added, equipment was secured and universities began to establish computer centers and institutes. Only a small number of universities made a determined effort to set up policies and goals and implement them. Since several existing disciplines were all using computers and researching computer methods, the first approach universities took was to develop a computer center for common access to the computer. This approach focused on using the computer as a tool for various faculties with diverse research interests. This was the "computer as a large

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[76] Allen Newell, interview by Arthur L. Norberg, tape recording, 10-12 June 1991, Charles Babbage Institute, Minneapolis.

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calculator" approach to computing. The staffs were built around the computer center instead of an academic program. These computer centers were initially for specialized faculty but eventually spread to student and administrative use.

While attempting to define the discipline, universities were faced with finding means to implement these centers. The establishment of computer centers varied from institution to institution. In 1949, the University of Illinois organized its Digital Computer Laboratory. The Ballistic Research Laboratory at Aberdeen Proving Ground in Maryland offered to pay for half of the cost of building two replicas of the von Neumann machine, one for the university and one for the Ballistic Research Laboratory. Outside resources and partnerships were used to build machines and create computer centers for academicians using these machines for scientific research. By 1956, the University of Illinois researchers had advanced to researching the latest topics in hardware development.[78]

This was the era in which universities, in a ripple effect, were establishing computation centers. The money came out of the universities, out of gifts and other internal sources. The majority of universities were feeling their way with this new device.[79] The MIT Computation Center was created in 1957 after IBM donated an IBM 704 computer to MIT for the combined use of MIT, IBM, and a group of

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[77] Ibid.

[78] *The Department of Computer Science Brochure*, 1968, University of Illinois Archives, University of Illinois at Urbana-Champaign.

[79] Dr. Louis Fein, *Study and Evaluation of the Status of University Programs in the United States in Computers, Data-Processing and Related Fields Including Recommendations to Stanford University on their Potential Role in the Fields*, October 1957, Stanford Collection, Charles Babbage Institute.

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cooperating colleges throughout New England. The center began to experiment with interactive communication for programmers at the end of 1958.[80] Similar computer centers were built at other large institutions. A survey of computing needs conducted for the MIT Center for Communications Sciences concluded that planning for the center should fit into an overall MIT policy toward computing. The MIT administration, in an attempt to define its policy, formed an *ad hoc* faculty committee in 1960 to estimate campus wide computing requirements and make recommendations on how to meet them.

In mid-1960, the committee formed a working group, also known later as the Long- Range Computation Study Group, consisting of representatives of various departments, laboratories, and centers around MIT interested in computing. By the fall of 1960, the working group concluded that MIT should plan its future computing around a large-scale, centralized computer that users would access by time-sharing. Several other universities across the country followed the MIT model.[81]

IBM was one of the external sources of funding for universities and was giving machines away to institutions offering computer courses. In the late 1950s, the computer centers often consisted of an IBM 650 sitting down in a basement. The scramble to obtain a free 650 computer from IBM was suspect in some cases.

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[80] Arthur L. Norberg and Judy E. O'Neill, *Transforming Computer Technology: Information Processing for the Pentagon, 1962-1986* (Baltimore: The Johns Hopkins University Press, 1996) 82.

[81] Ibid.

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Course titles and contents were created spontaneously to fit the IBM requirements. Faculties were assigned on the basis of their not having a full teaching load. This evidence indicated the lack of a clear well-defined policies and programs in some instances.[82]

As the early courses were initiated, many issues influenced their content. The diverse nature of the disciplines using the computer, the availability of hardware, and role of the computer center all impacted course development. The computer centers often serviced administrative and scientific computing requirements. It was not surprising given the many forces that influenced computers that academicians did not agree on computer curricula.

The Computer as a Thinking Machine, Artificial Intelligence

The concept of a machine that operated as a human brain appeared early in the design of computers and this research continues in academic endeavors in modern research. This theory was a fundamental departure from the computer as a calculating machine. Artificial intelligence became a major research topic in computer science programs.

Early in his first drafts von Neumann compared the parts he called the "central arithmetic organ," the "central control organ" and the "memory organ" of the machine to the associative neurons in the human nervous system. Later in the papers, he also made a comparison between input and output devices and

[82] Dr. Lous Fein, *Study and Evaluation of the Status of University Programs in the United States in Computers, Data-Processing and Related Fields Including Recommendations to Stanford University on their Potential Role in the Fields*, October 1957, Stanford Collection, Charles Babbage Institute.

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sensory and motor neurons respectively. Not satisfied with this simple analogy, von Neumann derived a simplified account of the functioning of the human brain and concluded that the neurons were bi-stable elements, that is, that the brain has all-or-none characters (quiescent and excited). He also concluded that these simplified neuron functions can be imitated by telegraph relays or vacuum tubes. He proposed the use of vacuum tubes in his computer not only for their speed and relative reliability but also because of their resemblance to the basic elements in the human brain.

This theme of the analogy between the human brain and the computer remained consistent throughout von Neumann's career. Von Neumann consistently referred to the parts of his machine as "organs", a term normally used to refer to parts of the body.[83] The early attempts to create machines that imitated man were usually very controversial. There were ethical issues and fear that the computer eliminated jobs.

In the area of computer designs, researchers investigated numerous approaches. At IBM, the goal of one research project was the design of a machine that exhibited the characteristics of human intelligence. Frank Rosenblatt at Cornell developed a computer called a "perceptron" using the neural net concept. These computers made decisions about possible patterns by assembling the evidence obtained from many small experiments. Meanwhile,

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[83] Linda M. Dupont, *An Investigation and Analysis of the Influence of John Von Neumann on Computer Design and Computer Science* (Worcester Polytechnic Institute, 1972) 23.

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Marvin Minsky was working on a similar idea and several students in the MIT artificial intelligence group investigated computers to replicate human motion.[84]

Simon, Newell and Shaw were early proponents of heuristic programming. They believed that information processing was related to the input-process-output cycle. Frustrated with the capabilities of the current language of the day, FORTRAN, these three gentlemen created the first artificial intelligence language, IPL.[85] They used IPL to create the first working artificial intelligence program, Logic Theorist. This program performed proofs of mathematical theorems.[86]

Marvin Minsky and John McCarthy helped found the Massachusetts Institute of Technology artificial intelligence project. John McCarthy, a professor in the electrical engineering department at MIT, had a broad vision of what could be accomplished in this area of research. In a period of about five years, he made two major breakthroughs: the LISP programming language and time-sharing. The first would be a blessing to artificial intelligence researchers to this day. The second literally revolutionized computer research in general.[87] Minsky was attributed with the generally accepted definition of Artificial Intelligence, the science of making machines do things that would require intelligence if done by

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[84] Arthur L. Norberg and Judy E. O'Neill, *Transforming Computer Technology: Information Processing for the Pentagon, 196-1968* (Baltimore: The Johns Hopkins University Press, 1996) 209.

[85] Susan J. Scown, *The Artificial Intelligence Experience: An Introduction* (Bedford: Digital Equipment Corporation, 1985) 161.

[86] Henry C. Mishkoff, *Understanding Artificial Intelligence* (Indianapolis: Sams & Co., 1985) 34:35.

[87] D.V. Pigford and Greg Baur, *Expert Systems for Business: Concepts and Applications* (Boston: Boyd and Fraser Publishing Company 1995) 19.

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humans.[88] Additionally, Minsky with the help of Dean Edmonds assembled the first neural network. During the summer of 1951, Minsky and Edwards returned to Harvard and assembled the first neural net machine from three hundred vacuum tubes and a surplus automatic pilot from a B-24 bomber.[89]

A small group of pioneers was among early researchers and designers of artificial intelligence systems. These individuals attempted to use the computer as a means for simulating various aspects of human intelligence. Because of this shared interest, a conference was held in the summer of 1956 at Dartmouth College. Now known as the Dartmouth Conference, this meeting was originally attended by only a handful of scientists in such diverse fields as mathematics, electrical engineering, neurology, and psychology.

The intent of the Dartmouth Conference was to explore the idea that every aspect of learning or other features of intelligence can be described well enough for a machine to simulate it. An outcome of the Dartmouth Conference was the establishment of initiatives for artificial intelligence. John McCarthy, Marvin Minsky, Nathaniel Rochester, and Claud Shannon chaired this first conference on Artificial Intelligence. The Dartmouth Conference is noteworthy not so much for what knowledge was gained at the conference, as for forming a network of experts in this area. There were no impressive scientific developments at the conference or unexpected insights that shook the foundation of the scientific

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[88] Daniel Crevier, *AI - The Tumultuous History of the Search for Artificial Intelligence* (New York: HarperCollins Publishers, Inc., 1993). 9.
[89] *Ibid.*, 35.

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community. The new field did achieve a name and attracted the elite major pioneers of artificial intelligence research in the United States to the conference. Currently, the leadership of the American artificial intelligence community is composed largely of the conference participants, their students, and their students' students.[90]

In the late 1950's, Newell, Simon and Shaw created the first rule-based computer program entitled Logical Theorist. It introduced symbolic processing as opposed to the typical numeric processing of the time. For example, given the statements "if x is a bird, then x can fly," the system can infer that a robin can fly if it is told the robin is a bird. Rules are fundamental to most artificial intelligence and expert systems today.

In 1957, Newell and Simon created GPS -- General Problem Solver. They attempted to incorporate human problem-solving techniques into a computer program. These techniques were gleaned from tape recordings of actual humans solving problems. GPS was the first system to separate the problem-solving structure of goals and subgoals from the particular domain and to attempt to find solutions independent of that domain. This coincided with Simon's observations that solving a problem was easier upon breaking it up into smaller problems and solving those first (means-end analysis). This is how today's expert systems approach problem solving. The General Problem Solver program, in theory

[90] Henry C. Mishkoff, *Understanding Artificial Intelligence* (Indianapolis: Sams & Co., 1985) 32.

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solved any sort of problem.[91] Newell and Simon received the Nobel Prize for their work on the General Problem Solver although it ultimately did not live up to its promises.

Simon coined the term "satisficing" -- or reaching what is thought of as the best decision based on the options seen so far. The key point here was making the decision without necessarily seeing all the options/alternatives available. This is how most humans reach their decisions in everyday life. He was also the first to realize that the human mind mostly functions by applying estimated solutions to problems based on inferred knowledge of the subject.[92] This thinking is the basis for the heuristic programming of today's expert systems.

In 1958, when McCarthy invented the LISP programming language, his inspiration was another list processing (processes lists of mathematical functions) language -- Information Processing Language, which had been developed by Newell, Simon and Shaw. Such languages can reproduce the associative and symbol-generating capabilities of the human mind.[93] More importantly, they enable the program to do recursive programming, as a human mind can.

Research activities concerning information science ranged from mainstream applications of psychology, the social sciences, and biology, to specific projects in encoding of basic information, self-organizing systems,

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[91] Susan J. Scown, *The Artificial Intelligence Experience: an Introduction* (Bedford: Digital Equipment Corporation, 1985) 162.
[92] Efrem G. Mallach, *Understanding Decision Support Systems and Expert Systems* (Boston: Irwin Publishers, Inc., 1994) 44.
[93] *Ibid.*

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heuristic and adaptive computers.[94] Time--sharing allowed the user to interact with the computer, and attracted the researchers who were interested in interactive methods of working with the computer and human-computer interfaces.

The government also had an interest in promoting research in specific computer-related areas. Government funding assisted certain institutions in obtaining the required hardware, software, and staff to conduct research. The government promoted the use of time-sharing in computers at California institutions to reinforce their interest in time-sharing. Contracts were awarded to Stanford Research Institute, the University of California at Los Angeles, the University of California at Berkeley, and Stanford University. All of the contracts specified the use of a specific government system. In some of the program plans, they are referred to as the "California Network Group."[95]

The group of separate contractors the government sponsored became a community of researchers with common interests and goals. This was how the government was instrumental in transferring the MIT community's concern for time sharing and interactive computing to California and created the basis for another time-sharing computing community. The computer had become more than just a calculating machine and its potential as a thinking machine seemed

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[94] Arthur L. Norberg and Judy E. O'Neill, *Transforming Computer Technology: Information Processing for the Pentagon, 1962-1968* (Baltimore: The Johns Hopkins University Press, 1996) 9-10.
[95] *Ibid.*

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unlimited.[96] The possibilities for the use of computers exceeded the number of people available to research them.

In the early 1960s, the Defense Advanced Research Projects Agency contracted a survey of the information sciences and their relevance to defense concerns. The purpose of the study was to compare the current situation in the Department of Defense with the information sciences, and recommend changes in department's practices. The survey results found five critical areas related to research and development in information science. These areas were (1) pattern recognition and formation of concepts on the basis of-data, (2) decision making, (3) communications, (4) control, and (5) information storage and retrieval, data handling, and data processing.

Computer professionals began to approach computing in a new way. They wanted a computer to be a partner in problem solving in an immediate, interactive, and responsive way. They wanted to converse with a machine and receive quick and intelligible responses immediately. The old methods of interfacing with a computer resulted in responses returned hours later. The responses they wanted were not numeric listings for analysis, but pictures, representing the numbers, that were able to be easily and quickly changed and responsive to changing requirements and ideas. They viewed computers as a shared resource and depository of accumulated knowledge, rather than independent individual tools. This method of using computers made the

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[96] *Ibid.*, 94.

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conceptual jump from the computer as a fast calculator to the computer as a partner able to enhance creative human thinking. [97]

These enthusiasts pushed for time sharing as an economical way to allow the interactive use of the machine by multiple users, thus facilitating the task of programming. They had experienced the benefits of interactive computing and preferred it to the batch method for their work. Fernando Corbato, a leader in the development of time-sharing systems, pointed to the Whirlwind Computer's effect on him and others the computing community. Corbato recalled, "many of us cut our teeth on Whirlwind ... and one kind of knew what it meant to interact with a computer, and one still remembered, and, we might add, one wanted to continue to interact with similar computers in the future."[98]

In 1961, the areas of computing that were "potentially fruitful" included the development of improved techniques in problem formulation, analysis, programming, and the development of procedures and languages for communication between computers and their users. The report called for basic research in pattern recognition, concept formulation and recognition, problem solving, learning, and decision-making, as well as research directed toward improving computer dependability.[99]

The funding and research for artificial intelligence and time-sharing created the resources for initial courses in this area. Departments and academic

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[97] *Ibid.*, 74.
[98] *Ibid.*, 80.
[99] *Ibid.*, 10.

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programs grew from the early computer courses and this research remained controversial and influential in spawning these programs. The curricular debates in the 1960s were based on the various purposes of computers. The computer as a thinking machine was a significant change from the earlier models designed to calculate military ballistic tables. The courses designed to teach the mechanical aspects of the computer continued to be taught in engineering programs. The courses reflecting the software and artificial intelligence aspects of computers resided in mathematics and behavioral science programs. Each of these models were reflected in different courses in particular institutions

Early Courses and Minors

As institutions obtained computers, the requirement to train people in their usage initiated some courses. The courses ranged from the specifics on constructing computers to the theories on numerical analysis and simulating human reasoning. The courses were as diverse as the faculty that taught them. Primarily, the early courses on computers appeared in engineering and mathematics departments at institutions funded for government computer research.

The popularity of computers continued to fuel the spread of courses that were developed at these institutions. The field of computer science was emerging as a discipline. Mathematicians had been interested in numerical analysis and in some aspects of computer science, but the potential of the field in terms of other interests like artificial intelligence, coding, and various uses in engineering and science

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seemed beyond the interest of many of the conventional mathematics departments. It was apparent that something new was coming along with computer science.[100]

In 1946, the University of Pennsylvania offered the first "course" ever given in the field of electronic digital computers in the Moore School of Engineering following completion of ENIAC. By the 1951-1952 school year, five courses were listed involving digital computers at that institution. In the same period, the University of Illinois Mathematics program offered a course in High-Speed Computing. In a 1951 University of Wisconsin report, a Mathematics 131 course on Theory and Operation of Computing Machines was described as offered in the spring of 1951. The course lists a lecture and laboratory section. The laboratory section was taught using an IBM Card Programmed Electronic Calculator.[101]

The 1956-1958 University of Illinois *Bulletin* indicated courses in both the Electrical Engineering department and the Mathematics Department. The electrical engineering course included Logical Design of Automatic Digital Computer Circuits and Electronic Analog Computers. The mathematics course work included High Speed Computing I & II and Digital Computer Programming.[102] Multiple departments working in different aspects of computers

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[100] Albert Bowker, interview by Pamela McCorduck, tape recording, 21 May 1979, Charles Babbage Institute, Minneapolis.

[101] University of Wisconsin, *The Computing Service, January-June 1951: A Report to the Committee on the Computing Service* (Madison: University of Wisconsin, 1951).

[102] University of Illinois, *University of Illinois Bulletin: Graduate College* (Urbana: University of Illinois, 1956-1958) 131-203.

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at the same institution was not an unusual occurrence. These courses were representative of courses that were taught at other institutions.

As early as 1956-1957, the University of Pennsylvania's Academic *Annual Report* states that specialties in the computer field had attracted students, particularly cooperative work that involved course work in computers for business applications. The *Bulletin*, of the same year described emphasis on research and development work for the armed services and for industry. The *Bulletin* stated "Since the ENIAC's inauguration in 1946 a complete industry has grown up in the electronic digital computer field."[103] By 1958-1959, this *Bulletin* advertised a Master of Science in Electrical Engineering that allowed specialization in an emphasis on large-scale computing devices.[104] The programs of computer specialization within Electrical Engineering at MIT and University of Pennsylvania were among the earliest in engineering programs.

The University of Michigan took an interdisciplinary approach to computer courses in the later half of the 1950s. Faculty from Linguistics, Philosophy, Mathematics, and Electrical Engineering were involved in the interdisciplinary program. When this group initially formed a department in the 1960s, its original title was Communications Sciences.[105]

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[103] University of Pennsylvania, *University of Pennsylvania Bulletin: The Engineering Schools.* (Philadelphia: University of Pennsylvania, 1956-1957).

[104] University of Pennsylvania, *University of Pennsylvania Bulletin: Graduate School of Arts and Sciences*, (Philadelphia: University of Pennsylvania, 1958-1959).

[105] Bernard A. Galler, interview by Enid H. Galler, tape recording, 8, 10-11, 16 August 1991, Charles Babbage Institute, Minneapolis.

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Mathematics departments were also developing early coursework in computers and produced computer science departments and programs. A University of Wisconsin Graduate School report for the years 1958-1963 documents the approval for a new Ph.D. program in Numerical Analysis. The same report indicates that a computer lab the Numerical Analysis Laboratory was funded to purchase a CDC 1604 computer to replace an IBM 650 that supported mathematical research and courses.[106] In this case, the computer center and the mathematics department contributed to the new program.

While some institutions initiated computer science programs or departments, other institutions created similar programs but with different names. The University of North Carolina at Chapel Hill created one of the early departments but named it the Department of Information Science.[107] The University of Wisconsin program began as the Numerical Analysis Department. In the early to mid 1960s "Computer Science" was just one name among many for this type of academic unit. The new academic unit at the University of North Carolina evolved from a computation center, as did many other departments. When the new academic unit was formed, courses from other disciplines were transferred over and modified as "Information Science" courses.[108]

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[106] University of Wisconsin, *The Graduate School Summary Report for July 1, 1958-June 30, 1963* (Madison: University of Wisconsin, 1963) 13.

[107] Peter Calingaert, *Growth of a Department: A Personal History of Computer Science at UNC-Chapel Hill 1962-1994* (Chapel Hill: The University of North Carolina, 1994) 4.

[108] *Ibid.*, 4.

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These new departments were often formed by combining existing engineering, mathematics, and business courses and joint appointments with faculty from these departments. It took time for computer science to develop an identity of its own. As these units began to form, curricular questions were raised and academia began the debate over computer science curricula. What was computer science and what courses comprised a computer science curriculum? This was a common question and factions formed around the diverse answers. The split began to form between those interested in computer engineering, business computing, and numerical analysis and problem solving. There were demands for scientists, business majors, and mathematicians with computer skills. Clusters of academicians began to form around how they approached the use or construction of computers.

Academia Begins to Define and Teach Computer Science

The early courses initiated by researchers interested in a particular topic or by administrators using them to secure the donation of a computer produced only a handful of people trained in using computers. Their courses were often very different depending on which institution they attended. The nation was facing urgent information processing problems, both military and civilian, in the areas of command and control, information storage and retrieval. The numbers of people skilled in the techniques of information processing were insufficient to attack these problems effectively and speedily. The techniques in information processing were still rudimentary because of the small number of people

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conducting research in this area. It was necessary to mount an educational program to train a larger cadre of people for research and teaching.

The faculty and students in these programs needed additional and more suitable equipment to accomplish this goal. Adequate facilities were needed for research and education, research was needed to develop the facilities and to support education, and education was needed to provide the necessary personnel for the development of facilities and to carry out basic research. These changes benefited students and faculty members by improving the educational environment. The nation's defense benefited from the research and results obtained from these schools.[109] The requirement for more computer professionals was very clear but how to educate them and in what topics was a contentious issue.

Manufacturers of computer products realized that the shortage of trained faculty and staff limited their industry and sponsored efforts to educate the workforce. While the computer industry was in its early stages, IBM had 90 percent of the tabulating business and, by 1957, after the conversion to computers, it had 78.5 percent.[110] Due to its large market share, IBM tried to assist in solving the supply of labor problem. In addition to IBM, the Association for Computing Machinery (ACM), an association for computer professionals, also

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109 Arthur L. Norberg and Judy E. O'Neill, *Transforming Computer Technology: Information Processing for the Pentagon, 1962-1986* (Baltimore: The Johns Hopkins University Press, 1996) 95.

110 Joan M. Greenbaum,, *In the Name of Efficiency: Management Theory and Shopfloor Practices in Data-Processing Work*, (Philadelphia: Temple University Press, 1979) 14, 27 .

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realized there was a shortage of labor. Within the ACM there was a Curriculum Committee on Computer Science which, from around 1962 to 1964, considered problems with computer science curricula in undergraduate programs.[111] For one week in the summer of 1964, the Curriculum Committee met at Poughkeepsie, New York. The purpose of the committee in general and the one-week session in particular was to arrive at concrete suggestions for a Computer Science curriculum.[112] As a professional organization, the ACM attempted to convene interested parties from industry, academia, and funding bodies to find a consensus on what constituted a computer science curriculum. The amount of available courses was limited at this time but continued to grow. In later years, other professional organizations also published their recommended curricula. This debate over computer science curricula continues in modern times among professional and academic organizations.

While government, industry, and professional organizations discussed curricula, some academic institutions studied the issue. Dr. Fein's recommendation to Stanford University advised that a new graduate school called the "Graduate School of Computer Science" be formally created by September 1958. It also advised that a policy committee including a dean and service department heads be appointed. The primary function of the committee was to

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[111] Association of Computing Machinery Curriculum Committee on Computer Science, "An Undergraduate Program in Computer Science--Preliminary Recommendations," *Communications of the ACM* 8 (September 1965): 543-552.
[112] *Ibid.*, 543-552.

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set and implement policy and budget for the new school. The committee was charged with studying issues related to an integrated program of instruction and research and the school's relationship to other university schools and departments. A five-year plan was to be available by September 1958 and the school was to begin its formal existence at that point.[113] This early attempt to organize a school of computer science eventually was implemented several years later.

This contributed to the question, did computer science constitute a discipline? Although a set of agreed--to criteria did not exist for determining whether or not a field rated as a discipline, there were several characteristics of accepted established disciplines. These characteristics were referenced when determining whether a given field was potentially a discipline. Several established disciplines, like mathematics, had the following characteristics: (1) the terminology had been established; a glossary of terms existed; (2) workers in the field did non-routine intellectual work; (3) the field had sometimes been axiomatized; (4) the field is open, i.e., problems were self-regenerating; (5) there was an established body of literature, textbooks exist, sometimes treatises-even handbooks; also professional journals; (6) university courses, sometimes departments and schools were devoted to the field. Most aspects of computers, data processing, and the related fields met these

[113] Dr. Louis Fein, *Study and Evaluation of the Status of University Programs in the United States in Computers, Data-Processing and Related Fields Including Recommendations to Stanford University on their Potential Role in the Fields*, October 1957, Stanford Collection, Charles Babbage Institute.

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specifications or did meet them in the next ten years. It was clearly the job of university people to create the axiomatization, theory, terminology, curriculum, etc.[114]

The subject of computers and their place in academic institutions began to appear in academic bulletins and annual reports. The 1960-1961 *University of Pennsylvania Annual Report* cited "...change in electrical engineering education ...centers around computers, and the objective is to break away from the modest problems which can be solved by hand, and to attempt to have students think in terms of much larger problems which require the use of machines for specific answers." It also reported that in spring 1961 the Moore School obtained delivery of an RPC 4000, a medium-sized versatile computer intended primarily for educational purposes.[115] The engineering program that created the ENIAC was now including scientific problem solving as part of its curriculum.

MIT was doing significant work in computers and most of the leadership was coming from the electrical engineering faculty. A segment of the MIT electrical engineering faculty proposed that computer science had emerged as a distinct and separate discipline and the debate over forming a separate computer science department continued in the electrical engineering department for a number of years. There were numerous discussions about the computer scientists leaving the engineering department to form their own department. It seemed that a lot of

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[114] *Ibid.*

[115] University of Pennsylvania, *Annual Report: The Moore School of Electrical Engineenng* (Philadelphia: University of Pennsylvania, 1960-1961).

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dynamic activity was taking place in something called computer science.[116] The challenge was to define computer science.

It became clear that computers had developed in such a way that most of the disciplines in the university had need for them at least as auxiliary devices. The question of whether or not computer science, not the computer itself, was a discipline worthy of study by the university was not yet settled. Stanford's Al Bowker commissioned Dr. Louis Fein to study "The Role of the University in Computers and Data Processing." Dr. Fein was an engineer and had worked on numerous government computer projects but was not an academician. He spent a year studying the matter and described the study in the following way:

> At that time also I went to every computer conference held and I talked at bars and computer conferences with the likes of Al Perlis, John Carr, John McCarthy, who was then at Dartmouth, Herb Simon and tens of others about the notion of the place of computers as a science in itself, like geology, economics, and mathematics as a discipline worthy of pursuit in a university, and on the other hand as another tool, a super-calculator, if you please.[117]

Dr. Fein was an engineer and was not familiar with curricular design. He needed to understand the process of curricular design for this investigation. In the study, he designed a computer science curriculum to gain experience with the principles of

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116 Albert Bowker, interview by Pamela McCorduck, tape recording, 21 May 1979, Charles Babbage Institute, Minneapolis.

117 Louis Fein, interview by Pamela McCorduck, tape recording, 9 May 1979, Charles Babbage Institute, Minneapolis.

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curriculum design before applying them.[118] When his study was complete, he discussed his curricular recommendations with several institutions that subsequently initiated computer science programs shortly after speaking with him.

Dr. Fein's theory was that computer science was a supra-discipline similar to mathematics. He described mathematics as a supra-discipline, because it was applied to many different problems, areas, and disciplines and was a study in itself. A discipline was largely studied on its own and there was not a large overlap with other disciplines. There were available courses that included engineering, mathematics for engineers, differential equations for engineers, mathematics for chemistry, and others. At that point in time, courses such as biology for chemists, or geologists, or geology for musicians did not exist. Dr. Fein believed that computer science would develop into a supra-discipline. While investigating what makes a subject worthy of pursuit in a university, he concluded some disciplines were surely worthy of pursuit, but clearly all supra-disciplines were worthy pursuits for a university.[119]

Dr. Fein's report was the first philosophical support statement and argument for why computer science was a supra-discipline. The report also explained why computer science needed to be a separate department to develop more theorems, make better computers, and better software. Computer science was applicable to all other departments. Dr. Fein envisioned a set of courses in a separate department,

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[118] *Ibid.*

[119] *bid.*

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beginning in a graduate school, because the body of knowledge for computers was insufficient for undergraduate study. The report laid out a set of courses for the school itself and for other departments, and a research program. The cost and sources of funding were also identified. Dr. Fein wanted to start with some seed money that was not merely for a computer center as many people were doing. It was difficult to get people to distinguish a computer center, which was a job shop from an academic department because they did not understand the issues.[120]

In a 1959-1960 brochure on the University of Illinois Digital Computing Laboratory, the purpose of the center was stated as (1) to carry out research and teaching in the design of high-speed computers and their components, (2) to carry out research and teaching in numerical analysis associated with the use of a high-speed digital computers, and (3) to provide computer facilities to be used as research tools by members of the University.[121] While the Digital Computing Laboratory had tenured faculty and high-speed computers, there was no curriculum in computer science. The computation center model had been adopted by many institutions and courses were being taught by these centers. Institutions were hesitant to move the courses to an academic department and unsure whether computer science should be an academic department by itself.

In each of the institutions that became the major computer science centers, usually it was possible to identify one or two people who were responsible for their

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[120] *Ibid.*

[121] University of Illinois Archives, *University of Illinois Brochure*, (Urbana: University of Illinois, 1959-1960).

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success, that is, people who really cared about building a computer science program institutionally. At Carnegie Mellon, there was a precursor to the Stanford department and Purdue began to form a separate group within the mathematics department. Some units existed within others as at MIT and Harvard. Hence academic computer science units began in the early to middle 1960s in the United States. In 1999, practically every major university in the country has a computer science department or, in several cases, an electrical engineering and computer science department.[122]

Conclusion

The path from independent research projects to computer centers and eventually to the discussion of academic computer departments began after World War II and spanned the decade of the 1950s to the early 1960s. The computer as a calculating machine expanded to the computer as a thinking machine that could interact with people. The focus shifted from building computers to the numerous ways to use a computer and the specialty groups that formed around these topics. The issues explored included: the purpose of computers, how universities could maximize the use of computer resources, and the requirements of government and industry for trained computer specialists. The construction of a computer no longer required university research teams. Industry had mastered the techniques of mass production of computers. As machines proliferated throughout business and universities, the demand for skilled computer professionals increased tremendously.

[122] Joseph F. Traub, interview by William Aspray, tape recording, 29 March 1985, Charles Babbage Institute, Minneapolis.

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These issues all influenced the eventual development of academic computer science departments, and curricula. Initially, individual courses were offered at universities and then specialty fields in computers within existing departments. The creation of separate computer science departments was the logical next step. The creation of these departments and programs raised curricular issues that eventually led to additional specialty areas within computer science.

The transition from computer centers to academic departments occurred in several research universities from 1962 to 1965. In fact, the beginning of computer science departments did not happen with a lot of fanfare. Departments were connected to grants in some instances and the reason various departments existed was because funding was available.[123] Some departments formed as a result of splitting from the department that had originally initiated them. Differences in philosophy or the quest for resources were often the impetus for a new department to be created from an initiating group. Despite the diverse number of reasons why an actual program began, the middle 1960s brought the formation of several separate academic units.

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[123] Allen Newell, interview by Arthur L. Norberg, tape recording, 10-12 June 1991, Charles Babbage Institute, Minneapolis.

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CHAPTER THREE

COMPUTER SCIENCE PROGRAMS

At the beginning of the 1960s, computer centers and courses had already been established in numerous universities and colleges. Initially, the computer centers taught the early computer courses. This reflected the previous belief that the computer was a tool that was shared by many departments and not a separate course of study unto itself. The dilemma for these institutions then became whether or not to form separate academic computer programs and departments. Those institutions that elected to form programs and departments had to make decisions on what the focus of their program was and how to develop an appropriate curriculum.

Computer science courses were housed in a variety of academic departments. Primarily they were a part of engineering and mathematics departments but they were also found in psychology, business, and physics. As discussed in the previous chapter, in numerous universities these courses resided in multi-disciplinary computer centers. The courses varied from engineering courses on hardware design to programming languages and artificial intelligence. As separate departments and degree programs were formed, the debate continued over the content of computer science curricula and who should.

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teach it. The term "computer science" was used but there were other similar names used by several institutions. Dr. Louis Fein had first thought of using the term computer science in 1956, while working on a study for Stanford University. According to Dr. Fein,

> To my knowledge that was the first use of that phrase. It wasn't published in a report until 1957 and so far as I know even that was the first publication of the phrase 'computer science' but it occurred to me obviously in writing the report because I deliberately looked for it. It was not as if it just occurred to me out of the blue. It was a conscious search for an appropriate term for the name of the department, in this case a school dealing with computers and data processing related fields.[124]

Only a decade later, the term "computer science" caught on and was in wide spread. The common acceptance of the term "computer science" only added to the debates over what constituted an academic computer program. The Stanford program reflected "computer science" modeled after traditional science programs. "Computer engineering" was also a popular term for the new discipline and reflected an engineering model. At that point in time, "computer science" was often used as the title of programs despite the program model. The use of a common program title without a consistent curriculum resulted in continued contention over what was a "computer science" program.

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[124] Louis Fein. Interview by Pamela McCorduck, tape recording, 9 May 1979. Charles Babbage Institute, Minneapolis.

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While industry and professional organizations watched universities debate the definition of computer science, their needs for trained employees were increasing. Professional organizations such as the Association for Computing Machinery (ACM) and the Data Processing Managers Association (DPMA) attempted to implement standards. The DPMA provided a certificate that would certify an individual in data processing. "Data processing" was a title used by the business community and those supporting business computer applications. This certificate was not designed to meet academic requirements but to insure an employer that a person had a specific skill level to work with computers in a business environment. The course requirements were seen as integrated steps to a broader goal: the advancement of the data processing profession. The DPMA indicated that one of the most serious problems was the lack of established standards of education and experience. They sought to create standards that would serve as a guide for people in the field, business, education, and government. They provided a definite path for people who sought to fulfill a professional level of education, training, and experience. An additional goal was to assist colleges and universities in becoming more uniform in their course offerings in this area.[125] Other initiatives included the Association of Computing Machinery and Institute of Electronic and Electrical Engineering (IEEE) model curricula designed for university programs. Computers were in such

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[125] John K. Swearingen, "The Certificate in Data Processing: A Progress Report". *Journal of Machine Accounting* (November 1962): 50.

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widespread use and in very diverse areas that a single curriculum did not address all concerns. This problem remains and is still addressed in modern curricular debates.

Several important constituencies were involved in defining computer science programs. Professional organizations, industry, government, and universities contributed to the new discipline. Each of these participants brought different perspectives on the future of computer science. While there were many diverse views of computer science, the debate over theoretical versus applied aspects of computers was a contentious issue. The various opinions on the purpose of computers resulted in very disparate programs and curricula.

Computer Science: Theoretical versus Applied

The construction and improvement of computer hardware dominated the early history of computers. Universities such as MIT, Harvard, and the University of Pennsylvania achieved remarkable advancements with the machines they built at their institutions. Engineers working with mathematicians and physicists were the primary participants in designing and constructing these machines.

Software and business use of computers became important topics after the construction of computers became common and industry, not academic, institutions produced most of the machines. The curricula in institutions that had focused on building hardware did not resemble the curricula in universities focusing on software and business requirements. These conflicting priorities fueled the debates on curriculum in the new computer science programs and departments as the new discipline attempted to define a common body of knowledge.

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Research scientists found that the improved computer hardware combined with the latest software allowed them to solve mathematical problems that had been beyond their reach in the past. Two professions related to mathematics, computer science and statistics, became essential tools for research. Both statistics and computer science evolved from the established analytical expression of mathematical science. The use of statistics and computer science was necessary to assist in the generation and analysis of information. It was destined that computer science, statistics, and their interface came to share an important position with the established components of mathematical science research. The interface of computer science and statistics evolved from the interlacing of two paths: (1) the development of the mechanical prerequisites to the computer and the mathematical prerequisites to computer science and (2) the continuing development of the established area of probability and statistics. This resulted from the common origin of computer science and statistics in mathematical science. The use of computers to solve advanced mathematical problems was essential for modern research. Computers were necessary not only for information processing, but also for numerous theoretical investigations. These advanced investigations had previously been beyond mathematicians prior to the development of the computer. Mathematicians' past contributions in various areas of computer science resulted in computer science programs residing in mathematics departments at some institutions and engineering departments at other institutions. Curricular discussions included advocates for computer science courses to address the design of future

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hardware improvements, supporters for computer science courses addressing software development, and the use of computers to solve scientific and mathematical problems.[126] Universities were expected to produce both research-oriented faculty in computer science and also meet the business and industry requirements for trained computer specialists.

The academicians in statistics, mathematics, physics, and other substantial users of computers knew they could improvise whatever computing techniques they required as they conducted their research. Convincing academics that computer science was going to be a discipline unto itself and that computer science absorbed the intellect of researchers who were involved in that discipline took vision. Defining computer science as an independent discipline implied that everyone who created a single program was not necessarily a computer scientist. That was not a popular concept among academicians and created a lot of the skepticism.[127] Professors of computer science were often asked, "was there such a thing as computer science, and if so, what was it?" Allen Newell, Alan Perlis, and Herbert Simon provided one of the more notable responses to that question,

> Whenever there are phenomena, there can be a science to describe and explain those phenomena. Thus, the simplest (and correct) answer to 'What is botany?' is, 'Botany is the study of plants.' And zoology is the

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[126] A. F. Goodman, "The Interface of Computer Science and Statistics: An Historical Perspective", *The American Statistician* (June, 1968):17.

[127] Albert Bowker. Interview by Pamela McCorduck., tape recording, 21 May 1979.Charles Babbage Institute, Minneapolis.

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> study of animal, astronomy the study of stars, and so on. Phenomena breed sciences. There are computers. Ergo, computer science is the study of computers. The phenomena surrounding computers are varied, complex, rich. It remains only to answer the objections. [128]

The reason that people, although they were at a university, thought of computers as an exotic calculator, was that computers were not perceived as having anything to do with science. A similar example was a Marchant hand calculator that had nothing to do with astronomy although astronomers used it. Academicians, the mathematicians among them, were interested in puzzles but did not view the computer as a part of the academic structure of a university. They viewed it as a part of the apparatus, and as an important apparatus but not part of academics.

People like Howard Aiken and Jay Forrester at MIT, and Eckert and Mauchly created machines and happened to be at a university but it is likely that they would have created computers anywhere. The Department of Defense, during the war effort, supported numerous researchers, which facilitated the development of computers, (both analog and digital computers). Computers were associated with war and people asked, "what did that have to do with the academy?" This was a common viewpoint that plagued computer science. This might have been an important reason for people not seeing computers that were originally financed by

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[128] Allen Newell, Alan Perlis, Herbert Simon," What is Computer Science". *Science*. 157, No. 3795, (September 22, 1967): 1373-1374.

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and motivated by the war department as academic research.[129] . The academy was used in the war effort but the academic outcomes were not thought of as making war materials. Computers were part of the academy and science.

The use of computers had crossed multiple disciplines and included both applied and theoretical research. The initial projects to build a machine that performed mathematical calculations had escalated into projects that included computers used for diverse purposes. Developing software for these diverse requirements had also become a thriving sector of computer science. Business and science alike looked to the computer for greater productivity and solutions to their problems.

The government had broadened the focus of the research it was funding from primarily hardware design to other areas. These areas included software development, interfaces to the hardware, and timesharing concepts. Instead of continuing to develop specific computing machines, as they had done in the 1940s and 1950s, government officials generalized their interest in computing into the Information Processing Techniques Office (IPTO). In 1962, IPTO became the newest, and perhaps the most significant action of the Department of Defense's activities in computing.[130] In 1965, the program areas and specific emphases included: research into command and control processes, particularly human-

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[129] Louis Fein. Interview by Pamela McCorduck. tape recording, 9 May 1979. Charles Babbage Institute, Minneapolis.

[130] Arthur L. Norberg and Judy E. O'Neill, *Transforming Computer Technology: Information Processing for the Pentagon, 1962-1986* (Baltimore: The Johns Hopkins University Press.1996) 15.

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machine interaction, computer languages, advanced programming techniques, timesharing, advanced computer systems, and their organization as related to defense problems and computer usage.[131]

In the 1960s, IPTO used its management practices to support research in technical areas and selected projects to produce more interactive and flexible computer systems. Projects in artificial intelligence were selected to produce more intelligent and capable systems and network research to promote the efficient sharing of resources and community building. Since these projects represented the focus of IPTO in its early years and through this research, the style of computing changed markedly.[132]

The principle stakeholders in computers--government, industry, and academia--all faced a common problem, the increasing requirements for trained employees in computer skills. The arguments over computer science continued to be conducted through journals, conferences, and social gatherings and prompted the next step for the universities. The stage was set for several institutions to establish computer science programs and departments independent of the parent departments. From 1962 to 1967, several important computer science departments were established at universities.

The Early Academic Computer Science Units

There was a flurry of activity in the middle 1960s as several institutions began

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[131] Ibid., 44.

[132] Ibid., 66.

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establishing computer science departments. The move to establish independent academic units began early in the 1960s. At the University of Chicago, there existed an Institute for Computer Research, which was purely a research institute with some teaching responsibilities, but there were no students admitted to that unit. The faculty in that unit taught in other programs, in the school of business and applied mathematics programs.[133] This popular model was found at numerous other institutions.

Other departments often viewed the advent of new computer science departments as threatening because resources were scarce and monies normally allocated to existing departments might be diverted to the new department. Anyone who brought in a new idea that required money from a common budget posed a financial and professional threat. The ability to fund a new department and contention for resources within the institution contributed to some institutions delaying the decision to create an independent department.

The cost of computers in the early 1960s was a prohibitive expense for many institutions. In 1957, Stanford was looking for a million-dollar machine and considered a good computer essential to the success of any academic computer science program. The RADAC and UNIVAC were three million dollar machines and beyond the budget of many institutions.[134] Government research contracts were a

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[133] William F. Miller. Interview by Pamela McCorduck, tape recording, 22 May 1979. Charles Babbage Institute, Minneapolis.

[134] Louis Fein. Interview by Pamela McCorduck, tape recording, 9 May 1979. Charles Babbage Institute, Minneapolis.

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popular method to obtain funding for purchasing or producing a machine but did not constitute a commitment by the institution to keep a computer science program in place long term. Research funding brought enough attention to obtain a faculty position and teach a few courses but not a long-term commitment to computer science as a discipline.

Many institutions did not consider the idea of computing as a discipline worthy of pursuit at the university. Dr. Fein had approached several institutions after 1957 regarding his research for Stanford on starting a computer science department. When queried in an interview about what institutions he approached, Dr. Fein responded, "Well, I remember Purdue; John Carr at the University of North Carolina, who pushed the idea but I don't remember that what he said about being in support of it or not; Berkeley; Stanford; and I talked to John McCarthy who was at Dartmouth but that was just incidentally."[135] Later, Dr. Fein promoted the idea of separate computer science units in papers he wrote. These papers were really motivated by the work he did for the Stanford consulting report. He presented these papers at an ACM conference. Although interested in the Fein report, institutions still hesitated to establish separate computer science departments. Finally in 1962 a few institutions took the first steps to establishing independent academic departments.

University of Wisconsin

In 1962, the Numerical Analysis Department at the University of Wisconsin was established as a separate department from the mathematics department with

[135] Ibid.

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responsibilities both for the computing facilities and for teaching and research in numerical analysis. The Numerical Analysis Department was in the College of Letters and Science, which had primary responsibility for staff selection and staff budgets.[136] The 1963 *Bulletin of the University of Wisconsin College of Letters and Sciences* listed computer sciences as a department. A 1966 brochure indicated that the computer sciences department was created in July of 1964 with a staff of 29 from the old numerical analysis department. Baccalaureate, masters, and doctoral programs were offered beginning in 1964[137]. The University of Wisconsin was unique in offering a baccalaureate program at that point in time. Most of the other institutions created only graduate programs initially.

Purdue University

In October 1962, the Computer Science Department of Purdue University was formed and doctoral and masters programs established. The initial faculty consisted of seven members with Samuel Conte as the first department head. The faculty was formed from members of mathematics and engineering departments. Initially this department was part of the Division of Mathematical Sciences. The division consisted of three departments: mathematics, statistics, and computer science. Each department had their own degree requirements and

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[136] University of Wisconsin, *The Graduate School Summary Report for July 1, 1958-June 30, 1963* (Madison: University of Wisconsin, 1963) 14.

[137] *Computer Science Brochure*, University of Wisconsin Archives, 1 November 1966, University of Wisconsin at Madison.

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had independent personnel committees. There was only one Ph.D. qualifying exam for the division, one graduate committee, and a common budgetWhen the department initially formed, Samuel Conte was both the Director of the Computer Sciences Center and Head of the Computer Sciences Department. These positions separated in 1968, when Saul Rosen became Director of the Computer Sciences Center and Samuel Conte remained Head of the Computer Sciences Department.[138] . The complete separation of the departments did not occur until 1968.

The focus of the master's degree was to train computer scientists for industry. The Ph.D. areas were numerical analysis and theory and programming systems. The undergraduate program followed in 1967. There was a computer science option in the mathematics undergraduate degree before 1967. The initial mix of students included engineering, science, and business students. This mix of students, even at this early stage of computer science, was not a successful one due to the varying skills and levels of mathematics preparation. Similar problems were encountered at other institutions and led to different academic programs in computer-related areas.[139] As a land grant institution, Purdue targeted its master's degree at producing computer specialists for the workforce and developed a large graduate program very quickly.

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[138] John R. Rice & Saul Rosen, *History of the Computer Sciences Department at Purdue University*, CSD-TR-1003 The Computer Sciences Department, August 1990. Purdue University.

[139] Ibid.

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University of Illinois

In 1957, the University Board of Trustees at the University of Illinois reorganized the Digital Computing Laboratory as a department with the authority to appoint staff members and grant tenure to its faculty.[140] This was a first step in moving toward a computer science department and degree program. The 1959-1960 *Bulletin* indicated there were 10 faculty members for the Digital Computer Laboratory. These faculty included physicists, mathematicians, and electrical engineers. The *Bulletin* clearly states that there was no curriculum or degree in digital computers. The faculty assigned to the Digital Computer Laboratory held appointments in regular departments of the university as well. The Digital Computer Laboratory identified three primary focuses: (1) to carry out research and teaching in the design of high-speed computers and their components, (2) to carry out research and teaching in mathematical problems associated with the design and use of a high-speed digital computer, (3) to provide computer facilities to be used as research tools by members of the university.[141]

At its 24 November 1964 meeting, the board of trustees voted to change the name of the Digital Computer Laboratory to the Department of Computer Science. The board reaffirmed that the instructional program would continue through related departments. This established them as a computer science

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[140] *The Department of Computer Science Brochure*, University of Illinois Archives, 1968, University of Illinois at Urbana-Champaign.

[141] University of Illinois Archives, *University of Illinois Brochure*, (Urbana: University of Illinois, 1959-1960).

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department with faculty but no curriculum or authority to award degrees.[142] By 1966, the University of Illinois moved to award Master of Science and Doctor of Philosophy degrees in computer science and authorized the computer science department to create these programs at the 20 April 1966 meeting. The minutes reflect the following statement at that board meeting,

> The recommendation has been developed in recognition of the emergence of computer science as a unique discipline and in response to the need for competent faculty and research personnel to make possible the training of large numbers of programmer, coders, and analysts who are needed to staff governmental and industrial computing facilities. Currently it is estimated that 35,000 such persons are needed each year, a figure comparable to the present number of engineering baccalaureate degrees produced annually in the United States.[143]

This action established the Department of Computer Science as a degree-granting academic program at the University of Illinois.

University of Pennsylvania

The University of Pennsylvania authorized a computer and information science group to offer a master's degree and expressed the expectation of a doctoral program in the 1964-1965 school year. The CIS group was formed

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[142] University of Illinois Archives, minutes of Board of Trustees meeting 24 November 1964, p.240

[143] University of Illinois Archives, minutes of Board of Trustees meeting 20 April 1966, p.1123

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within the electrical engineering department of the Moore School.[144] The *Bulletin* of the same year describes the computer and information sciences program as guided by an interdepartmental committee and broader than the previous specialty courses in large-scale computers. The *Bulletin* further describes the availability of a M.S.E. and Ph.D. in the areas of theory of automated processes, data-processing systems, programming, and switching theory.[145]

The University of Pennsylvania 1965-1966 *Bulletin* further clarified the description of the previous year on the CIS program. The name changed from the Computer and Information Sciences Program to the Information Sciences Program, still guided by an interdepartmental committee under the Electrical Engineering Committee. The original degree in 1959 allowed other fields related to modern data-processing to obtain both the M.S.E. and the Ph.D. (in engineering) degree in the areas of theory of automata, data-processing systems, programming, switching theory and numerical analysis for computers, and information retrieval. This had been instituted to satisfy a growing need from industry for an integrated program in the scientific foundations of the field. The new computer and information sciences curriculum, leading to both masters and doctoral degrees, was an outgrowth of the pioneering contributions by the

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[144] University of Pennsylvania, *Annual Report: The Moore School of Electrical Engineering* (Philadelphia: University of Pennsylvania, 1964-1965).

[145] University of Pennsylvania, *University of Pennsylvania Bulletin: Graduate School of Arts and Sciences*, (Philadelphia: University of Pennsylvania, 1964-1965).

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University of Pennsylvania in the development and use of large-scale electronic computers.

The information sciences curriculum was intended for students with undergraduate training in any one of a broad range of disciplines. This curriculum was distinct from the long-standing electrical engineering program with specialization in the engineering of digital computers, although the two programs had a number of courses in common. Students with bachelor's degrees with a major in areas related to modern information-processing theory, including engineering, mathematics, the physical sciences, philosophy (logic), linguistics and business were eligible to enroll. The central theme of the program content stressed the logical representations of computer programming, hardware design, and mathematical models, as well as the importance of systems design. In systems design, emphasis was placed on the relative capabilities of equipment and computer programs. These concepts were broadly applied in such fields as mechanical languages, mechanisms, and devices, automata theory, programming theory, numerical analysis, information retrieval, and switching systems.[146] The University of Pennsylvania model was important because the computer science unit remained in the electrical engineering department. This model reflected the path that MIT, Harvard, and other institutions chose that focused on hardware development.

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[146] University of Pennsylvania, *University of Pennsylvania Bulletin: Graduate School of Arts and Sciences*, (Philadelphia: University of Pennsylvania, 1964-1965).

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Carnegie Mellon

Carnegie Mellon followed a path similar to other institutions and Alan Perlis served as both the Computer Center Director and Chair of the Mathematics Department from 1960 to 1964. During that time, an undergraduate programming course was available to all students. In 1962, Professor Perlis became Co-Chairman of an interdisciplinary doctoral program in Systems and Communication Sciences. This led to the establishment of an ARPA supported program in Computer Science. The Department of Computer Science was formed in July 1965 with Professor Alan J. Perlis as its head.[147] Carnegie Mellon established its program early with government funding and support. Their research reflected the ARPA goals and the trend away from primarily hardware research.

University of North Carolina

The University of North Carolina at Chapel Hill had created a computer center for their computing requirements. In 1962, the director's position was vacated. While interviewing potential candidates for that position, the search committee spoke with Frederick Brooks, Jr., a Duke University graduate, and Corporate Processor Manager for IBM. Mr. Brooks gave a lecture that inspired university leaders to consider a new academic department. A committee was formed to study the idea and in 1963 recommended the creation of a new department in the College of Arts and Sciences. This interdisciplinary committee

[147] Carnegie Mellon Archives, *Alan J. Perlis Obituary*. Computer Science Department minutes. (Pittsburg: Carnegie Mellon University. 1990).

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consisted of representatives from English, biostatistics, psychology, business administration, physics, and mathematics. They chose the name Department of Information Science for their proposed new unit. The department was officially created on 1 July 1964 with Frederick Brooks, Jr. as its part-time leader. Since IBM still required the services of Mr. Brooks, they allowed George Cramer to become the first full-time faculty member in the department.[148]

The mission of the new department was to train the teachers who would educate computer scientists. The emphasis was on research and only graduate programs. The department was authorized on 19 March 1965 to offer a master's degree with plans for a future doctoral degree. Four faculty members, some part time, taught the first two years. To begin their curriculum three courses were transferred from the mathematics department. The first masters degree was awarded in December 1966. Their early research efforts were supported by grants from IBM and from the Atomic Energy Commission.[149] The University of North Carolina department was created with a notable exception to the previous departments discussed in this chapter. Their first department chair was an industry professional and not an academician-- an unusual circumstance for a research institution. Their department chair remained an IBM employee throughout the early years of the department.

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[148] Peter Calingaert, *Growth of a Department: A Personal History of Computer Science at UNC-Chapel Hill 1962-1994* (Chapel Hill: The University of North Carolina, 1994) 4.

[149] Ibid., 5.

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University of Michigan

The Engineering Department at the University of Michigan had been involved in constructing computers since the early 1950s and the university had established a computing center in 1959. There was a group of interdisciplinary faculty who formed in 1956 and 1957 and called themselves Language Models. This group had a degree program and awarded doctoral degrees. The group was comprised of people from linguistics, philosophy, mathematics, and electrical engineering. In 1965 they formed the Communication Sciences Department with Arthur Burks as the first chairman. The department offered courses on behavioral systems and biological systems as information processors, and programming courses. Two years later, the group changed the department name to "Computer and Communication Sciences". This department offered many courses that were found in other computer science programs around the country. In 1984, they eventually merged into the engineering department.[150] This department started as an independent unit and then later merged into the engineering department. The path from independent unit to a unit under engineering was a departure from the usual path from a departmental sub-unit to an independent unit.

Stanford

Stanford had been interested in the idea of a computer science

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[150] Bernard A. Galler. Interview by Enid H. Galler, tape recording, 8, 10, 11, 16 August 1991. Charles Babbage Institute, Minneapolis.

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department and school earlier than most institutions. The report Dr. Fein was commissioned to write in 1957 was an attempt to establish the feasibility of a school of computer science at Stanford. Despite their early interest, Stanford delayed a few years in actually implementing their idea. George Forsythe was their Director of their Computer Center, a position he eventually relinquished to become the head of the new Department of Computer Science. It was not until January of 1965 that the Department of Computer Science was formed. George Forsythe was a strong advocate for computer science and defended the position that computer science was an independent discipline. Forsythe was able to recruit top researchers and graduate students. The Stanford Computer Science program quickly became one of the foremost in the nation.[151] Since the several initial computer science departments came into existence almost simultaneously, the Stanford program did not have others to use for a model. However, this program quickly became a leading model as other programs developed in later years.

The academic programs examined in this section are not a comprehensive list of all programs that were initiated in the early 1960s but are representative of the various models and issues of their time. The institutions, their funding sources, types of research they conducted, and faculty were all contributing factors to how each institution reacted to the acceptance of computer science as a discipline and

[151] Alexandria Forsythe. Interview by Pamela McCorduck., tape recording, 16 May 1979. Charles Babbage Institute, Minneapolis.

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separate academic department. The role of the government and professional organizations in this process was significant. If the driving factor for development of the first computers was military requirements during World Wars I and II, the impetus for the development of computer science programs and departments was the tremendous demand for trained professionals in this area.

By the middle sixties, computer science departments were starting up all over the country. Despite the diverse goals of the various departments, computer science programs expanded rapidly. Twenty years later, they were finally reaching the Ivy League schools. Columbia had started a computer science department and Yale had had one for quite a while. Many people who are visionaries never see their visions come to pass but in this case the early computer scientists had at least witnessed the birth of computer science.[152]

Emerging Patterns of Organizational Academic Units in Computer Science

It was inevitable that not long after departments started being formed that institutions began to focus on what category or type of computer science curricula they wished to pursue. Places that had established the first courses and had the most resources, the Moore School at the University of Pennsylvania, Harvard with its Mark I, and M.I.T., did not establish independent computer science departments. In each of these examples and others, their programs remained under the engineering department. Several institutions left them under mathematics departments and

[152] Louis Fein. Interview by Pamela McCorduck., tape recording, 9 May 1979. Charles Babbage Institute, Minneapolis.

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others eventually formed under business departments. This was the beginning of the split of academic computer programs into the groups that served particular types of interests. Entire curricula and programs formed from these initial decisions. Three distinct patterns emerged early on in the process: curricula serving business requirements, curricula focused on hardware development, and curricula focused on mathematical models and scientific problems. These groups often formed departments and programs with the common name "computer science" but very different intent and curricula.

Purdue

The Purdue computer sciences program through the late 1960s had a mix of students and faculty from engineering, science and business. The original faculty for the department included a numerical analyst, an electrical engineer, a mathematician, an industrial engineer, a specialist in theory, and a specialist in programming systems, a very diverse group. The department continued to hire faculty from these areas and in 1968 hired a faculty member in business applications. The student population reflected the same diversity as the faculty with students from the sciences, engineering, and business.

The graduate programs leading to a master's degree and a Ph.D. in Computer Sciences were the first offered. The program started with 20 courses offered by the original seven faculty members and expanded over the years. The master's program was designed to train people for industry. The Ph.D. in programming systems presented some problems noted by the department: (1) most

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of the research was in industry, not academia, (2) there were no standard research journals, and (3) there were no textbooks. Other institutions starting programs faced similar problems in these areas. The undergraduate computer sciences program evolved from a few course offerings in programming to a option within the mathematics department to a baccalaureate degree in 1967. The curriculum was modeled after the *ACM Curriculum '68* recommendations. The course work included: Calculus, Linear Algebra, Programming 1& 2, Numerical Methods, Theory, Computer Systems, Programming Languages, and Statistics. Initially, many of the courses were dual graduate/undergraduate ones. Purdue had moved quickly within a few years to create a department and develop three degree programs.[153] The Purdue program focused on training industry professionals and reflected its origins in the mathematics department.

University of North Carolina

The University of North Carolina at Chapel Hill adopted a philosophy of not focusing on training workers but training teachers who would train the workers and preparing the professional computer scientists who would lead the workers. This philosophy allowed them to maximize the program's impact on the profession. The department chose to emphasize research and graduate programs to implement their philosophy. The first degree offered was a master's degree followed shortly

[153] John R. Rice & Saul Rosen, *History of the Computer Sciences Department at Purdue University*, CSD-TR-1003 The Computer Sciences Department, August 1990, Purdue University.

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thereafter by a doctoral degree in computer science. In 1971, a computer science option in the B.S. for Mathematical Sciences was offered.[154]

The new department chose not to emphasize numerical analysis, hardware, or business data processing in their new program. The initial faculty consisted of mathematicians, programmers, and an IBM manager as the department head. Faculty members from different countries were brought in within a few years and joint appointments with other departments were common. The joint appointments were used to assist in financing faculty members for the new department. In the 1965-1966 school year there were fewer than 20 graduate students: by the 1969-1970, the number increased to over 60 graduate students.[155] This institution had made a clear commitment to computer science from the beginning and despite some financial and staffing resource problems, was able to develop a successful department that attracted graduate students within a few years. This program had a primary purpose of research and chose not to research the topics offered by other institutions.

University of Wisconsin

The University of Wisconsin computer science program defined three areas of study: the first consisted of numerical analysis and mathematical programming, the second was systems programming and theory of computation, the third was models of intelligence and natural language processing. Thirteen of the early faculty had joint appointments in mathematics, one had a joint appointment in electrical

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[154] Peter Calingaert, *Growth of a Department: A Personal History of Computer Science at UNC-Chapel Hill 1962-1994* (Chapel Hill: The University of North Carolina, 1994) 4.

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engineering, six had joint appointments to the computing center and one each had joint appointments in linguistics, theoretical chemistry, internal medicine, and English. Only two professors did not have joint appointments with another department. This was a large department offering baccalaureate, masters and doctoral degrees in computer science.[156] There was a broad perspective in the three areas that were identified for the department. This was a significant change for a department that began as a numerical analysis department.

MIT

The events at MIT were representative of other institutions that chose to keep computer science with electrical engineering departments. Harvard, MIT, and the University of Pennsylvania had been heavily involved in the efforts to produce new hardware and supply governmental requirements during the war. They had established courses early in computer hardware related areas. Their graduate programs offered cognate areas or specialty areas in computer hardware in the 1950s. When the pendulum swung from hardware to software, these institutions were hesitant to embrace that focus. In 1966, there was an effort to separate the computer science and electrical engineering curricula and the idea of a separate computer science department was raised. The curricular debates eventually led to an associate department head for computer science but the computer science unit remained under the electrical engineering department. The department cited the

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[155] Ibid., 9.

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loss of resources to both areas that would have resulted if they separated as a reason to remain one department. The situation at the University of California at Berkeley was similar to that at MIT; namely, an electrical engineering and computer science department that later combined with a separate computer science department that had grown out of the mathematics department. In the middle 1970s, the department changed its name to "Electrical Engineering and Computer Science" but remained one department.[157]

The early years of these departments reflected their struggle to establish resources and graduates for their department. There were very diverse faculties that were used to implement the programs. The curricular debates that followed resulted from departments that were established with very different goals and purposes. In addition to creating new departments and programs, these pioneers had to defend the validity of computer science as a discipline while trying to define that discipline.

Conferring of Degrees in Computer Science

Some institutions that established independent computer science units produced their first graduates within two years. This indicated that students were already preparing in that area and acted quickly to move to the new program. Course work in graduate programs was the first area established with graduate degree programs following shortly thereafter.

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[156] *Computer Science Brochure*, University of Wisconsin Archives, 1 November 1966, University of Wisconsin at Madison.

[157] K. L. Wildes, and N. A. Lindgren, *A Century of Electrical Engineering and Computer Science at MIT, 1882-1982* (Cambridge: The MIT Press, 1985) 359-361.

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Purdue

Purdue University established a computer sciences department, masters, and Ph.D. programs in 1962. The first three master's degrees in Computer Science degrees were awarded in 1964 and the first two Ph.D. degrees, in 1966. By the 1965-1966 school year there were 31 graduates with master's degrees. The master's program grew rapidly and 1968 marked the hundredth M.S. degree awarded. Two years later in 1970 the two hundredth master's degree was awarded at Purdue. The doctoral program was successful but did not grow as quickly as the master's program. The first two graduates in 1966 from the doctoral program were Karl Usow and Kenneth Brown. The following year the institution awarded five doctoral degrees. The hundredth doctoral degree was not awarded until 1982. The undergraduate program was the last of three to be established. The first Bachelor of Science degrees were awarded in 1968 and by 1973 the hundredth baccalaureate degree had been awarded. Only five years later in 1978 the five hundredth baccalaureate degree had been awarded. These numbers reflect the tremendous growth in the computer industry and demand for qualified employees.[158]

Carneigie Mellon

The course of study leading to the Ph.D. degree in computer science was accepted by the Graduate Degrees Committee of Carnegie Mellon at a meeting

[158] John R. Rice & Saul Rosen, *History of the Computer Sciences Department at Purdue University*, CSD-TR-1003 The Computer Sciences Department, August 1990, Purdue University.

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held on 11 October 1965. Computer science was a new subject and with Carnegie Mellon's early experience in administering the program a growing understanding of what subjects should be taught, organizational issues indicated the faculty would probably have to continue to modify the initial program. Letters were sent to all the students who benefited by transferring from their present department or, in the case of new graduates, from the department into which they had been accepted, informing them of the new program. In addition, Professor Perlis held a meeting in which he discussed the programs of the new department and answered questions. Twenty-four students were admitted into the Department of Computer Science in September 1965. Students transferred from the interdisciplinary systems and communication science program; twenty-two students were from the mathematics department, and two were from the electrical engineering department. The distribution of students by year was thirteen first year (entered graduate school in September 1965), nine second year and two third year. During the year, one first year student dropped out, and one other second year student transferred into the department from the systems and communication science program.[159] Carnegie Mellon was representative of the pattern of graduate students shifting from their current program to the new programs in computer science as soon as they became available. This was a

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[159] Carnegie Mellon Archives, *Information Sheet on Computer Science Department* (Pittsburg: Carnegie Mellon University).

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common occurrence at institutions and allowed them to produce graduates in computer science fairly quickly.

University of North Carolina

The University of North Carolina awarded its first master's degrees in December 1966 to Gail Woodward and in May 1967 to Hung-Ching Tao. The first doctoral degree was awarded in the 1968-1969 school year. The following school year they awarded over ten master's degrees.[160] While this was a smaller number than some of the other institutions, it established the University of North Carolina's program. The decade from 1970 to 1979 brought a decrease in emphasis on the master's degree and an increase in emphasis on the doctoral degree. The numbers of graduates in those programs reflected that change. The middle 1970s saw the number of baccalaureate degrees from the computer science option in the mathematics department increase steadily.[161] The growth of the undergraduate program in the 1970s reflected the tremendous expansion that was occurring in computer science programs in that period.

University of Wisconsin

The University of Wisconsin granted its first doctoral degree in computer science on 21 May 1965 to Sister Mary Kenneth Kleller. By the 1969-1970 school year, the number of doctoral degrees awarded increased to nineteen in

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[160] Peter Calingaert, *Growth of a Department: A Personal History of Computer Science at UNC-Chapel Hill 1962-1994* (Chapel Hill: The University of North Carolina, 1994) 30.

[161] Ibid., 30.

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computer science.[162] The numbers continued to escalate in succeeding years as the requirements for trained faculty and researchers increased faster than the universities produced them.

University of Illinois

The University of Illinois cited in a 1968 brochure an average of 150 graduate students enrolled in computer science or studying computer science as part of another discipline.[163] This description identifies the problem in tracking computer science graduates. Many of these students were actually enrolled in engineering, mathematics, or other programs. Their degree title was not always computer science even if that was the area they studied. The demand in industry for anyone trained in the computer science area prompted many students to leave before completing their degree to accept industry positions.

Professional organizations were offering examinations and certification to meet industry's requirement for qualified professionals. Universities were under pressure to put degree programs in place and address the workforce demands. Higher education was faced with a shortage of trained faculty to teach these types of programs. These issues resulted in institutions either focusing on training researchers and future faculty or meeting the industry requirements. Several institutions tried to address both issues by offering baccalaureate,

[162] "Ph.D.'s Awarded at the University of Wisconsin", [electronic file] 27 June 1997. Available from Lorene Webber at lorene@cs.wisc.edu.

[163] *The Department of Computer Science Brochure*, University of Illinois Archives, 1968, University of Illinois at Urbana-Champaign.

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masters, and doctoral programs from the beginning. The quality and content of degree programs varied from institution to institution. These issues fueled the curricular debates that followed the rapid creation of departments and programs in the early to middle 1960s.

The conferring of degrees in computer science by independent computer science units was rare. Only a few institutions offered a separate computer science program initially. However, a computer science option within an engineering or mathematics degree was more common. There were debates about the purpose of the master's degree and whether or not it should be the first professional degree. Many programs found it easier to offer the master's degree while trying to construct a research program in computer science at the doctoral level. Other institutions offered the doctoral degree first and then a master's degree. The philosophy of the program usually dictated the order in which those degree programs became available.

Conclusion

The events surrounding the creation of computer science units in the early to middle 1960s indicated the impact the computer had on society and academia. The issues that brought about independent computer science units and the diversity of these units and their approach to curricula escalated curricular debates as computer science expanded. After the initial creation of computer science units and programs, there was explosive growth in computer science and many new programs started while existing programs expanded. As computer

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hardware became more affordable and additional faculties were available, smaller institutions began to offer computer science programs at the undergraduate level. The expansion of computer science brought about specialized curricula directed at the diverse nature of computers.

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CHAPTER FOUR

COMPUTER SCIENCE GROWTH AND EXPANSION

By the middle 1960s, there had been a flurry of activity as major universities established computer science programs and departments. Each institution chose the focus of its program based on resources, history of computer developments, and perceived future requirements for computer scientists. The philosophies of these programs were as diverse as the institutions that created them.

Computer science continued to strive to establish itself as a legitimate discipline. As doctoral programs were established and research documented, a body of literature and professional journals assisted in establishing computer science as a discipline. As computer science gained acceptance, this acceptance was the impetus for other institutions to establish computer science programs.[164]

The widespread growth of computers in industry, government, and academia created a tremendous demand for employees with computer skills

[164] John R. Rice & Saul Rosen, *History of the Computer Sciences Department at Purdue University*, CSD-TR-1003 The Computer Sciences Department, August 1990, Purdue University. p. 5

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. The major universities were the first to act in creating programs to fill this requirement. The affordability of computer hardware soon spurred smaller institutions to create computer science programs as well.[165] The result was a rapid proliferation of computer science programs in the middle to late 1960s.

The initial computer science departments established at the major universities strengthened their programs and firmly established the computer science units in their academic organizations. As the early programs graduated computer scientists, other academic institutions, as well as business, employed them. As more trained computer scientists became available, smaller institutions were able to begin computer science departments and programs of their own. Undergraduate degrees in computer science became as common as graduate degrees and fulfilled industry's requirement for skilled employees.

With the increase in the number of computer science departments and programs, the variety of computer science curricula increased. The curricular debates intensified as several factions advanced their concept of computer science curricula. Graduates from computer science programs often had very different sets of skills that depended on which institution and program they attended.

The state of computer science in the middle to late 1960s was that of an evolving, rapidly growing, young discipline. The evolution of the initial computer

[165] E. G. Grady, *Computing History at Southwest Texas State University*, 1983, Southwest Texas State University.

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departments, the proliferation of new programs and departments and the computer science curricular debates were important steps in the history of computer science.

Proliferation of Academic Computer Programs

The growth of computer science programs was remarkable in the decades of the 1960s and 1970s. The essential component for the growth of these programs was the availability of resources. The price of computer hardware and shortage of skilled computer scientists had previously inhibited the growth of computer science. The 1960s witnessed the recycling of hardware to smaller institutions and the inception of computer science programs that produced the faculty required to begin new academic computer science departments. These two events began a spiral fueling the creation of more departments and programs of computer science and its derivatives and continues today.

The evolution of computer hardware began with research institutions building machines and evolved to industry mass-produced computers. The early machines were large and expensive. These computers were cost prohibitive for both industry and academic institutions. Only the larger companies and universities were able to afford computers. As smaller faster machines were developed and industry manufactured more affordable computers, machines became available to smaller institutions. As the government acquired newer more advanced computers, their existing computers became available for purchase or donation to colleges and universities. Industry also found a market for its older computers and donated or

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sold them to smaller colleges or smaller businesses. Government funded research often included funding for a computer or access to computer resources. The computers used in the defense industry for weapons guidance were passed down to smaller institutions. In 1967 for example, Southwest Texas State University acquired a Univac Athena from an old Titan I air force missile system for their program.[166] As resources became available to these institutions, courses were implemented and eventually whole programs in computer science were established.

The gradual acceptance of the new discipline fueled the growth of more programs when the larger programs were successful. Computer science courses were evident even at institutions that did not create separate academic programs and departments. In the 1970-1971 academic year, the number of institutions that granted computer-related degrees included 364 granting associate degrees, 165 granting baccalaureate degrees, 133 granting master's, degrees; and 83 granting doctoral degrees.[167] This was a dramatic increase from 1965 when there were 17 baccalaureate, 30 master's, and 15 doctoral programs in the United States.[168] The figures in the study mentioned, however, cannot be considered completely accurate. In the study, some institutions were listed twice and degree titles were

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[166] E. G. Grady, *Computing History at Southwest Texas State University*. 1983. Southwest Texas State University.

[167] John W. Hamblen, "Degree Programs in Computer Science, Data Processing, Etc. Offered by Institutions of Higher Education During 1969-70, 1970-71, and 1971-72". SIGCSE *Bulletin* 4 (July 1972), 29-39.

[168] Association Computing Machinery Curriculum Committee an Computer Science, "An Undergraduate Program in Computer Science--Preliminary Recommendations", *Communications of the ACM*, 8 September 1965, 543-552.

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cited incorrectly in computer programming and systems analysis. The fact that institutions were listed twice in the study suggested that the figures are somewhat inflated but nonetheless demonstrated the number of schools that offered programs in computer science increased substantially in only a five year period. Many, if not most, of these departments were influenced by the Association of Computing Machinery's Curriculum Committee for Computer Science Education and Curriculum.[169]

In addition to recommending computer science courses, the Association of Computing Machinery also sponsored a program in which they paid some of the expenses for a team of distinguished computer scientists to visit and consult with colleges and universities which were interested in emerging academic programs in data processing and computer science.[170] Numerous colleges and universities requested and received such a grant. During 1-3 April 1970, Dr. Adams, Chairman of the Department of Computer Science at New Mexico State University, visited Indiana University of Pennsylvania to tour the facilities and make recommendations. Dr. Adams concluded that their computer-related courses overlapped too much. He recommended that the computer science department separate from the mathematics department and suggested the

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[169] Russell M. Armstrong, "Industry's Need and Computer Science Departments", SIGCSE *Bulletin*, 4 October. 1972, 41-44.

[170] Jack Thompson, *A Proposal for the Establishment of a Department of Computer Science at Indiana University of Pennsylvania*, 1 May 1970, Indiana University of Pennsylvania.

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program in general was in a rudimentary stage of development.[171] Other institutions received similar evaluations and were influenced by the standards of the Association of Computing Machinery professional society. Their efforts resulted in more programs being established in computer science.

Carnegie Mellon was one of the institutions where programs grew rapidly and generated Ph.D's in computer science that assisted in founding other computer science programs. In 1971, there were seven or eight faculty in addition to a couple of people who left shortly afterward. In 1979, there were fifty teaching and research faculty. Essentially, the department tripled in every dimension. There was another enormous burst of growth, at least another doubling of the department in the next few years. Carnegie was described as enormous and there were faculty who hardly saw each other because of its size. In the 1970s, Carnegie was really in a Golden Age.[172] Computer science in the 1960s and 1970s did enjoy a period of rapid growth and tremendous interest that challenged the academic institutions to keep pace with the widespread interest in computers.

Evolution of the Early Academic Computer Science Units

The programs at the institutions that pioneered computer science departments established themselves, quickly evolved, and provided models for other institutions. The universities described in chapter three experienced growth

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[171] J. M. Adam "Report an the Computing Facility and the Computer Science Academic Program at Indiana State University of Pennsylvania."

[172] Joseph F. Traub, interview by William Aspray, tape recording, 29 March 1985, Charles Babbage Institute, Minneapolis.

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in their programs and established their curricula. Each of these programs was successful in its efforts to create a viable department and program. Each of these institutions developed computer science programs that reflected that institution's role with computers and the founding department's roots. These factors produced different varieties of academic programs in computer science. Examining various models sets the stage for the curricular debates that erupted in the 1960s.

University of North Carolina

At the University of North Carolina, the years from the department's inception to 1970 brought rapid growth. The average number of graduate students initially was 15 but that number quadrupled by 1970 to 63. The number of students registered in the department's classes grew from 306 initially to 1,214 in the same period. The number of faculty increased to 11 by the 1969-1970 school year. The same school year saw the first continuing education course offered by the department. The department and the program had successfully established itself by the end of the decade.[173] The University of North Carolina program, while not as large as other institutions, was significant in its mission to produce researchers and future faculty members in computer science and in its focus on research. This program was a collaboration of the mathematics, business and other departments more than a derivative of a parent department.

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[173] Peter Calingaert, *Growth of a Department: A Personal History of Computer Science at UNC-Chapel Hill 1962-1994* (Chapel Hill: The University of North Carolina, 1994) 7-8.

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Institutions that developed computer science as a sub-group of another department struggled with the decision to form a separate computer science unit.

MIT

The Massachusetts Institute of Technology (MIT) had been teaching hardware oriented courses for computers for some time and had been involved in the creation of the early machines. The institution's focus initially was hardware and the computer scientists remained under the Electrical Engineering Department. This model was visible in several other notable institutions such as Harvard and the University of Pennsylvania. After 1963-1964, Project MAC (the MIT project to investigate artificial intelligence) got going and a significant momentum grew for a formal computer science curriculum. Project MAC generated new courses and people who were able to serve as computer science faculty. The procedure employed at MIT was that faculty members designed the curriculum, returned to the laboratories at the edge of knowledge, then reconvened with new ideas taught first to graduate students and then incorporated into the curriculum. The faculty built curriculum changes, and agreed on the content and approach for core undergraduate courses. This process was an important form of communication among the electrical engineering faculty members.[174] Computer science at MIT evolved from this group of electrical engineers.

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[174] K. L. Wildes, and N. A. Lindgren, *A Century of Electrical Engineering and Computer Science at MIT, 1882-1982* (Cambridge: The MIT Press, 1985) 359.

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By the time Peter Elias relinquished the position of department head in 1966, the computer scientists had been advocating an independent curriculum, and had raised the question of a separate computer science department. At that time Elias thought that the move might benefit the computer scientists but it would not be good for the Electrical Engineering Department. A split in the department would have weakened the opportunity for each area to reinforce the other. The Visiting Committee supported his view and confirmed the split as being counterproductive. They felt that American industry needed people who had an understanding of both hardware and software.[175] The issue of a separate department for computer science resurfaced a few years later.

In 1969-1970, significant changes were made in Project MAC, and Marvin Minsky's artificial-intelligence group, which was part of MAC, became a separate artificial intelligence laboratory. The period 1966-1974, during which Louis Smullin was department head, was a tumultuous one for many reasons. The era of national political ferment, student unrest, constant growth in the department despite shrinking budgets and ceaseless arguments over the separation of computer science from electrical engineering complicated his tenure as department head. His hopes for an integrated curriculum were eventually realized as a new consensus in the department gained strength. During this time, universities across the nation were watching each other to see how the computer science issue was handled. Stanford, which unlike MIT had a very small

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[175] Ibid.

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undergraduate body in electrical engineering, but had a large graduate school, established a separate computer science department. The University of California at Berkeley, which was similar in many respects to MIT, set up an electrical engineering and computer science department. The department was combined with a separate computer science department that had grown out of the mathematics department.

In American industry, comparable battles took place between traditional science and engineering groups and computer science groups. These conflicts reflected many kinds of motives, from genuine concerns about the nature and vitality of science to opportunistic empire-building. The conflict was a clash of cultures between outward-oriented engineering that was concerned with a world described by mathematical equations, and an inward-oriented science concerned with the ways in which people perceived things and organized their knowledge, the realm of human cognition and intelligence. To some of the participants, this was a distinct shift from hardware to software. When Louis Smullin decided to step down in 1974, the new department head was Wilbur Davenport, the person all factions trusted and wanted. It was during Davenport's term as chair that the department officially became Electrical Engineering and Computer Science. While the complete separation of the computer scientists did not occur, the compromise became a change in the department title to include both computer science and electrical engineering. The first computer scientist to head the

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department was Joel Moses in 1981.[176] Other institutions had evolved their computer science programs from roots in mathematics departments and left the hardware issues to the engineering program.

Purdue

The Purdue computer science program was rooted in the mathematics department. In the 1960s, Purdue University focused its efforts on course definition, the degree programs, and, indirectly, the field itself. The 1970s brought the department's maturation and growth into a characteristic university department. The first year of the program was 1962 and seven faculty members were teaching over 20 courses. Four additional faculty members were hired in the next two years and six more were hired by the end of the decade. This more than doubled the faculty in that short time span. These faculty members brought skills in theory, numerical analysis, business systems, and programming systems. The department moved in to the new mathematical sciences building in 1967. The following year the academic computer science department separated completely from the computing center and mathematics department. The undergraduate degree evolved from an option in mathematics to a B.S. in Computer Science in 1967.[177]

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[176] Ibid, 361.

[177] John R. Rice & Saul Rosen, *History of the Computer Sciences Department at Purdue University*, CSD-TR-1003 The Computer Sciences Department, August 1990, Purdue University. p. 2-4

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At the start of the 1970s, the department was through its pioneering years. Degree programs had been established, there was a faculty of 15 and the department was fully independent. There were dozens of computer science departments that had been established at other universities. The 1970s was a decade of consolidation and maturation. There were still serious challenges; perhaps the most difficult challenge for universities was hiring faculty. By 1970, there was an increased number of computer science Ph.D.s but the supply did not begin to meet the demand. Computer science departments were established rapidly, the computing industry had expanded steadily, and several other industries (oil, aerospace, banking) began to hire significant numbers of Ph.D.'s. Throughout the decade, almost every computer science department had unfilled positions for computer science Ph.D.'s, as did most major industries.[178]

There were significant issues that faced the department at Purdue. The shortage of faculty forced a heavy reliance on graduate teaching assistants. While recognizing that this was not a desirable educational environment, the department sometimes had graduate students teaching other graduate students in the 1960s and had graduate students commonly teaching upper division undergraduate courses in the 1970s. The only alternative was not to offer the courses. The second challenge for the computer science department was establishment of their scientific respectability. Acceptance by the scientific community was a problem nationwide and the new department as well as the

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[178] Ibid. p.5

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discipline had to fight for recognition. The third challenge was the evolution of courses. Due to the rapid advances in hardware and software development, there were always courses that needed complete restructuring. The department did not have enough faculty to keep all the courses current at all times. The quality of the degree programs improved significantly as the number of courses offered increased and better textbooks became available. At the end of the decade Samuel Conte, who had chaired the department since its inception, stepped down after 17 years as head.[179] This program enjoyed success as an independent department and grew rapidly, producing a large number of computer science graduates who met the requirement for industry employment.

University of Illinois

The University of Illinois computer science program announced for the first time in its 1967 *Bulletin* that the university was offering advanced degrees in computer science. This program was broad and attempted to cover many of the areas studied in computer science in an interdisciplinary manner. The Department of Computer Science offered graduate work leading to the degrees of Master of Science and Doctor of Philosophy in Computer Science. There was opportunity for specialization in circuit design, digital computer arithmetic, switching, and automata theory, computer organization, computer applications in physical science, software systems and languages, numerical analysis, pattern recognition, and information retrieval. This was an interdisciplinary program that

[179] Ibid. p.5-6.

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had prerequisites of twenty semester hours of electrical engineering, mathematics or physics. By 1967, the department listed nine professors, three associate professors, and three assistant professors. There were nine courses for graduates and undergraduates that ranged from mathematical theory of data processing to digital computer circuit design. There were fifteen courses for graduate students. These included coding theory, advanced numerical analysis, information theory, and advance theory of digital arithmetic.[180] A University of Illinois brochure described an assessment made by The American Federation of Information Processing Societies (AFIPS) that there were more than 35,000 computers at work in the United States in 1966 and predicted there would be 85,000 by 1975.[181] The curriculum described at University of Illinois in 1967 was representative of institutions that moved from an interdisciplinary computer center to an interdisciplinary academic department. The late 1960s and early 1970s was a period of development for these new programs and a fledgling discipline. The University of Illinois, like the Purdue program, was concerned with meeting the industry demand for trained computer scientists.

University of Pennsylvania

In another interdisciplinary program, the University of Pennsylvania *Bulletin* in 1967 described their program as Computer and Information Sciences. The

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[180] University of Illinois, *University of Illinois Bulletin: Graduate College*, (Urbana: University of Illinois, 1967).

[181] University of Illinois Archives, *University of Illinois Brochure*, (Urbana: University of Illinois, 1959-1960).

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Computer and Information Sciences program was organized under its own group committee. The program was different in focus from the specialty in large-scale computers in the engineering curriculum. The CIS program permitted students with backgrounds in engineering, physical sciences, and those who had specialized in other fields related to data-processing to obtain both the M.S.E. and the Ph.D. degrees. The areas of theory of automata, data-processing systems programming, switching theory, numerical analysis for computers, and information retrieval were included in this program. In 1959, an increasing need for an integrated program in the scientific foundations of the field had been identified and this program was instituted as a solution. Members of the faculties of Electrical Engineering, Industry, Linguistics, Mathematics, Philosophy and Psychology participated in the CIS program. The Ph.D. was granted under the supervision of the graduate group in Electrical Engineering. The CIS curriculum was intended for students with undergraduate training in any one of a broad range of disciplines, and was distinct from the long-standing electrical engineering program with specialization in the engineering of digital computers.[182] The University of Pennsylvania program attempted to span all areas from engineering to business that were computer science related but like the program at MIT remained significantly attached to the electrical engineering department.

[182] University of Pennsylvania, *University of Pennsylvania Bulletin: Graduate Studies*, (Philadelphia: University of Pennsylvania, 1966-1967).

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These computer science programs are distinct from each other in focus and organization yet all were concerned with genuine computer science topics. These differences in the way the programs evolved led to curricular debates for both the institutions and the new discipline. The breadth of topics and areas served by computers resulted in distinct curricula that formed around specific areas of computer science.

Curricular Debates: Round Two

As computer science programs formed around the country, it was apparent that there were different objectives and graduates from computer science programs did not necessarily have the same skills or backgrounds. These differences led to contentious debates over what comprised a computer science curriculum. The programs residing in electrical engineering departments did not resemble those that began in mathematics departments. Universities concerned with meeting the industry requirements for computer science graduates approached curricular issues differently from institutions whose priority was research and producing computer science faculty. All of these factors influenced the curricular debates. The challenge of defining a new discipline was intertwined with the curricular debates.

Prior to college programs in computer science, people learned the necessary technical skills several ways. The most popular method for learning computer skills was on-the-job experience. Other methods included training classes run by the company or computer manufacturers, private technical schools; and military training in computer occupations. By the 1960s, the

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demand for programmers and the expense of training people became too high for corporations. By having universities train a greater number of people to be competent employees, the supply of labor was able to partially meet the demand which enabled industry to lower employees' real wages and greatly reduce their cost of training new employees.

As industry's demand for more highly trained computer professionals increased in the middle to late 1960s, its push for more university-trained personnel also increased. The Association of Computing Machinery Curriculum Committee's 1965 report contained only preliminary recommendations for computer science programs. In March, 1968, the Committee published a second report which made much more detailed recommendations for academic programs in computer science. Computer Science was not the only title for computer-related programs, others included: "Data Processing," 'Information Science," "Computer Programming" etc. Because these were merely other names for essentially the same discipline, the ACM Curriculum Committee decided to call it "Computer Science," and "Computer Science" was the most widely accepted title.[183]

In 1965, the members of the Committee were guests of IBM at Poughkeepsie and their report was reviewed by several computer scientists. However, it is impossible to know how influential the business community was in

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[183] Association of Computing Machinery Curriculum Committee on Computer Science. "Curriculum 68: Recommendations for Academic Programs in Computer Science". *Communications of the ACM*, 11 March 1968, 151-197.

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drawing its conclusions. The 1968 report was clearer in this regard. The core of the 1968 Committee was composed of essentially the same people as in 1965 but unlike 1965, the 1968 consultants and contributors to the committee and their professional or business affiliations were listed. Of the 64 consultants listed, eleven (sixteen percent) were from private corporations. The corporations and the number of people from each of them included: General Electric, 2; Bell Telephone Laboratories, 3; IBM, 2; Radio Corporation of America, 1; Midwest Oil Corporation, 1; Auerbach Corporation, 1; and J. P. Stevens and Company, 1.[184] The remaining consultants were from universities. However, merely because the vast majority of people who were consulted by the Committee were from academia, does not mean they were not associated with private corporations. There are at least two instances of such a link. Jack Minker, a contributor, was listed as being with the University of Maryland and the Auerbach Corporation. David C. Evans, a consultant, was listed as being from the University of Utah. There is a strong possibility some of the people who were listed as being exclusively with universities were also consultants to private corporations. Once again, the degree of influence industry had over the Committee is impossible to know, but based on the consultants' and contributors' links to corporations, one can argue it had at least some influence.

The ACM "Curriculum 68" report was much more specific in its recommendations for undergraduate programs than the 1965 article from which it

[184] Ibid.

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evolved. Like the earlier article, a major purpose of the Committee's recommendations on undergraduate programs was to provide a sense of direction and a realizable set of goals for those colleges and universities which plan to provide computer science education for undergraduate and/or graduate students. Another purpose was to help alleviate the demand for substantially increased numbers of persons to work in all areas of computing. However, although programs based on the recommendations of the Curriculum Committee contributed substantially to satisfying this demand, the programs did not cover the full breadth of the need for personnel.[185] Clearly, the purpose of the proposed programs was to increase the supply of labor for industry.

While the "Curriculum 68" article made reference to master's and doctoral programs, by far most of its emphasis was on undergraduates. The appendix contained recommendations on: (1) a suggested approach to teaching each of the courses; (2) a detailed outline of the courses, content; (3), a bibliography for each course; and (4) suggestions about the amount of time which should be devoted to the different topics in each of the courses. In total, the ACM committee recommended 22 courses. The Committee fully expected that each individual school would modify these recommendations to meet its specific circumstances, but it hoped that these modifications would be expansions of or

[185] Ibid.

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changes in the emphasis of the basic program proposed, rather than reductions in quantity or quality.[186]

A serious challenge and common problem for all computer science departments was to establish their scientific respectability. Many science and engineering faculty based their knowledge of computing on their contact with FORTRAN programming, and they assumed that was all there was to computer science. This limited notion of computer science was analogous to believing that mathematics consisted of arithmetic using really big numbers, or physics consisted of analyzing structures with a large quantity of levers and pulleys. Even top rated computer science programs had to reaffirm continually their permanence and value to other parts of the university. While there were still residual feelings, by the end of the 1970s numerous university administrators and faculty believed computer science was a serious scientific discipline that was here to stay.[187]

In addition to contending with defending the new discipline, the computer scientists debated how to define computer science curricula. These differences in some instances delayed the growth of computer science at institutions. At Berkeley, there were two departments, and two departments were occasionally worse than none. There was a bitter battle between Abe Taub and Lotfi Zadeh. Abe Taub was a mathematician recruited from Illinois to head the computer center and to build a

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[186] Ibid.

[187] John R. Rice & Saul Rosen, *History of the Computer Sciences Department at Purdue University*, CSD-TR-1003 The Computer Sciences Department, August 1990. Purdue University.p.6.

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computer science department in the School of Letters and Sciences. Lotfi Zadeh was the head of the electrical engineering unit but had people working in computer science. In the late 1960s, the country watched while this bitter battle was waged at Berkeley between the two departments. Engineering persevered over Letters and Science, and eventually there was an Electrical Engineering and Computer Science Department of great distinction, with a computer science unit. Zadeh was the winner, certainly, in the battle of getting Berkeley to form one department, and that became a department of great distinction.[188] These disputes often centered around curricular debates over courses on hardware versus an emphasis on software. Several other institutions experienced similar debates within their programs.

In some instances, these debates were the impetus for a new department to be formed. Several years later than Berkeley, the computer science department at Columbia formed from an interdisciplinary group of faculty. Yet the debates were still continuing; Joseph Traub made these comments on the Columbia program, "There was some rather bad blood between the two efforts, Electrical Engineering and Computer Science, and Mathematical Statistics. I inherited the faculty from those two departments and formed a new department."[189] The Columbia program resulted in a very successful computer science unit and computer science prospered, and electrical engineering boomed. There were advantages to being joined to an electrical engineering department. One of the major thrusts of computer science

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188 Joseph F. Traub, interview by William Aspray, tape recording, 29 march 1985, Charles Babbage Institute, Minneapolis.

189 Ibid.

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was intimately connected with computer engineering through the development of integrated systems, software put into hardware. The model used at MIT was thought to encompass the field in the department of Electrical Engineering. Opposing individuals believed that this risked the field being dominated by hardware. Hardware made great strides but still many of the unsolved problems and many of the interesting problems dealt with a variety of these applications. These programs felt their success came from not focusing on the engineering curriculum.

The Stanford computer science program originated in the mathematics program, not in engineering. The advantage of Stanford's program growing out of a mathematical department orientation was their focus on fairly rigorous theoretical problems that were recognized as rigorous problems. The Stanford program sought to establish credibilty for the computer science program and followed the model of traditional science disciplines as opposed to that of an engineering or applied discipline.[190]

The interdisciplinary view was to foster the kind of cooperation between the theoreticians and the computer scientists and the engineers by putting them all in one department. Several programs tried that approach but it was not successful in all institutions. The discussions on theoretical versus applied science and hardware versus software approaches were often unresolved. A factor in these discussions was the unwillingness of many faculty to allow new faculty with different ideas to be added to their departments. Faculty who felt they were protecting theoretical

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disciplines did not want applied computer scientists as colleagues. The Stanford computer science department became a separate unit partially due to the resistance of the mathematicians to hiring non-mathematical but legitimate computer science faculty.[191] It was difficult to get consensus on a curriculum with the variation in the composition of computer science units.

The focus of the programs, some on research and others on producing industry employees, also impacted faculty views on curriculum. The situation at Carnegie Mellon was an example of how different their focus was from some of the applied engineering perspectives. The faculty at Carnegie did not focus on curriculum. They felt that the students entering the program knew how to get A's in their courses. These students had accomplished that in high school and college. Carnegie's approach was that students entered an apprenticeship in research in their program. They sought to teach them how to research, and taught them to do research by having them work with a master. Courses were de-emphasized and students did not have to take any courses. The students had to pass a set of qualifying comprehensive exams that checked their breadth of knowledge in computer science and they had to write a major thesis. Curriculum was not the program's strong point. Distinguished visiting computer scientists from other institutions visited Carnegie in the 1970s and expressed some concern about the fact that the curriculum was weak. Typically, the incoming Ph.D. students might take

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[190] *William Miller, interview by Pamela McCorduck, tape recording, 22 May 1979, Charles Babbage Institute.*

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courses the first year but after that it was all seminars and there were no courses in greater depth. Yet, later one of the reasons other institutions got so strong was that they were hiring the products of the Carnegie program, who became enormously desirable to the faculty that had criticized the lack of curriculum. Carnegie's focus was not on curriculum but on research at the Ph.D. level. The major research area in computer science at Carnegie was that of artificial intelligence subject-area, with Newell, Simon, and Reddy as the leaders in architecture and software.[192]

Computer science and computer engineering brought very different views to curriculum and the applied versus theoretical debates continued into the 1970s. At the 1977 IEEE conference, the debate was continuing. Over the decade a difficult and sometimes violent struggle among professional societies, academicians, and those in industry made the development of model curricula that meshed computer science and computer contentious. There existed considerable concern among educators, individuals involved with the computer industry, and the students to whom such curricula were directed, that much needed to be done to provide cohesive computer science and engineering programs at colleges and universities, and even the junior or community college levels. [193]

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[191] Albert Bowker, interview by Pamela McCorduck, tape recording, 21 May 1979, Charles Babbage Institute, Minneapolis.

[192] Joseph F. Traub, interview by William Aspray, tape recording, 29 March 1985, Charles Babbage Institute, Minneapolis.

[193] Michael C. Mulder, *Current and Future Trend in the Development of Computer Science and Engineering Curricula,* Proceedings of the Computer Science and Engineering Curricula Workshop, 6 June 1977, IEEE Computer Society, Willamsburg, Virginia

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Conclusion

After the initial establishment of the academic programs, they propagated rapidly and became distinct in character. The advancement of the new discipline progressed with the expanding computer science departments. The growing pains of both the new discipline and the new academic departments were evident in the curricular diversity and debates of that time. The varied roots of computer science had spawned disparate computer science curricula. These curricular debates led to the formation of different foci or specialties within computer science that served different interests. These various models are grouped in this paper as computer science patterns of organization in engineering, business, mathematics, and hybrid models. Chapter five examines these models and compares their computer science features and roots.

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CHAPTER FIVE

PATTERNS OF ORGANIZATION IN COMPUTER SCIENCE ACADEMIC UNITS

Institutional roots and funding sources were factors in the organization and missions of academic computer science units. The academic units reflected the interests of their faculties and focus of their universities. The computer science units that had been early contributors to the development of the initial hardware breakthroughs tended to continue to have a hardware or engineering focus to their computer science units or housed the computer science units within the engineering department.

The computer science units that centered on producing graduates for industry and business tended to focus more on the industry requirements in their curricula even if they also had research functions. These institutions usually graduated more students and were typically state institutions.

Other computer science units pursued more theoretical problems and solved mathematical puzzles in scientific computing. These units primarily focused on software and not on hardware issues. The purpose of these computer science programs was not to produce employees trained for industry. They valued a curriculum with more accepted scientific methods and research. Numerous academic units began as a hybrid of different models and eventually

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found their focus in computer science. Although there were many unique units, three major patterns of organization emerged from the initial computer science units. These patterns were engineering, mathematical, and business focused curricula.

Computer science exhibited a dynamic degree of change over the previous twenty-five years, change that was reflected in several sources of historical information. Computer science units that focused on the labor market attempted to insure that their graduates had the required industry skills. The data on computer science students in the workforce did not indicate that students moved directly from college degrees in technical fields to the work force. In computer science fields, the industry job titles did not always have the same job descriptions from company to company. This made it difficult to collect and interpret data on computer science graduates in the workforce. Observers of economics and technology have observed that the computer has changed the infrastructure of work itself.[194] The impact of the computer went beyond the workplace to our entire society.[195] The prevalence of particular models was evident at different points in time. Examining data on college students majoring in computer science areas reflected change from the early dominance of computer engineering to other models as the discipline matured.

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[194] J. R. Beniger, *The Control Revolution: Technological and Economic Origins of the Information Society* (Cambridge, MA: Harvard University Press, 1986).

[195] A. Pacey, *The Culture of Technology* (Cambridge, MA: MIT Press, 1983).

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Students educated in the algorithmic bases, logic design, operating systems, and numerical analytic methods of technology were at the core of these broad changes. Unlike professional fields such as medicine, nursing, or law, computer science presented distinct problems for workplace analysis. There was a common understanding of the job description for a doctor or lawyer but computer-related professionals were subsumed under the larger category of information technology. The varieties of job titles reflected the reality of the computer's far reaching impact on diverse industries. They described what people did in a society where information technology permeated the daily work life, and where computing applications themselves existed in a changing mixture of communications technologies.

Instruction in computer science from the 1960s and to the early 1980s was influenced heavily by the engineering profession. This was natural because many upper-division courses in the field were housed in engineering schools or where computer science was taught outside mathematics departments. The engineering schools provided the administrative functions in many cases and the requirements for program accreditation in the engineering model curricula usually followed American Board of Engineering and Technology accreditation guidelines.[196]

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[196] A. B. Tucker, et al., *Computing Curricula 1991: Report of the ACM/IEEE-CS Joint Curriculum Task Force*, (New York: Association for Computing Machinery, 1991).

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In the absence of formal quality assurance mechanisms, what happened in the field of computer science was the emergence of entry level courses designed to filter out unqualified students early in the curriculum. The establishment of these "filtering courses" in any field was an important step in the evolution of an academic canon.[197] The entrance course or courses were middle-level and focused on the major tools and theory required for advanced students. The courses often served the additional function of sorting students. These courses occurred at a point in students' education, when they typically decided to choose an area of specialization. They were placed at a level of complexity and demand to test the students' ability to succeed in the computer science field.

By the mid-1980s, a pattern of mid-level courses in computer science had emerged for the purpose of filtering potential computer scientists. The evidence was empirical and informal with mid-level enrollment volume used in the cross-sectional surveys of departments conducted by the Conference Board of Mathematical Sciences. This source indicated that the courses and their national enrollments were as follows: (1) Assembly Language Programming, twenty-four thousand, (2) Data Structures, twenty-four thousand, (3) Introduction to Computer Systems, eighteen thousand, and (4) Introduction to Computer Organization, fourteen thousand.[198] The consensus among computer science units with a

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[197] M. Mueller, "Yellow Stripes and Dead Armadillos" in P. Franklin(ed.), *Profession*. (New York: The Modern Language Association, 1989).

[198] D. J. Albers, D.O. Loftsgaarden, & R. D. Anderson, *Undergraduate Programs in the Mathematical and Computer Sciences: the 1985-1986 Survey*. (Washington D.C.: Mathematical Association of America).

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mathematical model was that these courses were necessary for computer science majors. These were different courses from the engineering model.

There was a perceptible decline in the influence of engineering on the shaping of the pool of people who majored in computer science. The college courses taken by two groups of high school students were tracked and indicated that the enrollment in engineering courses declined over a decade. For students who graduated from high school in 1972, three of the top twenty-five courses resided in engineering departments. For students who graduated from high school in 1982, only one course, computer engineering, remained in the top twenty-five courses. That course category (computer engineering) dropped from 2.5 percent of total undergraduate time to 1.1 percent. The amount of time students spent in engineering computer courses declined as software design and business computing increased their influence in computer science.

As the influence of engineering on computer science declined, the position of mathematics held steady. The mathematics requirements for business degrees rose during the 1980s to a minimum of college algebra[199] and the business and computer science curricula penetrated each other. Some students who started out in business satisfied the mathematics requirement in business, and then switched over to computer science, where discrete mathematics was the underlying standard.

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[199] American Assembly of Collegiate Schools of Business, *Standards for Business and Accounting Accreditation*. St. Louis, MO, 1991.

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When examining the evolution of graduate programs in computer science between 1984 and 1993, three major trends were evident. First, there were strong established entrance and graduation requirements at the doctoral level. The number of Ph.D. programs increased by forty percent, and the proportion of those programs requiring an undergraduate degree in computer science grew from eleven percent to seventeen percent. At the same time, the number of masters' programs rose more slowly, only by eighteen percent, with the proportion requiring an undergraduate degree in computer science declining from seventeen percent to thirteen percent. The proportion of prospective computer science graduate students with an undergraduate degree in the field doubled to nearly sixty percent between 1978 and 1987.[200] This reflected the increased number of institutions offering computer science or related baccalaureate degrees. The demand for skilled employees in the workplace had spurred the growth in these undergraduate programs and increased the number of students with undergraduate degrees in computer science. These students were also potential graduate students. The master's degree focused on supplying the workforce and admitted both students with computer science undergraduate degrees and those from other disciplines. Many of the students with baccalaureate degrees in computer science went directly to the workforce now

[200] J. Grandy & N. Robertson, *Change in Field of Study from Undergraduate to Graduate School,* (Princeton, NJ: Educational Testing Service, 1992) GREB. No. 86-12P.

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without a master's degree. This forced the master's programs to admit students from varying undergraduate backgrounds to keep their programs alive.

The second trend was that the number of doctoral programs that offered degrees in more than one field of computer science declined. The average number of fields declined in the programs. This was a time and environment in which specialization was an indicator of organizational status[201] and in which competing graduate programs marketed themselves by subdivision. On a continuum, computer-related degrees at the bachelors level, ranged from hardware oriented (computer engineering) through software oriented (computer science and information science/systems) to management oriented (management of information systems) subfields. [202] The doctoral programs moved toward the center in computing, an indication of focus on research in the core underlying field. At this stage in the evolution of computer science, the outlines of a clear pyramid emerged. Th baccalaureate degree established the foundations in computer science education. The master's degree became a professional degree with research and interpretation reserved for doctoral degrees. The doctoral programs moved to admit students with undergraduate degrees in computer science that had a common foundation and allowed them to move directly into these research programs.

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[201] R. K. Bresser, "The context of University Departments: Differences Between Fields of Higher and Lower Levels of paradigm Development" *Research in Higher Education,* vol. 39, no.1. p. 38-44.

[202] A. J. Turner, "U.S. Degree Programs in Computing", *Computing Professionals: Changing Needs for the 1990s.* (Washington, DC: National Research Council, 1993).

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The third trend was the establishment of a clear distinction between the scholarly and instructional canons. The major degree changes at the Ph.D. and master's levels included declines in programs in computer programming, systems analysis, and data processing, and the opening of programs in microcomputer applications and 'other' fields, usually interdisciplinary. These changes were another sign of a maturing discipline that had developed stronger first level degrees in core subfields, had established its basic principles through earlier research, and moved these principles into the undergraduate classroom. The master's programs also served to explore and establish advanced methodologies in the software oriented and management oriented portions of computer and information sciences.[203] The evolution from engineering dominance of computer science programs to mathematical and business programs and eventually to hybrid programs reflected the changes in the technology that have occurred over the last fifty years.

The Computing Research Association was a body that was established in 1972 to facilitate communication among academic and industry personnel engaged research in the computer science field. The surveys of degree recipients conducted by them indicated only two categories, computer science and computer engineering, and one hundred ten of the one hundred forty nine

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[203] G. L. Eerkes, "Computer Science Master's Programs". *Communications of the Association of Computing Machinery*, vol.34, no. 1.

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departments surveyed in 1992-1993 were entitled simply "computer sciences" or "computing sciences."[204]

Engineering Education Pattern in Computer Science Units

The University of Pennsylvania was one of the primary universities involved in the development of computer hardware. Its courses and program are characteristic of the engineering influence in computers. In the late 1950s, graduate course work in electrical engineering already included computers. Courses such as "627, Digital Computers--Logic", "629, Digital Computer Solution of Engineering Principles", and "628, Digital Computers--Engineering Principles" are included in the graduate course offerings. Even in the engineering programs the impact of software and computers in business was recognized. Courses also included "634, Applications of Large-Scale Digital Computers in Business and Industrial Systems" and "667, Linear Programming and an Introduction to the Theory of Games" but were not part of the required program

The faculty included Adolph Matz, Ph.D., special lecturer on the application of large computers in business and industry; associate professor of accounting in the Wharton School of Business and Saul Rosen, Ph.D., special lecturer who taught computer courses. The *Bulletin* described the Master of

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[204] Computing Research Association, "1994 Taulbee Survey", *Computing Research News,* vol. 7, no. 2.

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Science in Electrical Engineering that allowed specialization in four specific areas including an emphasis on large-scale computing. [205]

In 1959-1960, the courses also included "543, Introduction to Digital Computer Systems" and most of the faculty was involved in teaching a computer course as part of their teaching load. Saul Gorn, Ph.D., associate professor of electrical engineering, was listed as the Director of the Computing Center. In this case, the computing center was managed by a faculty member directly affiliated with a specific department.[206]

In the 1960-1961, the Moore School *Annual Report* cites "a change in electrical engineering education ...centers around computers, and the objective is to break away from the modest problems which can be solved by hand, and to attempt to have students think in terms of much larger problems which require the use of machines for specific answers." [207] In the Spring of 1961, The Moore School obtained an RPC 4000, which was a medium-sized versatile computer intended primarily for educational purposes and one of their faculty, Dr. Rubinoff, was chairman of the National Joint Computer Conference. This conference was a national body coordinating the efforts of many technical societies interested in the computer field. Lecture series No. 2 on computer fundamentals was given on

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[205] University of Pennsylvania, *University of Pennsylvania Bulletin: Graduate School of Arts and Sciences* (Philadelphia: University of Pennsylvania, 1958-1959).

[206] University of Pennsylvania, *University of Pennsylvania Bulletin: Graduate School of Arts and Sciences* (Philadelphia: University of Pennsylvania, 1959-1960).

[207] University of Pennsylvania, *Annual report: The Moore School of Electrical Engineering* (Philadelphia: University of Pennsylvania, 1960-1961).

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campus and the "626, Continuous-Variable Computers" was listed on the program requirements. The faculty teaching computer courses continued to increase and included Grace Hopper as a special lecturer.[208]

Several new courses are listed in 1961-1962 including "634, Applications of Large-Scale Digital Computers in Business and Industrial Systems" taught by Matz , Woods, Hopper, "674, Formal Mechanical Languages," Programming languages, and "676, Numerical Analysis for Computers I". These courses indicated an expansion to include software and numerical analysis to the program. The computing center continued to be managed by Dr. Gorn who taught many of the new courses that were added in this year. Smabt Abian, Ph.D., special lecturer in the Moore School and assistant professor of mathematics and Richard S. Woods, Ph.D., special lecturer in the Moore School and associate professor of accounting in the Wharton School are listed on the faculty that year supporting the new courses.[209] Even though this was an engineering unit the faculty teaching courses represented mathematics and business disciplines. This reflected the growth of the computer outside of academe as a business tool. The hardware-dominated field was changing and the engineering units recognized the growth and change in the discipline toward business and scientific software development.

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[208] University of Pennsylvania, *University of Pennsylvania Bulletin: Graduate School of Arts and Sciences* (Philadelphia: University of Pennsylvania, 1960-1961).

[209] University of Pennsylvania, *University of Pennsylvania Bulletin: Graduate School of Arts and Sciences* (Philadelphia: University of Pennsylvania, 1961-1962).

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The 1962-1963 *Annual Report* cited "Professor Gray's development (with Dr. Prywes) of the Multilist Organization for Computer Memory has this year shown result in its application to one of the biggest inventory systems in the world, with very satisfying accomplishment. On the other hand, Dr. Gray's new book on computer engineering stands good chance of being a pace-setter for some years to come". Inventory systems in the future were more commonly addressed by business computing units than engineering units. In the early years of these units the specialization in computer fields were still being formed and there was diversity in the curricula. The report also noted meetings held on "current topics in design and application of digital computers" and included under heading symposia was usual monthly series on automatic computers and their capabilities.[210] The course "648, Seminar on Computers and Computer Complexes" was included in the course offerings. The *Bulletin* indicated a specialization in Computer and Information Sciences was now available in addition to the emphasis on large-scale computing devices.[211]

The *Annual Report* in 1963-1964 mentioned, "In the computer field: logic machines, coding, automata, mechanical languages, extension of the multi-list memory system (a major advance originating in the Moore school), problem solving, self-organizing systems, information retrieval." The report also noted

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[210] University of Pennsylvania, *Annual Report: The Moore School of Electrical Engineering* (Philadelphia: University of Pennsylvania, 1962-1963).

[211] University of Pennsylvania, *University of Pennsylvania Bulletin: Graduate School of Arts and Sciences*, (Philadelphia: University of Pennsylvania, 1962-1963).

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"major appointments to the faculty include Dr. John Carr III, former president of ACM--the largest professional society devoted to large-scale computers in all their aspects, and David B. Smith, formerly a vice-president for research and engineering of the Philco Corporation."[212] The next year brought major changes as the university initiated a new master's degree. The impact of the computer on business was evident with the changes made in the program that year. The new faculty cited represented these influences. This program began producing machines for weapons systems and calculations and now included a business focus.

The 1964-1965 *Annual Report* stated "Computer and Information Science faculty group authorized for the master's degree and will in the normal course of events evolve to include academic supervision of work toward a doctorate." This report recognized that computer information systems were evolving into a separate discipline. There were twenty graduate courses offered and the computer information systems group was formed within the electrical engineering unit with Dr. John Carr III as its chair.[213] While recognizing that a new field had formed, the academic unit remained housed in the engineering department. The *Bulletin* described the computer and information sciences program (CIS) as guided by an interdepartmental committee under the aegis of the group

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[212] University of Pennsylvania, *University of Pennsylvania Bulletin: Graduate School of Arts and Sciences,* (Philadelphia: University of Pennsylvania, 1963-1964).

[213] University of Pennsylvania, *Annual Report: The Moore School of Electrical Engineering* (Philadelphia: University of Pennsylvania, 1964-1965).

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committee in electrical engineering. This program was of broader scope than the specialty in large-scale computers outlined previously. It permitted both those with backgrounds in physical science and those who have specialized in other fields related to modern data processing to obtain both the M.S.E. and the Ph.D. degree in the areas of theory of automata, data-processing systems, programming, and switching theory.[214] The expansion of the electrical engineering scope to include computer science included further developments the next year.

In the 1965-1966 academic year, new courses in the application of computers to business and medical problems were developed. New courses for the graduate degree included "634, Applications of Digital Computers in Business and Industrial Systems" and was taught by Hopper and Di Roccaferrera, "640, Theory of Automata", "648, Seminar on Computers and Computer Complexes", and "673, Seminar on Information Retrieval".[215] These courses reflect the widespread use of computers in business and medicine. Dr. Hopper produced significant contributions in adapting computers for business use and it was reflected in her teaching in this program.

The 1965-1966 academic year the *Bulletin* described information systems as different in scope from that of the specialty in large-scale computers. A curriculum, leading to both the master's and doctor's degrees, was a outgrowth of

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[214] University of Pennsylvania, *University of Pennsylvania Bulletin: Graduate School of Arts and Sciences*, (Philadelphia: University of Pennsylvania, 1964-1965).

[215] University of Pennsylvania, *University of Pennsylvania Bulletin: Graduate School of Arts and Sciences*, (Philadelphia: University of Pennsylvania, 1964-1965).

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the contributions by the University of Pennsylvania in the development and use of large-scale electronic computers.[216] At this point the curricula had been defined and separated but the unit remained under the control of the engineering department. The changes in this department over the early 1960s when computer science units were formed reflected the development of other units that originated in engineering departments.

The engineering units represented the birth of early computer science. The evolution of courses directly related to hardware, faculty that managed the computing centers, and a curricula that moved to embrace the initiatives in software and business mirrored the changes that the discipline was experiencing in the middle to late 1960s. The large number of computer science units housed in engineering departments in the 1960s allowed these units to heavily influence computer science through that decade. As the use of computers expanded new specialization in computers influenced academic units.

Business Education Pattern in Computer Science Units

The major universities that formed computer science departments primarily developed them from the engineering or mathematics units. While they recognized that there were business and administrative requirements for computing, academia addressed this on a smaller scale, usually incorporating courses into their programs to assist with these requirements. Industry leaders

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[216] University of Pennsylvania, *University of Pennsylvania Bulletin: Graduate School of Arts and Sciences,* (Philadelphia: University of Pennsylvania, 1965-1966).

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such as IBM assisted the business community with their computing requirements and contributed to universities that offered business related programming courses.

In time, the computer influenced business management so heavily that the formation of Management Information Systems (MIS) programs became popular in university schools of business. By 1969, business data processing constituted over half of the use of computers measured by the number of machines, machine time, dollars spent, or people.[217] The increase in business requirements resulted in additional academic programs being developed at many institutions. These programs joined the earlier programs developed in mathematics and engineering departments. Computer oriented degree programs were broken down by category in the 1964-65 proceedings of an Electrical Engineering Commission on Engineering Education. The report indicated six programs were business data processing, thirteen were computer science, and five were an option in engineering, seven were options in mathematics, and ten were miscellaneous options at the bachelor's degree level.[218] Business was clearly a stakeholder in computer education. Prior to the rise of MIS, the smaller institutions typically designed programs to meet the business requirements for employees trained in computers. As early as the late 1960s and early 1970s, two-year programs were

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[217] Fred Gruenberger, "A Minority Report About the Majority Problem", NSF *Conference on* Computer Science Education 24 July 1969, 70.

[218] Commission on Engineering Education of the National Academy of Engineering, Proceedings of the Meeting on Computer Science in Electrical Engineering of the Commission on Engineering Education, 24-25 October 1968, 6.

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established at regional campuses and smaller colleges. A 1966-67 NSF funded study compared computer science degree programs to data processing degree programs. It identified 122 associate degree programs in data processing and seven associate degree programs in computer science. There were 11 bachelors' degree programs in data processing and 30 in computer science. Data processing listed four masters and one doctoral program. Computer science indicated 37 master's and 22 doctoral programs.[219] The smaller associate degree programs were better able to quickly produce students that had the skills required for business computing.

An example of this type of program was Purdue Unniversity Calumet a regional campus that established a two-year computer technology program. While the faculty at the main Purdue campus chose to focus initially on computer science with more of a mathematical approach, the regional campus attempted to meet the local business requirements for applied skills with computers. The curriculum was designed to prepare students to perform the functions of analyzing problems initially presented by a systems analyst with respect to the type and extent of commercial data to be processed, the method of processing to be employed, and the format and extent of the results. The program was developed in cooperation with the division of vocational education, Indiana Department of Public Instruction and had two options commercial and technical.

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[219] John W. Hamblen, "Computer Science and Related Degree Programs in U.S. Higher Education", Computer Sciences Southern Regional Education Board.

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There were twelve computer technology courses that were required and primarily addressed business programming requirements.[220]

By the 1974-1975 *Bulletin*, a baccalaureate program had been added to the two-year associate degree program. The program built on the knowledge of computer programming acquired in the first two years and emphasized the practical aspects of computer systems design and commercial systems analysis. The inclusion of elective courses allowed the students to pursue special interest areas. There were four areas of concentrations that included commercial systems, computer systems analysis, systems programming, and technical systems. All students were required to take Assembly, RPG, and COBOL programming languages in the first two years of the program.[221] Other courses included computer mathematics and computer operating systems. The focus of these types of programs was primarily to teach the business programming languages to students seeking employment writing business applications. The Purdue main campus included computer science, computer engineering, and computer technology. The growth of two-year and four-year programs in smaller institutions was significant in the 1970s. The smaller programs designed to produce business programmers increased very rapidly and eventually formed a new specialty in management information systems. The decade of the 1970s

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[220] Purdue University , *Purdue University Bulletin Calumet Campus*, (West Lafayette: Purdue University, 1969-1970).

[221] Purdue University , *Purdue University Bulletin Calumet Campus*, (West Lafayette: Purdue University, 1974-1975).

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witnessed business embracing computers as the price of hardware and software became more affordable. These industries required a large number of skilled workers and academia responded with these types of programs. Many institutions trained faculty from other related disciplines and developed courses to meet the business demand. The curricula at institutions offering these programs were very diverse and often not clearly defined

This dependence on computers and the volume of information produced by computers led to the development of the specialty area that became management information systems. As business computing diversified from computer science, it began to create its own canon and establish itself as a new discipline. Computer science had specialized enough to generate a new discipline. The first business analysts were born out of the industrial age. They were not concerned with computers or computer-based systems but were industrial engineers whose responsibilities centered on the design of an effective manufacturing system. Management information systems analysts evolved from the need to manage the computer resources including information processing and business applications.[222] Computers were expensive resources and proper management of these resources within a business became a specialty area.

An example of a computer science program with a clear business focus from its inception was the program at Indiana University of Pennsylvania. In July 1970, the university took its first steps toward computer science by renaming

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math and business management courses as computer science courses. In October 1970 the Board of Trustees approved the establishment of a computer science department.[223] According to Dr. Tompkins, the first chairman of the computer science department, the program had an applied computer science mission and the purpose was to train people to work in industry. The program rejected the ACM curricular recommendation because it was too science oriented.[224] While the department had a computer science title, the focus was clearly business applications.

The term 'management information systems' or MIS first appeared by the end of the 1960s and the first academic MIS programs were in place shortly thereafter. In their third decade of existence, these departments and the evolving MIS discipline rapidly incorporated changing technologies and attracted a diverse collection of professionals. These professionals' expertise spanned several disciplines. Early MIS academicians were drawn from a wide array of disciplines that ranged from the liberal arts to the sciences. Although current MIS faculties continue to display academic diversity, they have become more homogenous. As MIS programs have matured, they have evolved into distinct departments and increased numbers of faculty have degrees in MIS. Prior to 1980, approximately two of three MIS faculty had degrees from fields other than MIS. During the

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,[222] Jeffrey L. Whitten, Lonnie D. Bentley, and Victor M. Barlow, *Systems Analysis & Design Methods* (Boston: Irwin Publishers Inc., 1994) 8.

[223] Indiana University of Pennsylvania, Minutes of the Board of Trustees, 16 October, 1970, Pennsylvania.

[224] Dr. Howard Tompkins, tape recording, 11 October 1979, Indiana University of Pennsylvania,

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1980s this trend reversed, and two of three faculty members in these departments were from MIS degree programs. Since 1989, nearly eighty percent of MIS faculties have completed degrees in MIS.[225]

Management information systems became a popular field because of its variety of approaches, and their actual cross-fertilization. There was a debate among MIS faculty whether MIS was a science or should even have been treated as a science. There was a need to differentiate between maturation and progress within fields like MIS. Maturation and progress occurred when cumulative research knowledge was challenged. It was practical success that cumulated in science, not only the volume of knowledge.[226] These were similar issues that were contentious when computer science was established in the 1960s. This new discipline struggled to define and establish a canon. Management information systems discipline has continued to advance in this process.

The academic area of management information systems has been difficult to study for many reasons. Its short history is a primary problem. In addition, the distinctiveness of MIS faculty in academia has been complicated by the crossover of faculty from other disciplines like computer science and various business and

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[225] William D. Mangold, Luann Bean, and Maeve Cummings, "A Cohort Analysis of the Changing Gender Composition of MIS Faculty", *Journal of Computer Information Systems* (Fall 1998) 7-12.

[226] Claude Banville and Maurice Landry, "Can the field of MIS be disciplined?" *Communications of the ACM* 32(January 1989): 48-60.

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management science disciplines.[227] This was parallel to the development of computer science as a new discipline. MIS programs continued to utilize courses from other disciplines such as computer technology and software engineering while establishing its own identity. While MIS has been establishing itself as a separate discipline, it was only one of numerous computer-related degree programs.

Mathematical Education Pattern in Computer Science Units

The engineering programs dominated the early course work and influences in computer science and focused on hardware development. The computer science programs that originated in mathematics units focused on the use of computers to solve theoretical mathematical problems and numerical analysis. This was a very different focus from the engineering programs that developed computer hardware and used applied research methods.

The field of mathematics had been active in developing numerical analysis methods for use in business and scientific research. Mathematicians had been involved on computer science projects since the beginning of electronic computers. When academia began to form computer science units, some originated in mathematical departments. In general, there was interest in areas that were part of new applications of mathematics including computer science. The research in computer science and related activities had remained strong at Stanford and other universities. It also seemed this was an area in which the universities could with

[227]Sirkka L. Jarvenpaa, B. Ives, and Gordon B. Davis, *Communications of the ACM* 34, (January

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relatively little investment participate in computer science activities, although there was some argument about that.[228] In a manner similar to the engineering units, mathematical units attempted to determine how computer science related to their discipline.

Not all mathematicians embraced computer science; some viewed computer science as applied research. They were more theoretical and did not like to think in terms of approximate solutions and wanted the analytical or theoretical solution to a problem. However, some mathematicians were among the first to begin to use the computer on any campus and advocated for separate computer science units. Others were trying to solve problems that were applied, and needed solutions, whether they were approximate or not, and computers offered another opportunity to solve these problems. Galler, when relating his experiences at Michigan, stated, "mathematicians very grudgingly got into the computer field. I remember once it took several votes over a period of a couple of years, each time being voted down, to even recommend that mathematics students take computing courses."[229] But many mathematicians and mathematics units did spawn computer science units despite the dissention over the relevance of computer science to mathematics. The debate over the purpose

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1991): 86-98.

[228] Albert Bowker. Interview by Pamela McCorduck. tape interview, 21 May 1979. Charles Babbage Institute, Minneapolis.

[229] Bernard Galler. Interview by Enid Galler. tape interview, 8, 10-11, 16 August 1991. Charles Babbage Institute, Minneapolis.

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and place of computer science in academia was reflected in the key disciplines involved in developing computers.

The University of Wisconsin computer science program was initially titled "Numerical Analysis" and had its roots in the mathematics department. A 1966 brochure describes computer sciences as subjects supporting work in mathematical analysis, ordinary and partial differential equations, recursive function theory, logic and methodology of science, abstract algebra, probability and statistics, psychology of perception and cognition, neurophysiology, and formal linguistics. In contrast to the engineering program, the content areas identified in this brochure are clearly mathematical in nature and included numerical analysis, mathematical programming, systems programming, theory of computation, models of intelligence, and natural language processing.[230] In the years 1958 to 1962, the mathematics department taught a few courses in computers relating to research and the university had a computing facility devoted to research and teaching. In 1962, the university created a numerical analysis department responsible for the computing center and teaching.[231] This model also reflects the trend of academic units managing the computer center similar to the engineering model.

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[230] Computer Science Brochure, University of Wisconsin Archives, 1 November 1966, University of Wisconsin at Madison.

[231] University of Wisconsin Archives, *The Graduate School Summary Report for July 1, 1958-June 30,1963*, University of Wisconsin at Madison.

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In the 1961-1963 *Bulletin* for graduate courses, the "131, Theory and Operation of Computing Machines" course was listed and described a course in theory of computers.[232] By the 1963-1965 *Bulletin*, the 131 course on the theory and operation of computing machines was an undergraduate course and the description now included programming methods and languages. Another undergraduate course, "133, Introduction to Numerical Analysis" description included simulation and computer programming. The graduate courses of those years were listed as varied from year to year according to the needs of the students.[233] Computer science became part of the *Bulletin* by the years 1965-1967. Graduate instruction was explained as designed to provide students with a broad knowledge of numerical analysis, theory and application of computers, and of topics selected from the research interests of the staff. Research interests identified in the *Bulletin* included information retrieval, programmed instruction, and development of machine-based teaching, systems analysis and development, the theory of computer languages, functional analysis, approximation theory, artificial intelligence, and numerical aspects of differential equations. The admission requirements were a year of calculus and at least seventeen credits in mathematics. Two master's degree programs were offered one in computer science and another jointly between computer science and

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[232] University of Wisconsin, *University of Wisconsin Graduate School Bulletin*, (Madison: University of Wisconsin, 1961-1963).

[233] University of Wisconsin, *University of Wisconsin Graduate School Bulletin*, (Madison: University of Wisconsin, 1963-1965).

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mathematics. There was a doctoral degree offered in computer science and a minor in computer sciences offered to doctoral candidates from other fields. Seventeen courses were listed and included: "301, Computer Programming in the Physical Sciences", "315, Introduction to Data Processing Methods", "Introduction to Numerical Methods", "413, Introduction to Numerical Analysis", "415, Theory and Operation of Computing Machines", "425, Linear Programming Methods", "536, Introduction to Systems Programming I, II", "813" and "814, Advanced Numerical Analysis", "815, Numerical Aspects of Partial Differential Equations", and "837, Topics in Numerical Analysis and Approximation Theory."[234] This was a substantial increase in course offerings and the addition of degree programs from the previous *Bulletin*. When compared to the engineering model, there was a definite emphasis on applications programming and numerical analysis as opposed to the courses in engineering principles and mechanical languages.

The 1967-1969 *Bulletin* computer science section stated, "Even though introduced less than 20 years ago, automatic digital computers have already had a profound effect on important parts of our modern world, e.g., on certain kinds of scientific research and technological development."[235] It further stated, "It is to be expected that within the next twenty years computers will have a comparable

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[234] University of Wisconsin, *University of Wisconsin Graduate School Bulletin*, (Madison: University of Wisconsin, 1965-1967).

[235] University of Wisconsin, *University of Wisconsin Graduate School Bulletin*, (Madison: University of Wisconsin, 1967-1969).

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effect in most areas of human endeavor that involve the acquisition, organization, processing and use of information."[236] It described the subjects of numerical analysis, optimization methods, theory, and techniques for optimal automatic control, computer modeling and artificial intelligence and the development and theoretical analysis of methods for organizing and manipulating information as topics for computer science. The subject matter was divided into three separate content areas that were each separated into two parts. The first area included numerical analysis and mathematical programming and had a set of fifteen courses within that area. The second area was systems programming and theory of computation and included eleven courses. The third area was a model of intelligence and natural language processing. There were sixteen courses in the third area of specialty.[237] There was a focus on scientific methods and computing for scientific research. This became a specialization and distinguishable from engineering models that focused on hardware development and business programs that focused on practical applied applications for business. Scientific applications and artificial intelligence were the hallmarks of this model.

The program at the University of Wisconsin grew very rapidly from a mathematics department to a numerical analysis department and finally to a computer science department. This institution also had an engineering program

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[236] Ibid.

[237] Ibid.

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but in this instance the computer science department originated from roots in the mathematics area.

Hybrid Computer Science

As universities attempted to address the numerous functions of computers and how they related to academia, some institutions clearly had roots in mathematics or engineering. Other institutions developed programs that were a hybrid of mathematics and engineering and sometimes included several other influences as well. Their curricula attempted to address numerous issues in computers and chose not to focus on any one area. Some institutions started with this approach and then eventually found a more permanent focus. Bernard Galler described this situation at Michigan where an interdisciplinary group formed to support computing eventually becomes a computer science department and finally was established within an engineering department.[238] It was not unusual to see interdisciplinary hybrid programs in computer science. The equipment was expensive and faculty scarce, making it impossible for all but the largest institutions to start independent programs initially. Additionally, the new discipline was engulfed in controversy over how computer science was defined. The computing center established to support multiple departments was often the focal point for the first computer science department and diverse faculty banded together to form the early departments. These hybrid departments often fueled

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[238] Bernard Galler. Interview by Enid Galler. Tape interview, 8, 10-11, 16 August 1991. Charles Babbage Institute, Minneapolis.

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the problem of course descriptions and titles that varied considerably from institution to institution. They also became the focus of efforts to standardize the skills of computer science graduates because these types of programs were widespread and very diverse.

Conclusion

The curricular debates in computer science and its derivative programs spawned from the early patterns of computer science programs. As the discipline matured and began to define specialties within computer science, the process of new disciplines began again. The patterns of specialization presented in this chapter represent the growth of computers and their uses in very diverse areas. Each of these areas required trained specialists and research in that area. Academia responded by developing specialty areas that later became computer science, computer engineering, and management information systems.

The first evolution had been from only hardware developments to hardware and software. The second step was the recognition that not all computing requirements were similar. The split between scientific computing and business computing resulted in specialty and hybrid curricula in academic computer programs. These developments continued to fuel the debates on curricula and what constituted true computer science.

As in the past, the rapid development of new hardware and software technology continued to expand the academic programs teaching computer science. Curricula in these programs were always challenged to keep pace with

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the evolving technology. An understanding of the diversity in roots of three basic patterns of academic programs provided a foundation for future curricular decisions and expanded the matrix of computer related academic programs. The decades of the 1970s and 1980s brought tremendous growth in new technology and students enrolled in these academic programs.

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CHAPTER SIX

FURTHER DEVELOPMENTS

The development of computer science academic units and curricula has continued to expand into the 1980s and 1990s. The evolution of new technology in computer hardware and software proceeds at an ever-increasing pace. Smaller colleges and vocational institutions acquired hardware and software and began to teach "computer science". Business and industry continue to expand their use of computers and require employees with computer skills. Colleges and universities continue to teach computer coursework to sustain the increasing use of technology in business and industry. The requirement to manage these new technological resources gave birth to numerous academic programs.

The Diversity of Academic Computer Programs

Computer science covers a wide range of programs at levels from associate degree programs to doctoral programs. The content and focus of these programs are very diverse. This creates a problem for establishing standard outcomes for computer science graduates.

Unlike professional fields such as medicine, nursing, or architecture with clearly defined programs, hybrid computer science programs, and their derivatives present distinct problems for analysis due to the varied curricular

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descriptions associated with the same program title.[239] The study of computer occupations indicates that the software evolution itself caused the position of software engineers to decrease to that of a technical application analyst within two years. Ironically, computer design specialists construct their own obsolescence. Yet in the modern world, they find themselves recalled to higher-ranking positions when problems from an older technology such as programming mainframes to confront the year 2000 arise.[240] It is difficult to consistently define curricular content for undergraduate computer science programs.

Courses are labeled in such a way that they are classified as computer science, regardless of the school in which they are taught within in an institution. Courses that include a considerable number of computer skills (programming and applications) are taught in other areas of the curriculum and labeled in such a way that they are not classified as computer science. Examples of this situation include "Problem Solving in Chemical Engineering" and "Quantitative Research in Management". In these cases, it is reasonable to assume that mastery of complex software packages, spread sheets, and graphics is either assumed or taught in these courses.[241]

This type of crossover in course content sometimes leads to curricular turf battles over which departments should be teaching courses that have

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[239] National Research Council, 1993 *Computing Professionals: Changing Needs for the 1990s.* (Washington, D.C. 1993).

[240] Clifford Adelman, *Leading, Concurrent, or Lagging?: The Knowledge Content of Computer Science in Higher Education and the Labor Market*, (U.S. Department of Education. 1997).

[241] Ibid.

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interdisciplinary content. The same course resides in different departments across a number of institutions. As departments continue to expand their courses in other areas this continues to fuel the controversy.

Computer-related occupations are subsumed under larger umbrellas of information technology. Other occupations such as business planning consultant-analyst are associated with the content of information technology, so that their borders are always in flux. These titles are neither doublespeak nor inflation of reality. They describe what people do in an economy where information technology permeates daily life, and where computing applications themselves exist in a changing mixture of technologies.[242] These job titles cover "heterogeneous activities" that are "difficult to describe and label".[243] Academic computer units struggle with the same flux in program boundaries. During the 1970s and 1980s, the discipline struggled out of its dual-origins in mathematical principles and the kinds of heuristics, design principles, and applications that were at the core of engineering. The tensions are evident in the professional literature and reflect the exploration of boundaries and commonalties between computer science and computer engineering.[244] These issues are indicative of a maturing discipline discovering its place in academic institutions. Another factor is that computer science programs established in the 1980s often were in

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[242] *Ibid.*, 3.

[243] National Research Council, 1993 *Computing Professionals: Changing Needs for the 1990s.* (Washington, D.C. 1993) 50.

[244] P.J. Denning, et al. "What is Computer Science?", *American Scientist* 73 (1985): 16-19.

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colleges without engineering schools and therefore were not influenced heavily by engineering, as were the early programs.

Graduate programs in computer science between 1984 (the first year of mass marketing and accessibility of personal computers) and 1993 indicate considerable growth and contrary tendencies of differentiation and consolidation. The number of doctoral programs increased by forty percent and the number of those doctoral programs that require a first degree in computer science increased from eleven percent to seventeen percent.

While the proportion of graduate programs in computer science requiring an undergraduate degree in the field was fewer than twenty percent, the proportion of new computer science graduate students with computer science undergraduate degrees doubled to almost sixty percent between 1978 and 1987.[245] A continuum of computer-related degrees at the bachelor's level ranged from hardware oriented (computer engineering) through software oriented (computer science and information science/systems) to management oriented (management of information systems) subfields. The doctoral programs changed from disparate specialties to programs with a core body of knowledge. This was an indication of focus on research in the core-underlying field.

Another trend in computer science was the demonstration of a clear distinction between the graduate research programs and establishment of proven

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[245] J. Grandy and N. Robertson, *Change in Field of Study from Undergraduate to Graduate School* (Princeton: Educational Testing Service, 1992).

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concepts and programming methods for the undergraduate programs. The major degree field changes at the both doctoral and master's levels included declines in programs in computer programming, systems analysis, and data processing, and the opening of programs in microcomputer applications and "other" fields. These usually included interdisciplinary interests, such as human-computer interactions. These changes were a sign of a maturing discipline that had developed stronger first level degrees in core subfields.

The early research had provided the core knowledge and programming methods for computer science and these principles moved into the undergraduate classroom. The doctoral programs were relied on to produce the scholarly standard. Master's programs served to explore and establish professional programs in software oriented and management oriented computer/information science programs.[246] Computer science had established itself but continued to debate the curricular boundaries.

Summary

The history of computer science began with the initial endeavor to build a calculating machine. The development of the computer united academicians from various different disciplines in a shared goal to defend the country in two world wars. After the war, scientific and business purposes for computers became the focal point. Initial academic computer initiatives confronted contentious issues during the formation of the early computer units.

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[246] G.L. Eerkes, "Computer Science Master's Programs" *Communications of the ACM* 34(1991).

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The evolution from independent research projects to university computer centers began after World War II and spanned the decade of the 1950s to the early 1960s. Computers that were first created as calculating machines advanced to computers that were thinking machines that interacted with people. The challenges universities faced included defining the purpose of computer science, how to maximize the computer resources, and how to meet the requirement for trained computer specialists. The construction of a computer no longer required university research teams. Industry mastered the techniques of mass-producing computers and looked to the universities to discover new improvements. Academic computer science departments and curricula evolved from these events. The creation of independent departments and programs raised curricular issues that led to contention over resources and diversity of courses from institution to institution.

The events surrounding the creation of these units reflected the influence of the computer on industry and academia. Independent computer science units formed around specific specialty interests. The diversity of these departments among universities and their curricular foci escalated debates over the purpose of computer science. After the first group of computer science departments were established, there was rapid growth in computer science and new programs began while existing programs broadened. The expansion of computer science resulted in additional specialized curricula that reflected the diverse uses of computers.

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The disparate origin of computer science has produced diverse computer science curricula. These various models indicate patterns in computer science of organization in engineering, business, mathematics, and hybrid models. The oldest model in engineering focuses on hardware design and the software embedded in the hardware. This model developed from the first efforts to create the machines and continues to work on the improvement in computer hardware design and related software. These units are housed in schools or departments of engineering.

The mathematical model emphasizes the software for scientific computing and includes the areas of artificial intelligence and numerical analysis. Mathematics departments were the origin of many of these types of units and continue to house them today.

The business model supports industry requirements for data processing and represents a large number of programs. The separate discipline of management information systems evolved from this pattern. Industry contributed heavily toward providing resources for these programs and is still an active partner with many institutions.

These models are representatives of significant organizational patterns in computer science education. The models have continued to expand and diversify over the last decade with many specialty areas such as computer networking and World Wide Web focused courses and these programs exist in numerous institutions.

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The rapid development of new hardware and software technology continues to expand academic programs teaching computer science. Curricula in these programs are challenged to adapt to the evolving technology. As smaller institutions began to add coursework in computers, associate degree and certificate programs in computers were offered to students. These smaller programs often use "computer science" to describe their programs but in reality, the course work does not reflect the graduate research programs that established the discipline and are often hybrid programs.

Contemporary Situation

An understanding of the roots of computer science programs provides a foundation for future curricular decisions in the expanding array of computer related academic programs. The diversity of computer science curricula and faculty increases as additional programs are established. There is little consistency among offerings and hybrid programs are common. The requirements of local industry and the interests of the faculty members that develop the program often determine the courses at an institution. The shift from large mainframe computers to personal computers in the 1980s and the increasing use of computers for more specialty areas in industry has contributed to the growing diversity of content in computer science courses. Specialty areas within the identified patterns of computer science lead to many different curricula. Each area has a specific focus unique to their special interest. The titles of departments and degree programs include: "computer engineering," "computer

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science," "information science," "management information systems," "computer technology," and others.

The computer science programs evolved into scientific computing units with a research focus in many major universities. In many instances, these programs still reside in mathematics departments. Institutions that have engineering programs either develop a new program or department with the title computer engineering or create a subset of the existing engineering department for computer engineering.

Computer science is an unusual subject in that it has many facets. One facet is more mathematical and another is a type of engineering, and yet another is business-oriented. This fact is reflected in computer science history. People from different disciplines accomplished achievements in computers. They included physicists like Atanasoff, mathematicians like von Neumann, and engineers like Mauchly and Eckert.

Moreover, there are dichotomies within these facets. The mathematical aspects of computer science include not only computability and computational complexity, but also touch on logic, probability theory, and numerical analysis, which can be viewed as a direct outcome of the need for extremely heavy, accurate, computations. In addition, the engineering pattern of computer science

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is also a dichotomy. It includes designing and building hardware that in many ways is a different kind of endeavor from developing software.[247]

A number of sub fields exist from the original computer science foundations. Program titles include: "information systems," "computer technology," "management information systems," "computer programming." Some of these are specialty areas with their own foci but many of them are hybrid programs without a specific focus. The course work reflects some components of business computing, courses based on mathematical foundations, and courses from the engineering area. This often mirrors the diverse roots of the faculty who form these departments. At different institutions, the programs titled 'computer science' have very different curricula. The field of management information systems has developed and is establishing a body of knowledge for that discipline. These academic units often reside in a school of business and are not related to computer science units in the same institution. Sometimes they are hybrid programs between management and technology programs.

In addition to these issues, there is another problematic issue that directly contributes to the confusion of defining areas of computer science. The problem is rooted in the urgency of modern society to make people computer literate. There is a tremendous effort to integrate computers into education on all levels and in a wide variety of ways. This is a contributing factor to "computer science"

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[247] Judith Gal-Ezer and David Harel, "What (else) Should CS Educators Know?" *Communications of the ACM* 41 (September 1998) 77-84.

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to being confused with "computer literacy." Examples include algorithms compared with spreadsheets, programming with word processing and the average-case analysis with net surfing. Students enrolled in computer literacy are majors in programs titled "computer science."

The best method to investigate what the field is really about is to inspect the various curricula proposed for university-level study. The distinguished ACM 1968 curriculum for undergraduate study, and its revisions that appeared in later years, divided computer science into three basic categories. These categories are information structures and processes; information processing systems; and methodologies. Different kinds of divisions are proposed in other sources. One opinion argues that a beneficial way to view computer science is by the kinds of complexity it handles. These include computational complexity; system or behavioral complexity; and cognitive complexity.[248] These are some of the many lenses through which computer science can be viewed.

The engineering pattern now includes subareas such as computer hardware engineering, software engineering, and computer networking. The mathematical pattern includes the areas of artificial intelligence and expert systems, numerical analysis, and scientific programming. The business pattern has specialty programs in system analysis, databases, and management information systems. Hybrid programs and derivatives from these areas are

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[248] Judith Gal-Ezer and David Harel, "What (else) Should CS Educators Know?" *Communications of the ACM* 41 (September 1998) 77-84.

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common. Computer science has become a matrix with more specialty areas evolving from the origins of computer science.

Even in modern discussions of computer science, the diverse views of computer science are accepted. The complex nature of computer science with its special algorithmic way of thinking and relatively short existence has led to a diversity of opinions about its very meaning. As an example, two strikingly conflicting quotations by two prominent computer scientists illustrate the diversity of opinions. Marvin Minisky, a distinguished computer scientist stated, in 1979: "Computer science has such intimate relations with so many other subjects that it is hard to see it as a thing in itself."[249] In 1994, another distinguished computer scientist, Hartmanis, offered a very different perspective, "Computer science differs from the known sciences so deeply that it has to be viewed as a new species among the sciences."[250] The debate over the purpose of computer science continues. In some ways, both quotations are correct. Computer science is definitely a new and important science, but its relationships with other fields like mathematics, physics, business, and electrical engineering are also very significant.[251] The interdisciplinary aspects of computing continue to challenge the definition of computer science.

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[249] M. L. Minsky, Computer Science and the Representation of Knowledge. *The Computer Age: A Twenty Year View* (Cambridge: MIT Press, 1979) 392-421.

[250] J. Hartmanis, About the Nature of Computer Science, *Bulletin of EATCS* 53(1994) 170-190.

[251] Judith Gal-Ezer and David Harel, "What (else) Should CS Educators Know?" *Communications of the ACM* 41 (September 1998) 77-84.

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The challenge for all departments, programs, and faculties involved in teaching computer science and its related areas will be to avoid the curricular turf wars and build meaningful curricula in a rapidly changing area. History has repeated itself and again the tremendous demand for a workforce with computer skills exceeds the supply as the decade of the 1990s comes to an end. Programs and courses are sometimes created in a haphazard fashion in an attempt to meet the demand from business for skilled employees. Industry training or certification on vendor--specific software threatens computer-related degree programs. The inconsistency of standards and curricula across many programs is driving business to create software certification programs.

Academia must continue to strive for uniform standards in computer-related disciplines that change at an incredible pace. Studying the origins and patterns of computer science in the past will help guide future curricular decisions. The models and history presented in this study were intended to provide some foundation for these curricular issues. While it is not a comprehensive review of every computer program, representative programs are used to identify the important issues in the formation of academic computer science programs and provide basis for other curricular endeavors. Many of the problems facing academic units today are similar to those in the earlier evolution of these disciplines. By examining the problems and issues of the past, higher education has a more informed approach for building the future.

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Works Cited

Primary Sources

Books

Albers, D. J., D. O. Loftsgaarden, and R. D. Anderson, *Undergraduate programs in the Mathematical and Computer Sciences: the 1985-1986 Survey*, Washington D.C.: Mathematical Association of America.

Calingaert, Peter, *Growth of a Department: A Personal History of Computer Science at UNC-Chapel Hill 1962-1964*, Chapel Hill: The University of North Carolina, 1994.

Grady, E. G., *Computing History at Southwest Texas State University*, Southwest Texas State University, 1983.

National Research Council, *Computing Professionals: Changing Needs for the 1990s*, Washington DC, 1993.

Tucker, A. B., et al., *Computing Curricula 1991: Report of the ACM/IEEE-CS Joint Curriculum Task Force*, New York: Association for Computing Machinery, 1991.

Turner, A. J., "U.S. Degree Programs in Computing", *Computing Professionals: Changing Needs for the 1990s*, Washington, DC: National Research Council, 1993.

Wildes, K. L., and N. A. Lindgren, *A Century of Electrical Engineering and Computer Science at MIT, 1882-1982*, Cambridge: The MIT Press, 1985.

Periodicals

Association of Computing Machinery Curriculum Committee on Computer Science," An Undergraduate program in Computer Science--Preliminary Recommendations," *Communications of the ACM* 8 (September 1965): 543-552.

Association of Computing Machinery Curriculum Committee on Computer Science," Curriculum 68: Recommendations for Academic Programs in Computer Science," *Communications of the ACM,* (March 1968): 151-197.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Commission on Engineering Education of the National Academy of Engineering, *Proceedings of the Meeting on Computer Science in Electrical Engineering of the Commission on Engineering Education*, (October 1968): 6.

Computing Research Association, "1994 Taulbee Survery", *Computing Research News*, vol. 7, no.2.

Hamblen, John W., "Degree programs in Computer Science, Data Processing, Etc. Offered by Institutions of Higher Education During 1969-70, 1970-71, and 1971-72", SIGCSE, *Bulletin* 4, (July 1972): 29-39.

Hamblen, John W., "Computer Science and related degree Programs in U.S. Higher Education", Computer Sciences Southern Regional Education Board.

Mulder, Michael C., "Current and Future Trends in the Development of Computer Science and Engineering Curricula", *Proceedings of the Computer Science and Engineering Curricula Workshop*, IEEE Computer Society, (June 6, 1977).

University Publications and Documents

Adam, J. M., *Report on the Computing Facility and the Computer Science Academic Program at Indiana State University*, Indiana State University.

Carnegie Mellon Archives, *Alan J. Perlis Obituary*, Computer Science Department minutes, 1990.

Carnegie Mellon Archives, *Information Sheet on Computer Science Department*, Carnegie Mellon University.

Fein, Louis, *Study and Evaluation of the Status of University Programs in the United States in Computers, Data-Processing and Related Fields Including Recommendations to Stanford University on their Potential Role in the Fields*, October 1957, Stanford Collection, Charles Babbage Institute.

Indiana University of Pennsylvania, Minutes of the Board of Trustees, 16 October 1979.

Purdue University, *Purdue University Bulletin Calumet Campus*, Purdue University, 1969-1970.

Purdue University, *Purdue University Bulletin Calumet Campus*, Purdue University, 1974-1975.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Rice, John R., and Saul Rosen, *History of the Computer Sciences Department at Purdue University*, CSD-TR-1003, August 1990, The Computer Sciences Department, Purdue University.

Thompson, Jack, *A Proposal for the Establishment of a Department of Computer Science at Indiana University of Pennsylvania*, 1 May 1970, Indiana University of Pennsylvania.

University of Illinois Archives, minutes of Board of Trustees meeting 24 November 1964.

University of Illinois Archives, minutes of Board of Trustees meeting 20 April 1966.

University of Illinois Archives, *University of Illinois Bulletin: Graduate College*, Urbana: University of Illinois, 1950-1952.

University of Illinois Archives, *University of Illinois Bulletin: Graduate College*, Urbana: University of Illinois, 1956-1958.

University of Illinois Archives, *University of Illinois Brochure*, Urbana: University of Illinois, 1959-1960.

University of Illinois Archives, *University of Illinois Bulletin: Graduate College*, Urbana: University of Illinois, 1967.

University of Illinois Archives, *The Department of Computer Science Brochure*, Urbana-Champaign: University of Illinois, 1968.

University of Pennsylvania Archives, *University of Pennsylvania Bulletin: The Graduate School of Arts and Sciences*, Philadelphia: University of Pennsylvania, 1951-1952.

University of Pennsylvania Archives, *University of Pennsylvania Bulletin: The Engineering Schools*, Philadelphia: University of Pennsylvania, 1956-1957.

University of Pennsylvania Archives, *University of Pennsylvania Bulletin: Graduate School of Arts and Sciences*, Philadelphia: University of Pennsylvania, 1958-1959.

University of Pennsylvania Archives, *University of Pennsylvania Bulletin: Graduate School of Arts and Sciences*, Philadelphia: University of Pennsylvania, 1960-1961.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

University of Pennsylvania Archives, *University of Pennsylvania Bulletin: Graduate School of Arts and Sciences*, Philadelphia: University of Pennsylvania, 1961-1962

University of Pennsylvania Archives, *University of Pennsylvania Bulletin: Graduate School of Arts and Sciences*, Philadelphia: University of Pennsylvania, 1962-1963.

University of Pennsylvania Archives. *University of Pennsylvania Bulletin: Graduate School of Arts and Sciences*, Philadelphia: University of Pennsylvania, 1963-1964.

University of Pennsylvania Archives, *University of Pennsylvania Bulletin: Graduate School of Arts and Sciences*, Philadelphia: University of Pennsylvania, 1964-1965.

University of Pennsylvania Archives, *University of Pennsylvania Bulletin: Graduate School of Arts and Sciences*, Philadelphia: University of Pennsylvania, 1965-1966.

University of Pennsylvania Archives, *University of Pennsylvania Bulletin: Graduate Studies*, Philadelphia: University of Pennsylvania, 1966-1967.

University of Pennsylvania Archives, *Annual Report: The Moore School of Electrical Engineering*, Philadelphia: University of Pennsylvania, 1960-1961.

University of Pennsylvania Archives, *Annual Report: The Moore School of Electrical Engineering*, Philadelphia: University of Pennsylvania, 1962-1963.

University of Pennsylvania Archives, *Annual Report: The Moore School of Electrical Engineering*, Philadelphia: University of Pennsylvania, 1964-1965.

University of Wisconsin Archives, *Computer Science Brochure*, Madison: University of Wisconsin, 1966.

University of Wisconsin Archives, *The Computing Service, January-June 1951: A Report to the Committee on the Computing Service*, Madison: University of Wisconsin, 1951.

University of Wisconsin Archives, *The Graduate School Summary report for July 1, 1958-June 30, 1963*, Madison: University of Wisconsin, 1963.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

University of Wisconsin, *University of Wisconsin Graduate School Bulletin*, Madison: University of Wisconsin, 1961-1963.

University of Wisconsin, *University of Wisconsin Graduate School Bulletin*, Madison: University of Wisconsin, 1963-1965.

University of Wisconsin, *University of Wisconsin Graduate School Bulletin*. Madison: University of Wisconsin, 1965-1967.

University of Wisconsin, *University of Wisconsin Graduate School Bulletin*. Madison: University of Wisconsin, 1967-1969.

Taped Interviews

Bowker, Albert, interview by Pamela McCorduck, tape recording, 21 May 1979, Charles Babbage Institute, Minneapolis.

Fein, Louis, interview by Pamela McCorduck, tape recording, 9 May 1979, Charles Babbage Institute, Minneapolis.

Forsysthe, Alexandria, interview by Pamela McCorduck, tape recording, 16 may 1979, Charles Babbage Institute, Minneapolis.

Galler, Bernard A., interview by Enid H. Galler, tape recording, 8, 10-11, 16 August 1991, Charles Babbage Institute, Minneapolis.

Miller, William F., interview by Pamela McCorduck, tape recording, 22 May 1979, Charles Babbage Institute, Minneapolis.

Newell, Allen, interview by Arthur L. Norberg, tape recording, 10-12 June 1991, Charles Babbage Institute, Minneapolis.

Tompkins, Howard, 11 October 1979, Pennsylvania.

Traub, Joseph F., interview by William Aspray, tape recording, 29 March 1985, Charles Babbage Institute, Minneapolis.

Secondary Sources

Books

Adelman, Clifford, *Leading, Concurrent, or Lagging?: The Knowledge Content of Computer Science in Higher Education and the Labor Market*, U.S. Department of Education, 1997.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Beniger, J. R., *The Control Revolution: Technological and Economic Origins of the Information Society*, Cambridge: Harvard University Press, 1986.

Billings, Charlene W. *Grace Hopper: Navy Admiral and Computer Pioneer*, Hillside, NJ: Enslow Publishers, 1989.

Campbell-Kelly, Martin, & Aspray, William. *Computer: A History of the Information Machine*, New York: BasicBooks, 1996.

Crevier, Daniel, *AI - The Tumultuous History of the Search for Artificial Intelligence*, New York: Harper Collins, 1993.

Dupont, Linda M. *An Investigation and Analysis of the Influence of John Von Neumann on Computer Design and Computer Science*, Worcester Polytechnic Institute, 1972.

Grandy, J. and N. Robertson, *Change in Field of Study from Undergraduate to Graduate School*, Princeton: Educational Testing Service, 1992.

Greenbaum, Joan M., *In the Name of Efficiency: Management Theory and Shopfloor Practices in Data-Processing Work*, Philadelphia: Temple University Press, 1979.

Holbrook, Bernard D., *Bell Laboratories and the Computer from the Late 30's to the Middle 60's*, Murray Hill: Bell Laboratories, 1975.

Mallach, Efrem G., *Understanding Decision Support Systems and Expert Systems*, Boston: Irwin Publishers, 1994.

Minisky, M. L., *Computer Science and the Representation of Knowledge: The Computer Age A Twenty Year View*, Cambridge: The MIT Press, 1979.

Mishkoff, Henry C., *Understanding Artificial Intelligence*, Indianapolis: Sams & Company, 1985.

Mueller, M., "Yellow Stripes and Dead Armadillos" in P. Franklin(ed.), *Profession*, New York: The Modern Language association, 1989.

Norberg, Arthur L., and Judy E. O'Neill. *Transforming Computer Technology: Information Processing for the Pentagon, 1962-1986*. Baltimore: The Johns Hopkins University Press, 1996.

Pacey, A., *The Culture of Technology*, Cambridge: The MIT Press, 1983.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Pigford, D.V., and Greg Baur, *Expert Systems for Business: Concepts and Applications*, Boston: Boyd and Fraser Publishing, 1995.

Ritchie, David, *The Computer Pioneers*. New York: Simon & Schuster, 1986.

Scown, Susan J., *The Artificial Intelligence Experience: An Introduction*, Bedford: Digital Equipment Corporation, 1985.

Slater, Robert, *Portraits in Silicon*. Cambridge: The MIT Press, 1987.

Spencer, Donald D. *Great Men and Women of Computing*. Ormond Beach: Camelot Publishing Company, 1996.

Whitten, Jeffrey L., Lonnie D. Bentley, an Victor M. Barlow, *Systems Analysis & Design Methods*, Boston: Irwin Publishers Inc., 1994.

Periodicals

Armstrong, Russell M., "Industry's Need and Computer Science Departments", SIGCSE, *Bulletin*, 4 October 1972: 41-44.

Banville, Claude, and Maurice Landry, "Can the Field of MIS Be Disciplined?", *Communications of the ACM*, 32 (January 1989): 48-60.

Bresser, R. K., "The Context of University Departments: Differences Between Fields of Higher and Lower Levels of Paradigm Development", *Research in Higher Education*, vol. 39, no.1: 38-44.

Denning, P. J., et al. "What is Computer Science?", *American Scientist*, 73, (1985): 16-19.

Eerkes, G. L., "Computer Science Master's Programs", *Communications of the Association of Computing Machinery*, vol.34, no.1.

Gal-Ezer, Judith, and David Harel, "Whate (else) Should CS Educators Know?", *Communications of the ACM*, 44, (September 1998): 77-84.

Goodman, A. F., "The Interface of Computer Science and Statistics: An Historical Perspective", *The American Statistician* (June, 1968):17.

Gruenberger, Fred, "A Minority Report About the Majority Problem", NSF Conference on Computer Science Education, (July 1969): 70.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Hartmanis, J. "About the Nature of Computer Science", *Bulletin of EATCS*, 52 (1994): 170-190.

Jarvenpaa, Sirkka L., B. Ives, and Gordon B. Davis, *Communications of the ACM*, 34 (January 1991): 86-98.

Lee, J. A., "Unforgettable Grace Hopper," *Reader's Digest* (October 1994): 181-185.

Mangold, William D., Luann Bean, and Maeve Cummings, "A Cohort Analysis of the Changing Gender Composition of MIS Faculty", *Journal of Computer Information Systems, (Fall 1998): 7-12.*

Newell, Allen, Perlis, Alan, & Simon, Herbert, " What is Computer Science", *Science*, 157, No. 3795, (September 22, 1967): 1373-1374.

Swearingen, John K., "The Certificate in Data Processing: A Progress Report", *Journal of Machine Accounting* (November 1962): 50.

World Wide Web Resources

"Burroughs Corporation History", Charles Babbage Institute [http://ww.cbi.umn.edu/buhist.htm]

"Computer Pioneer George R. Stibitz, dead at 90" [http://dragon.union.edu/HTMLfiles/stibitz.html] February 2, 1995.

"Control Data Corporation Chronology", Charles Babbage Institute [http://www.cbi.umn.edu/minn/cdc/cdcchron.htm].

Cook, R. "History of Control data Corporation", University of Wales at Cardiff [http://www.cm.cf.ac.uk./User/R.J.Cook/project/cdchistory.html].

Do, Hien C. "John Vincent Atanasoff" [http://ei.cs.vt.edu/~history/do_Atanasoff.html].

"Howard Aiken an Innovator in Computer Science" [http://www.cs.rmc.edu/~jrr/cs105/chansfor/webpg.htm]

Jones, Douglas W. "The Digital Equipment Corporation PDP-8", University of Iowa [http://www.cs.uiowa.edu/~jones/pdp8/].

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

"John Mauchly and the Development of the ENIAC Computer", University of Pennsylvania Special Collections, [http://www.library.upenn.edu/special/gallery/mauchly/jwm1.html].

"Ph.D.'s Awarded at the University of Wisconsin", [electronic file] 27 June 1997. Available from Lorene Webber at lorene@cs.wisc.edu.

Voss, Natalie D. "George Boole" in "Jones Telecommunications and Multimedia Encyclopedia" [http://www.digitalcentury.com/encyclo/update/boole.html] 1995.

"Thomas J. Watson Sr.", Encyclopaedia Britannica Online, Inc. [http://alishaw.sscf.ucsb.edu/~sung/comm115/Watson.html] 1997.

"Who was William Seward Buroughs?", Charles Babbage Institute [http://www.cbi.umn.edu/burros/wsb.htm].

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VITAE

Education

I have a master's degree in education from Purdue University completed in 1994, specializing in instructional design. My undergraduate degree is a baccalaureate degree in management from Calumet College of St. Joseph awarded in 1991.

Professional Experience

My employment history includes: 1998 Purdue University Calumet Campus, Acting Department Head and Associate Professor of Information Systems and Computer Programming, 1992 Assistant Professor of Information Systems and Computer Programming, 1989 Supervisor of Computer Operations, and 1986-1989 Kelly & Associates, Corporate Headquarters, Supervisor of Computer Operations. I have fifteen years of experience in information systems and ten years of experience in higher education. I have worked in both corporate and higher education environments in the area of information systems. My skills include: project management, system analysis, instructional design, curriculum development, policy development, data center management and program assessment.

My research allows me to stay current with the rapidly changing technology and education theories. I have made many presentations at national and

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international conferences. My innovative work in distance learning has improved student learning outcomes at Purdue. I am widely published and network extensively with educational and organizational leaders.

Information Systems

I have been actively involved in computer-wide and local area networks, operating systems, and systems analysis. My experience includes projects in corporate and non-profit environments. I have developed multi-media presentations for classroom and training environments and have utilized presentation to disseminate information via the world wide web. I was responsible for monitoring and maintaining a mainframe network problem-free from a corporate Chicago headquarters to branch offices nationwide. I currently teach networking courses to prepare students for certification in Microsoft Networking products. I used systems analysis methodologies to mange system conversions and implementations. When STRADIS was adopted at a regional Indiana campus, I served on the committee to customize the methodology used by the Department of Computer User Support Services. I designed and provided documentation for disaster recovery plans for data centers and coordinated data center plans with site recovery plans.

Education: As the acting department head, I am active in research, instructional design and teaching. My work in higher education has led to

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numerous publications and presentations. I am a published author and speaker at international, national, and regional conferences on distance education via the Internet higher education and distance learning, and ethics in technology. I have overseen several curriculum development projects for technology and instructional programs. I have designed an implemented training programs for staff and faculty using computer technology. I worked with senior citizens and other community groups to teach technology as part of a community outreach program. My research in determining instructional barriers for minority students lead to conducting focus groups with minority students in technology programs. This data was evaluated for use in curriculum design. I have supervised program evaluations, areas of assessment include: teaching, course content, diversity, pedagogy, and technology. I participated in policy decisions on general education requirements, and evaluated programs for general education and technology requirements. I regularly design and deliver courses in computer networks, operating systems, expert and decision support systems in traditional and distance education formats.

Management:

I have managed data centers and directed many information systems projects including system conversions, system implementation, disaster recovery, and strategic planning. As project leader for the relocation of two date centers, I

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coordinated all facets of the projects. As project leader for system conversions, I identified alternative hardware and software solutions organized file conversion, coordinated training programs for the new systems, and managed purchases of replacement hardware and software. I have overseen re-configurations of computer laboratories, developed computer use policies, and have served as a liaison for academic departments, administrators, and students. As part of her contract management responsibilities, I reviewed and consolidated hardware maintenance contracts resulting in improved performance and annual savings.

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DISSERTATION APPROVAL SHEET

The dissertation submitted by Susan E. Conners has been read and approved by the following committee:

F. Michael Perko, Ph.D., S.J., Director
Professor of Educational Leadership and Policy Studies, and of History
Loyola University Chicago

Richard VandeVelde, Ph.D., S.J.
Associate Professor of Mathematics and Computer Science
Loyola University Chicago

Jennifer Grant Haworth, Ph.D.
Assistant Professor of Educational Leadership and Policy Studies
Loyola University Chicago

The final copies have been examined by the director of the dissertation and the signature which appears below verifies that fact that any necessary changes have been incorporated and that the dissertation is now given final approval by the committee with reference to content and form.

The dissertation is therefore accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

10 May 1999
Date

F. Michael Perko, SJ
Director's Signature

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