The IBM 650 - Little Computer, Big Impact

A historical study of the industry impact on establishing computer science as an academic discipline

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Introduction

Computer Science as an academic discipline that is roughly 50 years young and in that time there has been remarkably rapid developments in the field. This study attempts to analyze the state of computers and their applications from the 1930's through the 1960's while examining the role that industry played in the creation and development of Computer Science as an academic discipline. Studying the history of computer science is quite a broad topic so this paper will look at the industry involvement regarding three aspects of the evolution of computer science. The first part of the paper examines the early computers and university computing centers, secondly the study looks at the early computer science departments and finally the paper will look at the development of the curriculum. In a 1957 study of the impact of computers in the universities, Louis Fein states that "'Curriculum and research programs have been designed as supplements to the computing equipment. The reverse should be the case. The computer equipment should he a supplement–albeit an important one–to a well-organized and integrated university program in the computer sciences!"'[1] The hypothesis is that industry support of university computing environments, namely IBM's Educational Grant Plan that offered commercial computers at discount prices made the computer the "'supplement"' and unified the different fields with interests in computing machinery into the distinct field of Computer Science.

The remainder of this paper is organized as follows. Section II attempts to summarize the related work, Section III seeks to explore the early computers and the involvement IBM had with them. Section IV introduces the IBM model 650 and analyzes the possible impact of the 650 on the early computer science departments. Section V will focus on the development of the curriculum and investigate the industry involvement in establishing a formal computer science curriculum. Finally, Section VI will summarize the findings and Section VII will talk about future work that the author finds as appropriate extensions to this study.

Related Work

The history of computers is well documented, the IEEE Annals of the History of computing is an entire journal dedicated to the topic. This paper seeks to investigate industry involvement in establishing computer science as an academic discipline which sets it apart from most published work. The IBM 650 is mentioned in other works primarily in passing. For example, William Aspray and Bernard O. Williams published a piece titled *Arming American Scientists: NSF and the Provision of Scientific Computing Facilities for Universities, 1950-1973* in the Annals of the History of Computing in 1994.[2] Aspray and Williams mention the 650 and this work is related in the sense they also study what got computers onto university campuses but it is also different. Their focus was to examine the NSF impact of the formation of early computing facilities rather than industry involvement of getting computers onto campuses. The most closely related paper was one done by Bernard A. Galler titled *The IBM 650 and the Universities* published in the Annals of the History of Computing in January of 1986.[3] Galler's paper makes similar claims to this one regarding the 650's impact in universities however this paper is different because it attempts to examine the impact of industry and the IBM 650 on the formation of computer science departments.

Early Computers

While performing his doctoral thesis in Physics on "Theory of Space Charge Conduction", Howard Aiken saw the need for an automatic computing machine that could carry out complex calculations that would take too long for a human to tackle. Aiken drafted a proposal titled "Proposed automatic calculating machine" and submitted it to the Physics department at Harvard. Upon receiving approval Aiken first took his idea for a computing machine to George C. Chase at the Monroe Computing Company who, in Aiken's words, was a "very, very scholarly gentlemen." [4] Aiken explained to Chase what it could accomplish in the field of mathematics, science and sociology.[5]

"He (Chase) went to his management at Monroe and he did everything within his power to convince them that they should go ahead with this machine because, although it would be an expensive development, it would be invaluable in the company's business in later years. Now this is the thing that Tom Watson was never able to see." [4] "But in his moment of disappointment, it was he who said, Go to IBM, because IBM is very successful and they more apt to undertake a thing of this kind than anyone else." [4]

The IBM Automatic Sequence Controlled Calculator (ASCC), better known as the Mark I, was shipped to Harvard in February 1944, assembled and formally presented to the university on August 7 of that year. [1] Grace Hopper was tasked to program the Mark I and soon came to realize that it would be beneficial to have a set of library routines that could be reused by different programs.[6]

The Electronic Numerical Integrator and Computer (ENIAC) was a wartime project sponsored by the Ballistics Research Laboratory at the Arberdeen Proving Grounds. It was the work of John Prespert Eckert and John Mauchly along with others in the Moore School of engineering at the University of Pennsylvania. The ENIAC calculated firing tables for new weapons being delivered to support the war but it was to be more than just a special purpose machine like

[1] Information obtained from http://www-03.ibm.com/ibm/history/exhibits/markI

others that came before it.

"This is to work for any problem that we can conceivably put on it, except for the limitation, of course, that we're not going to put so much equipment in there that we never know how to use it."[7].

IBM was also familiar with the ENIAC and was manufacturing punched card equipment for the machine. Thomas Watson Jr. had first hand experience with the ENIAC from his days in the Navy and was already aware of the potential of this new kind of machine. Engineers from Endicott, New York that created the punched card equipment also experienced the ENIAC while it was under construction. [8]

John Von Neumann was also working on computing machinery at the Institute for Advanced Studies when in the summer of 1944 he heard about the work of Eckert and Mauchly being performed at the Moore School of Engineering. Von Neumann was interested in the ENIAC and began making regular visits to Pennsylvania and later joined Eckert and Mauchly to assist in the ENIACs successor, the Electronic Discrete Variable Automatic Computer (EDVAC). In 1945 Von Neumann published the *First Draft of a Report on the EDVAC* outlining the stored program architecture that is better known as the **von Neumann architecture**.[9]

Three pioneering efforts have been described here, the Mark I, the ENIAC, and von Neumann and the EDVAC. It is well documented that IBM funded and built the Mark I for Harvard but IBMs connection with the ENIAC and the EDVAC is not as concrete. What is not as well documented is that von Neumann was hired by IBM as a consultant in 1951.

"'It was very farsighted of Thomas J. Watson, Jr., that he took an extremely active interest in the IAS computer and made von Neumann a consultant to IBM just at the time that the 701 was being developed."'[10]

Another fact that is not widely published is that after von Neumann's passing in 1957 the computing projects at the IAS ceased and Goldstine who was also at IAS and worked on the ENIAC left and went to work for IBM. Herbert Goldstine later became the founding director of the Mathematical Sciences Department in Research at IBM.[10] So, if IBM did not see the potential for commercial computers when working with Aiken, one could deduce that they certainly caught on quickly since they later collaborated with von Neumann and hired on Goldstine.

The IBM 650

On July 14, 1953 the model 650 was announced by IBM and the first machine was delivered on December 8,1954. The 650 could store 2000 words in its magnetic drum and could perform approximately 78,000 additions or subtractions per minute, 5,000 multiplications per minute (multiplier = 5,555,555,555), 3,700 divisions per minute (divisor = 5,555,555,555), or 138,000 logical decisions per minute. The 650 also had a floating point add-on that could perform approximately 35,300 floating additions or subtractions per minute (4 shifts), 6,000 floating multiplications per minute (multiplier = 55,555,555), or 3,800 floating divisions per minute (divisor = 55,555,555)

The expected number of 650's to be installed was 50 but within two years there were 21 650's installed in the universities alone and by 1959 there were 59 universities that had one. [1] In total the number of 650's delivered was nearly 2000. No other electronic computer had been produced in such quantity. The IBM 650 was used for a variety of applications some of which are listed below. [2]

Uses of the IBM 650
Calculation of insurance sales personnel commissions
Market research analysis
Payroll processing
Missile design
Customer billing for a utility
Oil refinery design and engineering calculations
Analysis of flight tests made by supersonic aircraft
Actuarial computations
Centralized branch store accounting
Forecasting heart victims
Highway traffic safety
Planning profitable farm uses
Dairy herd improvement
Aircraft parts reliability
River studies
Highway engineering
Management decision game
Analyzing drug tests

The IBM 650 was also popular in the universities due to the educational grant that offered commercial equipment at discount prices. The original grant plan offered a 20 percent discount to universities, however Galler proposed a more aggressive discount structure. The 20 percent discount was still applicable, but if a numerical analysis or data processing class was offered then a 40 percent discount was awarded and if a university offered both a numerical analysis and a data processing class then equipment could be rented for 60 percent off.[3]

[2] Information obtained from the IBM Archives

The IBM 650 and the universities

The IBM 650 impact on universities was quite profound. It was mentioned earlier that as Grace Hopper was programming the Mark I she came to realize the usefulness of sharing programs within the machine boundary. The IBM 650 took this one step further and facilitated sharing across university boundaries. Since the 650 was so popular researchers at one university could share their programs with researchers at another university. A number of historians have commented on the impact of the IBM 650 and the Educational Grant Plan. In attempt to demonstrate the impact of the IBM 650 a few quotes are supplied here.

"‘The most important impact on university programs in these areas has been the educational program of IBM."’[1]

"‘The single strongest impulse for introducing computers on campuses in the mid-1950s did not come from the schools themselves or from any federal agency, but instead from IBM."’[2]

"‘Apparently computing courses got started in universities largely because IBM donated about 100 "free" computers during the 1950s, with the stipulation that programming courses must be taught. This strategy made it possible for computing to get its foot in the academic door."’[11]

"‘The IBM 650 had certainly played a crucial role in laying the foundation for computer science education at Stanford."’[12]

"‘It can be seen that the IBM 650 at Carnegie Institute of Technology played a significant role in the early research ... because it provided the occasion for developing the first widely used list-processing language, and a facility for training many early computer scientists in the concepts and skills required for using computers to do complex information processing."’[13]

"‘Other equally good commercial drum machines were available, but it was the IBM 650 that opened the tool of digital computation to American universities. A major contributing cause was the generous and farsighted grant of 60 percent rental provided by IBM."’[14]

"‘One can only guess how much later such computer science departments might have been established if the 650 hadn't been so readily available."’[3]

Existing literature suggests the the 650 had a great impact on universities however there is currently no literature that tries to show any correlation between early computer science departments and whether or not a 650 was installed at that university. The following figure is a list of colleges that had an IBM 650 obtained from the IBM archives. As part of this study this list was compared with the list of early computer science departments.[3]

Colleges with a 650 installed
Carnegie Institute of Technology, August 28, 1956*
Case Institute, Cleveland, Ohio*
Cornell University, Elmira, New York, February 3, 1957*
Drexel Institute of Technology, November 20, 1958
Illinois Institute of Technology, Chicago, Illinois*
Indiana University, Indianapolis, Indiana*
Iowa State College Statistical Laboratory, March 9, 1957
Massachusetts Institute of Technology, Cambridge, Massachusetts, February 29, 1960*
New York University College of Engineering, January 22, 1957
North Carolina State College, Raleigh*
Ohio State University, June 21, 1956*
Oklahoma A M College, Stillwater*
Stanford University*
University of California (3)*
University of Houston, Houston, Texas*
University of Michigan, Ann Arbor, Michigan*
University of Pittsburgh, Pittsburgh, Pennsylvania*
University of Rochester*
University of Wisconsin, Madison*
Washington University, St. Louis, Missouri*
Wayne University, Detroit, Michigan*
Yale University, November 17, 1958

University	Founding Date	650 Installed
Purdue University	1962	Yes
Miami University	1963	Unknown
University of Wisconsin - Madison	1963	Yes
University of Illinois at Urbana Champaign	1964	Yes
University of North Carolina	1964	Unknown
University of Virginia	1964	Unknown
Carnegie Mellon University	1965	Yes
Cornell University	1965	Yes
Stanford University	1965	Yes
The University of Iowa	1965	Yes

[3] The computer science department founding dates was obtained from http://www.cs.sunysb.edu/welcome/history/FoundingYears.html

University	Founding Date	650 Installed
University of California, Santa Cruz	1968	unknown
University of Central Florida	1968	unknown
University of Kansas	1968	Yes
Washington University in St. Louis	1968	Yes
State University of New York, Stony Brook	1969	unknown
California Polytechnic State University	1969	unknown
Iowa State University	1969	unknown
Michigan State University	1969	unknown
Montana State University	1969	unknown
West Virginia University	1969	unknown

The preceding tables appear to show some correlation that universities that had 650's tended to have a computer science department before those universities that did not have a 650. Of the first ten computer science departments in the 60's, seven have been confirmed to have a 650 installed. Of the last ten computer science departments in the 60's, only two have been confirmed to have a 650 installed.

In summary, the 650 facilitated sharing of software on a level that has not been seen before and there is also support from many other authors indicating the impact of the 650 on universities. Also, the fact that seven out of ten of the first computer science departments had 650's installed seems to indicate that the 650 had an overwhelming impact on the formation of computer science as an academic discipline.

Industry Involvement in the development of the Curriculum

The development of the computer science curriculum from the 50's to the 60's can be broken down into three categories. Pioneering departments of the early 60's did not have any formal recommendations to go by, nor was there an abundance of teachers or resources to go around. This period of curriculum development is somewhat ad hoc and based on resources of the individual universities and interests of the faculty. IBM did have an impact on this ad hoc period of curriculum development due to the stipulations in the Educational Grant plan. So, if a university wanted a 650 at the best price then they would add a data processing and a numerical analysis class to the schedule. In his 1959 publication, Fein also states that "'The scramble to get in on a free 650 computer from IBM is a disgrace in some cases. Course titles and contents have been created on the spur of the moment to fit IBM requirements."'[1]

The second period of curriculum development seems to come in the mid-60's with a seminal article from the **Communications of the ACM**. In 1965 the ACM Curriculum Committee produced a report titled *An Undergraduate Program in Computer Science - Preliminary Recommendations.*[15] The work was a result of three years of work attempting to understand the needs for a computer science curriculum. The committee recommendation for required courses was largely focused on mathematical theory however, recommended electives included Logic Design and Switching Theory, Analog Computers, and Electronics. So, there was some emphasis on electronics and hardware. The formal committee consisted of nine participants from universities around the United States, there was no industry representation credited in this article.

Finally in 1968 formal recommendations are produced by The ACM Curriculum Committee. The report titled *Curriculum 68 - Recommendations for Academic Programs in Computer Science*[16] is an evolution of the preliminary recommendations of 1965. This report emphasized mathematical theory to a greater extent and de-emphasized the hardware and electronics classes originally recommended in the 1965 report. For example, the following table summarizes the recommendations for the applied hardware portion of the curriculum. It is interesting that there is no longer an electronics class or anything that really resembles a hardware class except for *Digital and Pulse Circuits*.

APPLIED HARDWARE
Data Structures
Models of Computation
Computer Design and Organization
Computer and Operating Systems
Computer Graphics
Optimization Theory
Mathematical Logic
Digital and Pulse Circuits
Coding and Information Theory

The report acknowledges sixty-four contributors, eleven of which represented commercial companies including IBM, Bell Labs, GE, and RCA among others. So, seventeen percent of the contributors were from industry which seems to indicate a sizable representation and that industry and universities felt similarly that there should be an emphasis on mathematics and theory. Fein supports this view in a 1973 short where he states "'Virtually all department heads in the companies I interviewed stated that they wished their applicants to have a particular kind of theoretical background; they themselves would provide the practical experience and training — in hardware and software; in large systems and small."'[17] So, Curriculum 68 had industry representation and the IBM educational grant plan had some impact on the early developments of the computer science curriculum.

Other articles studied seem to uncover some dis-satisfaction with the 1968 recommendations from both industry and from universities. For example, in the 1968 **ACM Turing Award Lecture**, R. W. Hamming states that "'Without real experience in using the computer to get useful results the computer science major is apt to know all about the marvelous tool except how to use it."'[18] Other articles voice similar concern, some quotes are supplied for support. One article surveyed twenty-five universities[19] and another cited reactions from industry professionals.[20]

"'The average curriculum ignores the largest sector of the computer-using community namely business"'[19]

"'Some computer science departments have done such a magnificent job of de-emphasizing the importance of the experimental laboratory in their program that their graduates emerge thoroughly unprepared to tackle the intricacies associated with design work in the real-life world - both in software and hardware."'[21]

"'From my contacts in industry it has been disappointing to observe some recent M.S. students who have been trained in the theoretical aspects of computer science but who were not able to apply their training to the solution of practical problems facing industry."'[20]

It has not been determined if this is contradicting information coming from industry or it is another part of the evolution of the curriculum development. This is something left for future work. However it is clear that the Educational Grant plan did have some impact on the curriculum development since if the universities wanted a 650 they had to offer data processing and numerical analysis classes.

Conclusion

This study examined the industry involvement in the universites from the 1930's to the 1960's and has shown that IBM was involved with early pioneers such as Howard Aiken, Herman Goldstine, and John Von Neumann to name a few. The Educational Grant plan of IBM had a great impact on introducing computers to universities and there also seems to be some correlation between universities that had 650's being the first to start computer science departments. The impact of the 650 was not only the sheer number installed, but this also facilitated sharing of information like never before. The study also highlights some industry involvement with the curriculum development although further investigation is required in that respect.

It might be said that IBM exists today because of the experience obtained from its involvement with early university computing environments and the collaboration with great scholarly minds. However, the universities needed industry too. The universities needed a company like IBM to create a general, reliable, and inexpensive computer to crystallize the field of computer science. In attempt to not overstate the claim, if IBM had not been the first to mass produce a commercial computer than some other company would have and this paper would most likely be talking about some other company and some other system. As Fein stated in 1957 the computer should be the supplement and IBM and the model 650 did just that, it made the computer the supplement. Therefore, this study concludes that industry support of university computing environments, namely the IBM 650 and the Educational Grant Plan that offered commercial computers at discount prices made the computer the "'supplement"' and unified the different fields with interests in computing machinery into the distinct field of Computer Science.

Future Work

There are many interesting avenues that one could take to build upon this work. The author of this paper is most interested in expanding the study to cover Canada, Europe, Germany, and other countries. It would be interesting to see if industries in the respective countries played similar roles and how that affected computer science as a discipline in other countries. Another extension that interests the author is to study more closely the industry involvement in creating a computer science curriculum. As discussed, there appears to be some level of involvement in helping to create a computer science curriculum, examples being the IBM Educational Grant Plan requirements for data processing and/or numerical analysis classes and the industry representation on the Curriculum 68 committee from the ACM. However, there seem to be a number of interesting remarks from young professionals and others that state the unprepared-ness of students entering the workforce. This seems to be conflicting information coming from industry professionals, on one hand there is talk of a theoretical emphasis and on the other there is talk of students not being prepared to tackle 'real-world' problems facing industry today. It would be interesting to study this area more closely and see exactly what industry expects of students coming out of universities.

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