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Donald Ervin “Don” Knuth

Donald Ervin “Don” Knuth was born on January 10th, 1938, in Milwaukee, Wisconsin to Ervin and Louise Knuth. He went to Lutheran high school where his father also taught at. His father also played a very important role in determining Donald's interests, and it was through his father that that Donald gained his love for education, music, and mathematics. While in high school, Don entered a competition set up by Ziegler, a confectionary manufacturer. The goal of the contest was aimed to see how many words could be made with the letters of “Ziegler’s Giant Bar.” Don found 4500 words; however, the judges of the competition had only found 2500, Knuth was the clear winner. Knuth received a scholarship to attend Case Institute of Technology in Cleveland, Ohio, where decided to major in physics. He was a man that had a passion for programming. He even stated in an interview, “It’s like I wake up in the morning thinking I’ve got to write a program” (The Art Of Computer Programming 1).

During the summer between his freshman and sophomore years, Knuth worked in the statistics lab drawing graphs, punching key cards, and using a card sorter. At this time, he spotted the newly installed IBM 650 computer. At some point in his undergraduate career, he decided that he would switch his major to mathematics. He would use his passion in mathematics and computer science to continue to write computer programs. Specifically, he created a program to analyze the performance of the college basketball team that he managed. “Knuth was so good at mathematical studies at Case that the faculty awarded him an M.S. in mathematics when he finished his B.S. work” (Walden 1). .Knuth was also awarded two fellowships, a Woodrow Wilson Fellowship and a National Foundation Fellowship. Knuth decided to attend the California Institute of Technology in order to purse his PhD in mathematics. While in graduate school, Knuth consulted and wrote compilers. In January 1962, Addison-Wesley asked Knuth to write a book about compilers. Don sketched twelve chapters and signed a contract. This was the beginning of Don’s long career as an author.

During his time as a PhD student, Don read many technical articles, and he saw that there was a need for someone to write a book which organized and reliably presented what was known in the computer science filed. Knuth used his writing abilities and his instincts for organization to write such a book. He used a quantitative rather than qualitative approach, and emphasized the creation of programs that are beautiful. The book reaching 3,000 hand-written pages, Addison-Wesley decided that the book should be reorganized into 7 volumes, with a chapter or two per volume. The first four volumes are based on concepts and information structures, random numbers and arithmetic, sorting and searching, and combinatorial algorithms. Volumes 5-7 are based on more compiler specific chapters such as lexical scanning and parsing, context free languages, and compiler techniques. Volume 1 of The Art of Computer Programming, which will be referred to as TAOCP from here on out, was published in 1968. By 1973, Knuth had published volumes 1-3 of TAOCP emphasized a mathematical approach for comparing algorithms to find out how good a method is. Arguably, the books established analysis of algorithms as a computer science topic in its own right. Knuth has stated that developing analysis of algorithms as an academic subject is his proudest achievement. Following his success in writing, many other accomplishments followed. In 1974, Knuth was awarded the Association for Computing Machinery's Alan M. Turing Award. The collections of technique, algorithms, and relevant theory in these books have served as a focal point for developing curricula and as an organizing influence on computer science.

Knuth has made many contributions to mathematics and computing during his illustrious career. A couple of his contributions include the Knuth-Bendix algorithm and the invention of TeX. The Knuth-Bendix algorithm, an algorithm for computing with algebraic structures, particularly with groups and semigroups. This important contribution, published jointly with his student Peter Bendix in 1970, attempts to solve the word problem in algebraic systems by deriving consequences of given relations to give a complete set. Furthermore, Knuth's invention of TeX, a language for typesetting mathematical and scientific articles. He developed a computer software system for alphabet design. Consequently in 1977, Knuth began developing a new typesetting system to enable high quality computerized typesetting, in particular for TAOCP. This system was announced in his 1978 American Mathematical Society Gibbs Lecture entitled *Mathematical Typography*. “Knuth had two goals for his system:

(1) Achieving the finest quality printed documents

(2) creating a system that would be archival in the sense that it was independent of changes in printing technology to the maximum extent possible” (Walden 1). Knuth's system, developed with help from Stanford students and colleagues, had three primary components: the TeX typesetting engine, the METAFONT font design system, and the Computer Modern set of type fonts.  Combined, these revolutionized digital typesetting. Knuth made his code publicly available, and it has been widely adapted by commercial typesetting systems. Knuth put hooks in his TeX engine so that others could make additions, with the condition that any resulting system be give a different name. That produced a vibrant, worldwide community of users and developers for TeX and related systems like LaTeX, ConTeXt, and LuaTeX. Knuth's TeX was an early success story for the free and open-source software movement. Knuth thought his typesetting work would take a year or two, but it was not until 1990 that he announced that he would make no further changes to his systems except to correct serious bugs. Additionally, he developed the KMP algorithm. The KMP Algorithm is a linear time string matching algorithm. The KMP algorithm was conceived by Donald Knuth and Vaughan Pratt and independently by James H. Morris in 1977. KMP keeps the information that naïve approach gathered during the scan of the text. By avoiding this waste of information, it achieves a running time of O(m+n).

According to Knuth, “But I feel the biggest thing that I developed was the mathematical approach to compare algorithms in order to find out how good a method was so I worked out quantitative ways you could say that one program is going to be, say, 2.3 times better than another one and the mathematics that goes with it and it’s called the analysis of algorithms. It’s what I’m most proud of - in developing an academic subject, but it’s key to the successful use of the machine” (The Art Of Computer Programming 1). At Stanford he supervised more than 30 PhD students. He created important courses such as *Analysis of Algorithms*, *Concrete Mathematics*, and the legendary *Programming and Problem Solving Seminar*. In addition to his own teaching and research, Knuth has served the computing community on professional society committees, as an invited lecturer on many occasions, and on the editorial boards of more than 30 technical journals. He is the holder or co-holder of 5 patents. Knuth considers TAOCP his masterwork, and in 1993 he retired early to spend more time writing additional volumes. He had produced revised editions of volumes 1-3 in 1978-1979. He designed a new hypothetical computer to replace the MIX computer of volumes 1-3 for the analysis of algorithms; this new computer was described in Knuth's 1999 book devoted to the topic. Knuth began releasing volume 4A of TAOCP, on combinatorial algorithms, in fascicles ranging from 128 to 250 pages. In early 2011 the 921-page volume 4A was published, but the later parts of chapter 7 were reserved for future volumes. Donald Knuth is one of the preeminent computer scientists of our time. He has made major contribution to many areas, in effect pursuing multiple simultaneous and serial careers, any one of which would be a proud lifetime achievement for other people. He credits much of the success of his work to combining theory with practice. Knuth is the rare theoretician who writes many lines of code every day. Programming is an art he practices often.

Works Cited

"The Art Of Computer Programming." Interview by Donald E. Knuth. *The Chartered Institute for IT*. BCS, June 2011. 19 July 2013. <http://www.bcs.org/content/conWebDoc/40462>.

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