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Ubiquity Symposium

The Science In Computer Science

Opening Statement

by Peter Denning

Editor's Introduction

The recent interest in encouraging more middle and high school students to prepare for careers in science, technology, engineering, or mathematics (STEM) has rekindled the old debate about whether computer science is really science. It matters today because computing is such a central field, impacting so many other fields, and yet it is often excluded from high school curricula because it is not seen as a science. In this symposium, fifteen authors examine different aspects from what is science, to natural information processes, to new science-enabled approaches in STEM education.

Peter J. Denning
Editor

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The recent interest in encouraging more middle and high school students to prepare for careers in science, technology, engineering, or mathematics (STEM) has rekindled the old debate about whether computer science is really science. It matters today because computing is such a central field, impacting so many other fields, and yet it is often excluded from high school curricula because it is not seen as a science.

The same debate comes up in research, where critics accuse us of trying to get by without adequate experimental testing of our hypotheses. An early example of this criticism came in 1995, when Walter Tichy and his students at the University of Karlsruhe analyzed more than 400 research papers in software engineering; only 40 percent of those with testable claims actually ran the tests. A recent example came in 2012, when ACM President Vinton Cerf asked why we do not make more use of experimental methods to understand complex software systems and make them more reliable. These two critics are not alone in believing that we are not living up to our claim to be a field of science. They believe we would be much better off it we did.

Science Since the Beginning

Whether computing is a science has been a persistent question since the beginnings of the field in the 1940s. The pioneers who planned and built the first electronic computers were strongly motivated by visions of computers helping science. The first computer science departments, formed in 1962 at Purdue and Stanford, were staffed with faculty who had strong interests in supporting science with computing.

As other universities started to form their own CS departments, skeptics challenged whether the new field was really a science and whether it was different enough from electrical engineering or mathematics to justify a separate department. In 1967, Allen Newell, Alan Perlis, and Herbert Simon famously defended the new field as a true science concerned with all aspects of "phenomena surrounding computers." In 1969, Simon went further, arguing in a famous book, *Sciences of the Artificial*, that several fields, including economics and computer science, met all the traditional criteria for science, and deserved to be called sciences even if their focal phenomena are "man-made as opposed to natural."

The early pioneers realized their big visions could not be attained without reliable computer systems and networks. The engineering challenges of doing so were immense and soaked up much of the energy of the young field. The focus on computer system engineering lasted well into the 1980s and seemed to provide grist for the critics of computing's claims to be a science. When I was ACM President, I backed ACM's efforts to help the U.S. National Science Foundation establish programs in experimental computer science. In 1980 I wrote that the experimental method is essential in computer science, and a year later that the subfield of performance modeling and prediction exemplified the ideals of science.

A renaissance began in the 1980s. It did not come from within, but was forced on us by strong external events. Science visionaries from many fields saw ways to employ high-performance computers to solve "grand challenge" problems in science. They said computing is not only a tool for science, but also a *new method of thought and discovery in science* (i.e., computational thinking). Biologists, such as Nobel Laureate David Baltimore, began to claim that biology had become an information science. Soon scientists in many other fields were reaching similar conclusions. In 2008, Kari and Rozenberg wrote an excellent overview of natural information processes that intersected with computer science. The old lament that computing dealt solely with artificial information processes went by the wayside. Research funding agencies devoted substantial resources to computational science. Collaborations between computer scientists and other scientists rose sharply.

Within computing, experimental methods have regained their stature because they are the only way to understand very complex systems and to discover the limits of heuristic problem solution methods. New fields heavily based in experimental methods have opened up: network science, social network science, design science, data mining, and Bayesian inference, to name a few.

This brief history suggests computing began as science, morphed into engineering for 30 years while it developed technology, and then entered a science renaissance about 20 years ago. Although computing had subfields that demonstrated the ideals of science, computing as a whole has only recently begun to embrace those ideals. Some new subfields such as network science, network social science, design science, and Web science, are still struggling to establish their credibility as sciences.

The 30-year lull of interest in computing science, and the dearth of leadership voices advocating computing as science, coincided with trends in education away from the STEM fields. With the recent resurgence of interest in STEM education, we are facing a high-school system that resists expanding attention to computing. The high-school system often seems convinced that computing is about keyboarding and coding, but not about science.

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