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COMPUTER MODELING OF SCIENTIFIC AND MATHEMATICAL DISCOVERY PROCESSES[1]

BY HERBERT A. SIMON[2]

Just forty years ago, in Chicago, John von Neumann delivered the eighteenth Josiah Willard Gibbs Lecture. His topic was the ergodic theorem and statistical mechanics. Within a month of that occasion, he and his colleague, Oscar Morgenstern, published their seminal work, *The theory of games and economic behavior*, applying discrete mathematics to problems of bargaining and competition in economic and social affairs.

Neither lecture nor book gave any hint of von Neumann's new preoccupation with the electronic digital computer, which had begun in the summer of that same year, 1944. We were then standing on the very brink of the computer era, and within a decade some of us found, in the new computer programming languages, a novel mathematical formalism that seemed ideally suited to building and testing theories of human decision making and problem solving. Some of us became so intrigued with the power and possibilities of these new languages that we largely adopted them in place of the older formalisms of applied mathematics—derived from analysis, discrete mathematics, topology, and logic—as our principal tools of theory formulation, especially in cognitive psychology.

Programming languages as formalisms. In this paper I should like to show how the new programming languages can be used to express theories of human problem solving; and I shall take as my domain of examples, theories about problem solving that require applying mathematics to empirical phenomena. Hence, the paper will have two intertwined, and perhaps incestuous, themes: the first concerns the processes for applying mathematics; the second concerns computer programming languages as mathematical formalisms for expressing theories of such processes. So we shall deal with mathematics applied to the theory of how mathematics is done.

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[1] The Josiah Willard Gibbs Lecture presented at the 90th Annual Meeting of the American Mathematical Society in Louisville, January 25, 1984 under the title *Computer programs that model the process of scientific and mathematical discovery*; received by the editors April 23, 1984.

[2] The publications on which a large part of this Gibbs Lecture are based are the product of the BACON project, in which Patrick W. Langley, Gary L. Bradshaw, Jan Zytkow and I have been engaged over the past five years. I want to acknowledge the partnership of these colleagues, while absolving them of responsibility for the particular form that this exposition of our work takes.

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