# AN EVALUATION OF INTRODUCTION TO COMPUTER SIMULATION: THE SYSTEM DYNAMICS APPROACH

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## Introduction

With the goal of introducing system dynamics to high school students, a set of six learning packages were written during the 1979-80 academic year under Grant Number GOD7903439 from the US Office of Education. Co-authors of the material are Nancy Roberts, David Andersen, Ralph Deal, Michael Garet, and William Shaffer. The evaluations from pilot testing done during the grant year in six Greater Boston high schools suggest that the materials indeed can effectively accomplish this introductory role. The teachers involved generally made very positive comments about both the value of system dynamics as an exciting high school subject as well as the appropriateness of the particular materials. [1]

This past year the authors have been negotiating with publishing companies for the publication and distribution of the materials. In addition, several other people have used the new curriculum. This paper attempts to summarize the evaluation of this past year's use of the materials as well as to describe the form in which they will be published by Addison-Wesley.

## Selected Case Studies

Groton School. A physics and a mathematics teacher from the Groton School, an independent high school in Groton, Massachusetts, used the materials to create a new two-year applied mathematics curriculum for junior and seniors. The two year sequence is equivalent to three years of high





school mathematics. The course is open to anyone who has completed a pre-calculus course.

The course begins with an introduction to computer programming in BASIC using Apple II microcomputers. System dynamics is next introduced. The students are taken through the learning package materials up to and including the first full model in package six, the Kaibab Plateau Model. The SYSDYN Package, a BASIC program that allows students to write table functions and get plotted outputs for their models, is used. The rest of the first year consists of teaching differential calculus, an introduction to probability and statistics, and an introduction to integral calculus. The final project of the first year is the Flu Epidemic Model, the second modelling exercise in package six.

The second year consists of linear algebra, enough calculus to complete the CEEB BC calculus syllabus, and an introduction to differential equations. In addition, a minimum of one more system dynamics model from package six is covered.

The Groton course in applied mathematics is held together by system dynamics. First, system dynamics gives students some powerful problem solving techniques. Second, it serves as an excellent introduction to mathematical modelling. Third, the concepts of rates and levels pave the way for derivatives and integrations and for differential equations. Finally, system dynamics gives students some concepts, problem solving strategies, and mathematical skills that can be used in many other disciplines at Groton.

Simon's Rock. The learning pachages were used in a course called System's Seminar, a required course for juniors or seniors who are either environmental or computer science majors. This course was also taught using BASIC because DYNAMO is not available for the Digital Equipment Corporation's

PDP8. All but one of the students had some computer background. The student who had no previous computer course had the most difficulty with the material. The learning packages were the only text used in the course. The instructor translated package V, "Introduction to Simulation", into BASIC. The students went through the first five learning packages and the Kaibab Plateau Model in package VI in one term. The instructor found the packages to be "tremendous teaching devices". The students found the materials clear and well written even though they were obviously intended for a younger audience.

Boston University. Learning packages one through five were used in a one term, undergraduate introductory sociology course along with a sociology text. The students worked through packages I to IV on their own. When they got to package V, they were given a running model of the general negative loop shown in Figure 1. Their assignment was to apply this general model to a specific problem to which they personally could relate. Figure 2 is an example of a specific application of the general model.

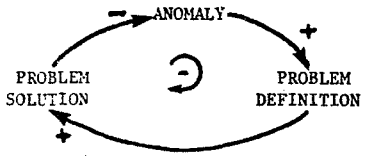


Figure 1. General Problem Statement

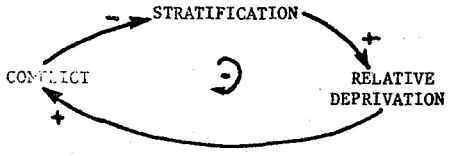


Figure 2. Specific Problem Statement: One Person's Reaction to Another



The validity check was "Does the model output make sense in comparison to what actually happens in your life?"

The evaluation by the professor was that system dynamics has the potential around which to structure a whole undergraduate curriculum. In fact, he is attempting to organize a faculty committee to consider just this. He felt the learning packages as written were too repetitious for college level use and could be tightened up considerably. Again, the students running into difficulties were those with no previous computer experience.

MIT. The materials were used for a required course in the Sloan Fellows Program, the middle management executive training program. The materials were chosen for the course because the professor saw them as a way to teach the Sloan Fellows to actually build system dynamic models. For the past fifteen years only a small percentage of the class actually went on to model building. The goal this year was to have the entire class get through at least one modelling project in package VI.

Over the years, most Sloan Fellows had seen little relevance to their concerns of system dynamics. This feeling did not change this year. In addition, except for the people from government agencies, the rest of the class, primarily from industry, did not like these particular materials because:

1. the general subject matter of the examples was not on problems relevant to them;

2. the underlying tone of the examples is ecological and environmental, which, for the past ten years, has been perceived as anti-industry preaching.

In spite of all these problems, the quality of the term projects was very good, with far more widespread accomplishment than in any other previous year. In addition, the final tests demonstrated significant learning had been achieved. Next year the semester-length course will become elective, with

several required introductory sessions as part of the Decision Models course. The professor plans to use the materials again but because the class will be self-selected, does not anticipate encountering the problems with subject matter of the examples or relevance of system dynamics.

Revisions and Publication Plans

The six learning packages are being published as a college text by the computer science division of Addison-Wesley. However, the book will also be marketed by Addison-Wesley's high school division. Book distribution and promotion will be coordinated with Addison-Wesley's production and distribution of DYNAMO for the Apple II microcomputer. In light of the fact that the primary audience is now seen as college undergraduates, the following revisions are being made by the authors:

1. The tone of the material is being changed. It will be more formal in the language used and some of the repetition included for high school students will be eliminated.

2. The audience for book adoption has been reassessed as comprising a wide range of faculty teaching in the social, policy, and administrative sciences. There will be some changes in the subject matter of the exercises and examples to reflect the interests of this group.

3. More explicit discussion will be added throughout the text relating system structure to system behavior. A new chapter is being written for package V that will give students a series of small models chosen to illustrate a variety of simple structures and their resulting dynamic behavior. Publication date of both the book and the Apple II version of DYNAMO is scheduled for next spring.





REFERENCE

1. Roberts, N. "Developing An Introductory Curriculum in System Modelling and Simulation: The System Dynamics Approach," Technology Forecasting and Social Change, scheduled for publication, Fall, 1981.