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Microcomputer-based Models and Modeling Systems Software for Educational Planning

A Qualifying Paper
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INTRODUCTION

Purpose

The purpose of this paper is to review the literature and assess the state of the art of microcomputer-based models and software that supports modeling of the structured and semi-structured problems that concern planners, policy-analysts, and decision-makers at the institutional and national levels in education; e.g., target-setting models including models for demographic analysis and enrollment projection, resource allocation models, financial planning models, models for studying educational effects, etc.[1]

The study will yield two types of information. The first is descriptive:

(1) Identification and description of some of the more popular and currently useful languages and modeling systems available for the construction of planning-related models in education, and

(2) Identification and description of problem- and institution-specific models that could be made more broadly useful in educational planning.

The second type of information is more analytic in nature:

(1) A general review of the state of the art of microcomputer-based modeling in education and analysis of models and modeling systems characteristics,

(2) Assessment of the relative strengths and weaknesses of varying approaches to model

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[1] Specifically not included in the current review is consideration of project management software, highly specialized software that permits the modeling of both large- and small-scale projects and the allocation and tracking of project resources, i.e., project planning and management.

development and use; e.g., programming languages vs. modeling systems vs. specific-use models, and

(3) Review and assessment of a set of selected programming languages and modeling systems in terms of their utility for educational planning.

Structure

This paper is divided into three main sections.

Section I presents a brief and generalized historical review of planning-related modeling on mainframe and minicomputers. The review covers the period from the mid-1960s through the introduction of VisiCalc, the first spreadsheet modeling system for use on microcomputers. The review begins with a general discussion of model use in educational planning and includes a subsection on spreadsheet-based modeling. The review provides a basis for examining current modeling efforts on microcomputers.

In Section II microcomputer-based modeling in educational planning is reviewed with attention to the variety of modeling systems approaches that are available. Specific models and modeling software are introduced in this section with references to more detailed reviews of selected models and software that are included in the Appendix.

In Section III, a general review of the evolution of decision support systems (DSS), the role of models in DSS, and an introduction to "prototyping" and "iterative design" are presented that provide insight into the directions modeling is evolving.

AN HISTORICAL REVIEW OF COMPUTER MODELING IN EDUCATIONAL PLANNING

Introduction

Models were used by educational planners and policy analysts to facilitate better planning decisions well before computer-based modeling came into general use. Most models are implicit - outlined or understood in general terms, but not necessarily expressed in specific detail. Implicit mental models form the basis for most decision-making. Models may be expressed explicitly using words, symbols, graphs, geometric representations, maps, physical materials, or sketches.[2] Regardless of the form they take, making a model explicit involves "...taking one's implicit model of reality and systematically recording its assumptions -- the values of, and relationships among, the various factors influencing the problem, the constraining aspects of the real world situation, and the possible courses of action available..."[3] Model building involves "...synthesizing known facts, theories, and judgments into a meaningful pattern."[4]

Computer-based modeling, as developed and used by educational planners over the last two decades, has been designed to represent highly structured activities, processes and

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[2] Hopkins and Massey, 1981; Davis, 1980.

[3] Bloomfield and Updegrove, 1981.

[4] Hopkins and Massey, 1981.

problems, or selected aspects of more complex semi-structured problems. Educational planning models are built as operational conceptualizations of the complex of factors and interrelationships that comprise and "drive" educational systems.

Models and the process of model building can be of value in a number of significant ways.[3] Models, when implemented can:

(1) Aid more consistent and accurate analysis, particularly for more structured problems;

(2) Permit the consideration of a greater number of alternatives;

(3) Help to clarify the limits of existing data;

(4) Encourage consideration of the future; and

(5) Encourage and support policy-related dialogue.

Involvement in the process of model construction can:

(1) Lead to a greater understanding of the system or problem being modeled;

(2) Improve communication among policy makers, planners, and others who may be effected by the outcomes of the model; and can

(3) Lead to a sense of intellectual control over the model, e.g., a greater sense of the model's strengths and limitations.

In the broadest sense, models may be characterized as either heuristic or algorithmic.[4] Heuristic models are those used to explore broad, open-ended problems involving a significant degree of qualitative judgment. Their purpose is the

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[3] Bloomfield and Updegrove, 1981; Kirchling, 1976; Hopkins and Massey, 1981; Davis, 1980; Bryan & Natella, 1985.

[4] Fox, 1972; Davis and Hudson, 1980.

identification of salient issues, the discovery of conflicting points of view, and the development of strategies that accommodate divergent opinions and interests. Algorithmic or mathematical models are employed when factors central to the problem of concern are predominantly -- although not exclusively -- quantitative in nature, and the relationships among factors can be expressed in arithmetic or algebraic form.

Models developed on computers have, until recently, been almost exclusively algorithmic. The reason for this is that algorithmic models take advantage of the primary utility of computers, which is the manipulation and processing of large volumes of data at extraordinary speeds. However, recent advances in computer graphics and printing capabilities and emerging "dynamic systems" software and "expert systems" approaches, e.g., the codification of rules of thumb, have made the development of some computer-based heuristic models possible.

Two kinds of algorithmic models have been used frequently in educational planning -- optimization models and simulation models.[7] In optimization models the objective is finding an optimal solution, e.g., maximizing output or minimizing cost, from among a set of variables. Simulation models permit the investigation of alternative solutions or the effects of varying selected parameters or values of variables and assist planners in examining trade-offs among variables, testing the sensitivity of a particular outcome to changes in selected variables

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[7] Masland, 1981; Brinkman, 1984 (in Tetlow); Davis, 1980.

(sensitivity analysis), or in identifying the specific value of a specified variable required to achieve a desired resulting value in another specified variable (goal-seeking). But the most common use of simulators has been for simple "what if" testing; i.e., what will be the effect on the outcome if I change this or that value.

Mathematical models may be further characterized by the specific mathematical technique employed, for example, linear, non-linear or quadratic programming.[8] Most applications of mathematical programming in education have used linear programming to calculate optimal values and then used parametric programming and sensitivity analysis to simulate the effects of changes on the solution and activity levels, .e.g., more or less resources or changes in technological coefficients, e.g., pupil-teacher ratios.

Another common method of categorizing models is by the institutional level that is modeled and/or served by the model. McNamara (1971) uses the broad categories of "macroanalytic" to describe models that address the national or state level, and "microanalytic" to describe models of, and/or models used by, single institutions and local school districts.

Davis (1980) suggests that models may be categorized broadly, in terms of use, by whether they are meant to describe,

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[8] See McNamara, 1971; Schiefelbein and Davis, 1979; Davis, 1980; Masland, 1980, for a more detailed description/definition of the categorization and use of these and other techniques in modeling.

explain, or forecast, but warns that models often serve multiple purposes. Schiefelbein and Davis (1979) and Davis (1980) break uses down into more useful detail as follows:

(1) Comprehensive systems models, which usually contain a series of linked sub-system models;

(2) Target-setting models, which include models for demographic analysis and population projections, models for projecting school enrollments, and models projecting manpower requirements;

(3) Resource allocation models;

(4) Costing and cost-effectiveness models;

(5) Models for administrative and organizational analysis, which include heuristic models of system structure and the design and location of physical facilities;

(6) Teaching/learning models; and

(7) Models for studying educational effects.

Davis (New Volume, forthcoming, Chapter One) provides a multi-dimensioned typology of models by domain, authority, approach, and form.

Computer-Based Modeling in Educational Planning

Comprehensive systems modeling dominated early efforts at computer modeling in educational planning. By the middle of the 1960s, computers made it feasible to link models for population, enrollment, and manpower projections with models for resource allocation, scheduling, and costing to create computerized comprehensive systems models. However, construction of comprehensive planning models was a fairly complex endeavor in the 1960s and early 1970s, requiring a high degree of knowledge

regarding the system being modeled and significant technical programming skills. Early models were developed on an individual basis using programming languages such as FORTRAN.

Comprehensive models can be enormously helpful to policy-makers and planners as an aid to their understanding of how a given system works in the broadest sense. In their more sophisticated forms, e.g., the Schiefelbein comprehensive model of education in Chile,[9] comprehensive models facilitate planning for the simultaneous attainment of multiple social and economic goals and permit the tracking of changes across a large system over time for the purpose of monitoring progress within the system toward the attainment of stated goals.[10] This is accomplished by programming goal targets in both the objective function and constraint equations of mathematical (linear, quadratic) programming models. For example, the objective function can set attainment manpower targets or social goals (providing for the enrollment of all rural females in schools), at minimal cost while staying within the resource constraints of the system.

While they can be very useful, such models tend to be "black box" models. That is, while they permit one to examine quantitative relationships between inputs into the system and outputs and effects from the system, they do not reveal, nor are they specifically concerned with, the details of what takes place

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[9] Schiefelbein and Davis, 1974

[10] Davis, 1980

within the system itself. They do little to indicate to planners what could, or should, be done to attain instructional effects in the most direct manner. These models do not make decisions, nor can they replace judgments. What they do provide is a way of assessing the effects of alternative programs and courses of action (inputs) on broad goals or outcomes.

A "Black Box" Model of An Educational System[11]

INPUTS	EDUCATION SYSTEM	OUTPUTS	OUTCOMES/EFFECTS
Facilities		Learning	Product/Earnings
Equipment	[????????]	Yrs of Educ-	Technology/Scien tifiv Develop.
Instr Materia		# of Grads	Political/Social Development
Teachers		Research & Knowledge	
Students		Soc.Service	

Most comprehensive systems modeling in education at the national level has been for developing nations, and to a lesser extent, Europe. This is explained by the national, centralized school systems which require centralized planning in these countries. Most have been comprehensive national models based on a social demand or manpower planning approach and have been in the form of systems projection models (GDP, population, etc.) or linear program models with elements of dynamic or quadratic

[11] From Davis, 1980, Vol. II, pg.11

programming.[12] Variables of concern include enrollments and resources used/needed at all levels of the educational system and in all types of programs -- primary, secondary, crafts, technical and university -- and education and training outputs that will contribute to the social and/or manpower needs of the country. In contrast, modeling at the national level in the U.S. has been restricted to models of post-secondary education.[13] In all cases the major factors that drive the models have been population dynamics and national manpower needs resulting from economic growth.

Interest and activity in national level comprehensive modeling peaked in the mid-1970s. Despite general agreement among planners and educational managers that modeling at the national level had been of value in some significant ways, a number of problems and concerns plagued model development efforts. Among the common concerns and problems were:[14]

(1) As models become elaborate enough to reflect reality, they become increasingly less understandable, hence, less useful;

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[12] For a more detailed discussion, see Schiefelbein and Davis, 1974, Part I, and McNamara, 1971. McNamara, 1972, provides an extensive bibliography of materials on mathematical programming in education through 1972. Davis, 1980, Vols. I and II cover the subject in depth.

[13] ~~See Dresch, 1975, and Lydell, 1976, for extensive~~ discussion of the two major national level efforts in the U.S. -- The Federal Planning Model of the National Center for Higher Education Management Studies and the Post-secondary Education Finance Model of the National Commission on the Financing of Post-secondary Education.

[14] McNamara, 1971; Schiefelbein and Davis, 1974; Dresch, 1975; Lydell, 1976; Kirshling, 1976; and Davis, 1980.

(2) The high level of aggregation did not permit attention to qualitative elements, for example, the nature of the teaching/learning process;

(3) Models often required vast amounts of data, data that was often not available, inadequate in terms of form, or incorrect;

(4) Rigidity of modeling forms and operational procedures limited changes that could be made;

(5) Models, particularly in the U.S., were built on an assumption of stable growth and did not adequately project labor market changes;

(6) Model outputs were often overly extensive and in a form that limited their usefulness by decision-makers;

(7) Managers and decision-makers often did not possess the analytical skills necessary to understand and use the models; and

(8) Models were highly technical, and as such, expensive to develop and maintain.

The positive features of national level models most often cited include:[19]

(1) Model development requires that assumptions, values, and preferences be made explicit;

(2) Models promote dialogue and communication among planners, politicians, economists, and others;

(3) Linking diverse elements of the educational, social, and economic system often serves to alert planners and decision-makers to critical gaps in services and to the cumulative impact, or competing influences, of varying policy decisions; and,

(4) Models reduce uncertainty to a degree, limiting the range of alternatives that need to be considered by eliminating those that are clearly inconsistent with goals and objectives built into the system.

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[19] Ibid.

While attention to national level planning models has been significant in developing countries, interest, activity, and progress in the development of models for use in educational planning in the U.S. was most dramatic at the college/university level. Efforts began in the mid-1960s to develop large-scale comprehensive cost simulation models for examining the effects on institutional resources of changing operating conditions. Early systems models included CAMPUS (Comprehensive Analytical Methods for Planning in the University Sphere) and RRPM (Resource Requirements Prediction Model). The primary function of these models was to relate activities across levels within the institution to resources required and to provide estimates of total and component costs. Exogenous variables of concern included both those related to organizational policies, as well as those related to external factors, e.g., population demographics, government policies. These early models were significant in that they reduced the degree of technical skills required for model development by providing a uniform format, i.e., a modeling system, within which institution-specific models could be developed. This was accomplished by standardizing procedures for data input and routine financial calculations, predefining relationships between programs and teaching departments and disciplines,[14] and developing an interactive modeling language and dialogue system. To use these systems it

[14] The Induced Course Load Matrix (ICLM) was the method most often used to specify these relationships. See Suslow in Mason, 1976 for a description of the ICLM.

was necessary to be familiar with the system structure and commands but not necessary to know the programming language used to create the modeling system itself. Using RRPM, for example, the user first supplies specific department, course, and student level definitions. Next, instructional types, faculty ranks, staff categories, and other expenditure categories are entered. The user must then provide data on student enrollments and program requirements and data on faculty rank, teaching loads, and contact hours. Lastly, the user supplies a broad range of data on salaries and other operating costs. When all data is entered, the model is "run" and the results (faculty and course sections required, departmental costs, etc.) are calculated. The effects of alternative policies, e.g., changes in admissions standards or program requirements, are tested by changing the appropriate input values and running the model again. A detailed schematic of the logical flow of RRPM is included in Appendix A-1.

Although values could be changed to simulate alternative future states in these earlier models, data requirements were extensive, operation was slow (many were punchcard batch-processed systems), the models were not fully interactive, and comparison of the effects of alternative variable values was often a complex and time-consuming undertaking. In addition, for many users the structures were too rigid, output reports were limited, technical support personnel continued to be essential, and adapting the model to meet user specifications could be

expensive.[17]

In the early '70s many smaller and more flexible models appeared, including SEARCH (System for Evaluating Alternative Contributions in Higher Education), HELP/PLANTRAN, and CAP:SC. These were somewhat more interactive and flexible, but the size of the systems that could be modeled was limited.

Early comprehensive simulation models were only moderately successful at best. Plourde (1976) reports that in a study of 176 users of four early systems (CAMPUS, RRPM, HELP/PLANTRAN, and SEARCH) sponsored by the Center for Educational Management Studies, 57% felt that models were somewhat successful at their institutions. Only 24.6% considered modeling highly successful. Among the most critical elements identified with successful use were:

(1) Organizational commitment at a sufficiently high level,

(2) The model itself, i.e., features included and appropriateness for desired uses, and

(3) The availability of in-house technical expertise.

Those reporting less than successful experiences cited as reasons:

(1) A lack of organizational support, and

(2) A lack of available personnel (an indicator of the degree of organizational support.)

Plourde concluded that what was needed was "more feedback to model builders from users and simplified input and output requirements." He also identified and emphasized the need for

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[17] Bloomfield and Updegrove, 1981.

"considerable effort" in the development of operational data bases that could support the use of models. Perhaps most significantly, Plourde reported that despite less than spectacular success, of those responding (119) to the question, should the use of an analytic model in higher education be fostered, 97.7% responded positively.

Wyatt, Emery, and Landis (1979) attributed the "rather spotty success" of early modeling efforts largely to the failure of models to address the specific needs of individual institutions and to a lack of involvement of decision-makers in the modeling process. The most important characteristics of a good model they suggest include:

(1) Simplicity of design and accurate characterizations of fundamental properties and processes;

(2) Completeness on important issues and explicitness regarding what is excluded;

(3) Ease of control and consistency of procedures;

(4) Stability of performance and outputs;

(5) Output formats that are familiar to decision-makers;

(6) Adaptability to changing needs; and

(7) The model must be easy to communicate with.

Mason (1976) blamed the failure of many modeling efforts on "oversell" by model builders and "overexpectation" on the part of model users. Kirchling (1976) argued that problems resulted from an overemphasis on the techniques of modeling at the expense of attention to the details of problems that models were intended to

address. Lydell (1976) added that emphasis on technique often resulted in the identification of problems that were good targets for modeling, rather than the identification of the most critical problems. For many others "much of the blame for the ineffectiveness of modeling efforts was ascribed to the wide gulf between modelers and policy-makers."[16] Modelers were considered largely concerned with technical details and issues and not always sensitive to the needs of practitioners.

The trend by the mid-1970s was clearly toward increased attention to the needs of the endusers of models. There was greater concern for the decision-making styles and skills of the primary users of models, for closer involvement of decision-makers in the modeling process, and for the development of models and modeling systems that facilitated a greater degree of user involvement in the model building process.

Spreadsheet Modeling Systems

It was with the introduction of spreadsheet-based modeling systems in the late 1970s that truly interactive, flexible, and more realistic modeling arrived.[17] Spreadsheet modeling systems are based on a simple row/column matrix format. Within this general framework model construction is left entirely to the user. Unlike earlier modeling systems there are no predefined system structures. The model builder is free to specify any and

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[16] Updegrove, 1981.

[17] Hopkins and Massey, 1981; Updegrove, 1979.

all variables desired and to define all relationships among the variables. However, typically, in spreadsheet models the first column is used to label and define variable values, and the first row is used to identify time periods. The second column is used to hold base year data with individual cells in the rows containing user defined variable values and/or formulas that define relationships among variables. Columns to the right of the base year are used to project future variable values; and, as in the base year, individual cells in the rows may contain user defined variable values. But more often the values are derived from a set of user defined formulas that relate variables over time.

Use of the matrix format was not the only feature that served to distinguish the first spreadsheet modeling systems from earlier systems. To make specification of the formulas that relate variables easier, spreadsheet modeling systems provide a set of automated mathematical formulas and functions, e.g., for adding and averaging columns of numbers, calculating net present values, developing more complex conditional formulas (if-then), etc. Some spreadsheet modeling systems also include more complex subroutines for such operations as sensitivity analysis, goal seeking, feasibility searches, etc. Additional subroutines are often available for the development of graphs and customized reports. Built-in functions and subroutines serve to free the model builder from the tedium of step-by-step, keystroke-by-keystroke program development. Model construction, including

easy use of built-in system features and the reduction of user input errors, are facilitated by the use of standardized command terminology and operating procedures that define logical and syntactical command structures. Thus it was the use of a matrix format and development of a much more sophisticated modeling language that distinguished spreadsheet modeling systems.

The EDUCOM Financial Planning Model (EFPM) was the first spreadsheet-based modeling system specifically designed for use in educational planning. EFPM was developed as a generalized version of the institution-specific TRADES model that had been developed and proven highly successful at Stanford University.[30] EFPM resides on a mainframe computer at Cornell University and is accessed through EDUNET, a network of university computer centers, and by using Tymnet or Telenet links. EFPM has been used, and is still used, at hundreds of colleges and universities in the U.S. and Europe.

EFPM employs a matrix that is capable of handling up to 560 variables over 12 time periods and contains a broad range of built-in mathematical functions and operational subroutines. Use of the modeling system is facilitated by a set of system menus that correspond to specific operational categories. Menus contain English language words that correspond logically to the function or operational subroutine. The heart of the system is a command menu off of which branch a set of operational menus.

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[30] Updegrove, 1979.

Models are built, alternative values tested, goal seeking, feasibility, impact and sensitivity analysis accomplished, reports generated, etc., by moving from one menu branch to another and invoking desired procedures or subroutines by entering the appropriate keyword in response to the system prompt. EFPM also introduced a capability for testing changes in variable values and/or relationships without necessarily altering the original or "base" model. This was accomplished by the automatic creation of a duplicate of the base model called the "trial." Alternative scenarios were played out in the trial version only. The base model may only be modified by use of a set of specific commands. Appendix A-2 contains a diagram of the EFPM system structure.

Other spreadsheet-based modeling systems were introduced about the same time as EFPM, including MAPSS, EMPIRE, and IFPS (Interactive Financial Planning System). Like EFPM, all are accessed via terminals connected to mainframe or minicomputer timesharing systems. But unlike EFPM, these systems may be purchased and installed on an institution's own mainframe or minicomputer. Of these, IFPS was the most popular in educational settings with EXECUCOM, the developer and distributor of IFPS, reporting it's use in 350 colleges and universities in 1980.

What distinguishes IFPS most significantly from EFPM and other modeling systems is the range of special data/model analysis features that are incorporated into the modeling system.

In addition to "what-if" testing that permits the assessment of changes in both variables or relationships, IFPS also includes subroutines for goal seeking, sensitivity analysis, risk analysis using the Monte Carlo method, and investigating the impact on a selected model variable of changes in other variables.[21]

The rich diversity of applications for which models have been developed using systems such as EFPM and IFPS was unanticipated by their developers.[22] Although originally intended as tools for comprehensive centralized budgeting and forecasting, the high degree of flexibility provided by spreadsheet-based systems allows their use for a broad range of planning problems. In addition to the development of comprehensive institutional models, models have been developed throughout the subunits of many institutions for specific applications including student enrollment projections, faculty distribution and tenure planning, facilities needs planning, financial aid planning, etc.[23]

The development of spreadsheet modeling systems responded to the needs and concerns of planners and administrators for systems that were less technically demanding yet more adaptive to

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[21] IFPS is available in a microcomputer version which is reviewed in more detail, including comparison to the mainframe ~~version, in Appendix B-12.~~

[22] Bloomfield and Updegrove, 1981.

[23] See EFPM User Documentation, 1981, and Bloomfield and Updegrove, 1981, for detail on applications at a number of colleges and universities.

specific individual and institutional needs. Not surprisingly, their introduction resulted in a dramatic increase in the number of institutions that incorporated modeling into their planning processes. Over the past eight years more than 25 spreadsheet modeling systems have been introduced for use on mainframe and minicomputers.[24] Many of the original mainframe and minicomputer systems have been updated to accommodate the construction of larger models and make them easier to use. Using EFPM, for example, it is now possible to include up to 1000 variables and span 20 time periods in a single model and to chose from a list of 99 built-in report formats. These newer systems and updated versions of the earlier systems are still widely used and likely to remain in use for some time to come. They do, in general, continue to offer more advanced model interrogation features, such as goal seeking and sensitivity analysis, and easier access to larger institutional databases than do microcomputers. However, despite the advantages of minicomputer-based systems, use and development of microcomputer-based models and modeling systems has become increasingly popular since the introduction of the spreadsheet-based program VisiCalc.

VisiCalc, the first spreadsheet modeling system for use on microcomputers, was introduced in 1979. Although VisiCalc did not contain any of the advanced model analysis features of the

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[24] See the magazine Hardcopy, November 1985, Vol.14, No. 11, a special issue on financial planning and accounting software.

mainframe and minicomputer modeling systems programs, such as EFPM and IFPS, and the size of models that could be built was limited, it was relatively inexpensive, easy to learn, even more flexible, and could be used on microcomputers, which were far less expensive than minicomputer systems. Perhaps the most significant feature of VisiCalc was it's use of "full screen editing"; e.g., changes and additions could be made at a precise location in a model by moving the cursor freely to the desired location vs. editing from a command line removed from the model proper, that characterized earlier mainframe and minicomputer systems. VisiCalc sparked a revolution in computer-based modeling that, aided by advances in computer hardware and software technologies, continues today.

MICROCOMPUTER-BASED MODELING IN EDUCATIONAL PLANNING

Introduction

Until recently computer-based modeling required access to a large mainframe or minicomputer and a high degree of programming skill or use of one of only a limited set of modeling packages relevant for use in educational planning. Over the past five years, the affordability of microcomputers, their increasing power, and the introduction of advanced programming languages (e.g., Turbo Pascal and True Basic), "application generators" (specifically "modeling software", e.g. VisiCalc, Multiplan, Lotus 1-2-3), and the conversion of some earlier mainframe programs (e.g., IFPS) for use on microcomputers have resulted in the widespread use of computer-based modeling in education. In the few short years they have been available, microcomputers have been used for the development of planning-related models in institutions at all levels of education in the United States and throughout Europe, at the World Bank to address educational problems in Third World nations, by consultants and consulting groups working with the U.S. Agency for International Development (AID), and in a number of institutions and ministries in developing countries.

The most prevalent use of microcomputers has been for the construction of target-setting and costing models of educational systems and subsystems at the institutional and national level. Generally these models have tended to be one of two types --

either "demand-derived models" or "resource or budgetary constraint models." In demand-derived models future enrollments are estimated or projected on the basis of forecasts of economic demand (product growth and manpower requirements) or social demand (population increase and/or value shifts). Resource requirements and costs are derived from these demands based on enrollments and a set of policy and quality input standards, e.g., teacher/pupil ratios, which are the basic input standards that determine costs in many systems. In resource or budgetary constraint models, available revenues and resources are estimated or projected first. Future enrollments are determined on the basis of a set of policies and quality standards, but must fit within user-defined budget and resource constraints. To the extent that inputs and relationships in a given model can be varied, it becomes possible to simulate and compare the effects of alternative scenarios, thus allowing the planner/policy-maker to assess the effects of policy changes and/or changes in available resources, and to test the effects of tradeoffs among programs within budget and resource constraints.

Models have been, and continue to be, developed on microcomputers using both programming languages and modeling systems software. Each approach has particular strengths and limitations which, in the absence of empirical studies, may explain or suggest its use in given situations.

Modeling Using Programming Languages

Applications development using programming languages, particularly of more complex applications, has generally been considered the most difficult approach in terms of the level of programming skill required.[23] Although this remains basically true, recent versions of earlier programming languages, e.g., True BASIC and Turbo Pascal, and more recent languages, such as C, LISP, and Prolog, make the construction, maintenance, and alteration of models using programming languages much easier than it was five years ago.[24] These programs are designed for ease of use and contain interactive, full-screen editors,[27] on-line help and debugging utilities, and a wide range of built-in mathematical functions and subroutines. In addition, they come equipped with on-screen tutorials and extensive documentation and are very inexpensive. Further, they are designed to support, and in fact encourage, modular program development. These new programming languages represent a significant advancement of earlier languages and might more accurately be called "programming development systems." However, to date, most models developed with programming languages have used earlier languages, particularly versions of the BASIC language.

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[23] Liang, 1985.

[24] Crabb, 1986.

[27] Full screen editing refers to the ability to move freely about the computer screen and to make changes at an exact location in the model.

In the hands of a skilled programmer, programming languages permit:

(1) Construction of an almost unlimited range of model applications;

(2) Development of a wide range of user interfaces, e.g., how the model looks on the screen, the character of the dialogue system between the model and the user(including the language used,i.e, English, French, etc.), the form of output reports, etc.; and

(3) Extremely efficient use of computer hardware resources.

With careful development and testing, highly accurate and error-free models can be developed around even the most complex concepts, thus providing highly advanced analytical methods to users who might otherwise not have the benefit of them. On the other hand, as was experienced with early comprehensive models on mainframe computers, such models can take on an aura of mystery, i.e., "black box" models, to those who are not closely involved in their development. Assumptions upon which the models were built and the techniques employed may not be obvious.

In terms of computer resources required, programming languages permit the development of very efficient models. Using programming languages, one need only include in a model those specific functions, subroutines, report formats, etc., that are required. This is in contrast to modeling systems which have, until recently, required space within the computer's main memory to hold all available subroutines and functions, whether they are used in a model or not.

As was true of similar earlier efforts on mainframe and

microcomputers, development and maintenance can be time consuming and expensive.[26] Modeling using programming languages requires a high degree of pre-planning to be most successful. Program structures, including data requirements (although not necessarily the actual data), methods of analysis, and the range of questions/problems that the model addresses must all be carefully predetermined.

Problems that can be characterized as highly structured and conceptually simple and models for use in situations where computer resources are limited seem ideal candidates for model development using programming languages. More conceptually complex problems might also be modeled using programming languages; but a greater degree of care, user involvement in pre-design, particularly of output formats, user education re analytical techniques employed, user training, and readily available user support are suggested by earlier experiences with educational modeling on mainframe and minicomputers.

Programming languages are also appropriate for the development of "teaching or policy-dialogue models," i.e., models that are highly structured for the purpose of teaching specific concepts or generating directed discussions.[27] In such models user interaction points are carefully predetermined and designed to facilitate maximum educational benefits. Such models, or a series of smaller models, might be used to prepare for the use of

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[26] Liang, 1985.

[27] Evans, 1986.

more complex decision models; or, with adjustments, actual models might be adapted for training purposes.

The use of programming languages for model development has been important in national or sectoral planning offices in developing countries, although spreadsheet modeling is more widely used lately. Programming languages have been used to build "generic" national level population and enrollment projection models and more complex models that incorporate the results of projection models into resource allocation and costing models, models for measuring the efficiency of educational systems in terms of student flow rates (promotion, repetition, and dropout). The term "generic" simply refers to the fact that the models, while problem-specific, are intended for use in any of a number of countries. The model provides a generalized structure; the user must supply country-specific data.

Models that have been developed for use in developing countries using programming languages include:

(1) EDSIM (Education and Demographic Simulation Model.

AID and The Futures Group, Washington, D.C., 1983, 1985.

Focus: Population and school-age projections and enrollment projections by sex, age, and level.

Level: National

Programming Language: BASIC

(Reviewed in detail in Appendix B-2.)

(2) Education Finance Simulation Model.

Manny Zymelman and F. Yee, IBRD.

Focus: Calculation of the number of students that can be served, teachers needed, and material costs against the limits of the education budget.

Level: National

Programming Language: ?

(3) EDP Menu, a package of programs for measuring school productivity and projecting enrollments.

Jose Dominguez-Urosa, The World Bank Education Programs, 1984.

Focus: A package of seven programs for the generation of promotion and repetition rates, projecting enrollments, assessing internal efficiency, simulating effects of efficiency improvements, and calculation of recurrent costs.

Level: National but could also be used for district or school level if data available.

Programming Language: BASIC

(Reviewed in more detail in Appendix B-3.)

(4) HOST/PETS,

Research Triangle Institute and Harvard University, 1986.

Focus: Calculation of transition rates at the primary level in a school system, projection of student enrollments, and calculation of educational efficiency measures.

Level: National but may be used for district or school level if data is available.

Programming Language: Turbo Pascal

(Reviewed in more detail in Appendix B-4.)

Although Crabb (1986) reports a developing trend in the U.S.

toward the use of advanced programming languages, the use of modeling systems software has dominated the development of microcomputer-based planning models in the U.S. Examples of models developed using programming languages that are in active current use are limited. However, one notable exception was the recent development of a population and enrollment model using the BASIC programming language that is currently in use in the state of Massachusetts. Sponsored by the State Board of Regents, the model permits the tracking of student preferences for courses of study, shifts in enrollments by age groups and geographic regions, and shifts in general population. Based on historical data the model's stated purpose was to support program development and help focus recruitment efforts at individual schools. Its unstated purpose was the encouragement of futures planning within the state higher educational system.[30]

Modeling Using Modeling Systems Software

The term "modeling software" is used to refer to any applications generation software designed specifically for the development of models on computers. Although generally associated with the spreadsheet software packages that have dominated model development since the introduction of VisiCalc in 1979, it includes more recently introduced "dynamic systems" modeling software such as Microdynamo and Stella, software

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[30] Interview with Stephen Coelen, Director, Center for Population Studies, University of Massachusetts.

designed for the development of linear and nonlinear optimization models such as LINDO and GINO, software designed for trend analysis and forecasting such as FORECAST MASTER, and some parts of general statistical packages. Our concern here is mainly with elaborated spreadsheet modeling.

Modeling software is a class of software that provides a general structure for model development, including usually a broad range of available subroutines and functions and a powerful yet relatively easy-to-use applications development language. Within the constraints of the general structure, a broad range of applications can be developed and modified interactively with the user specifying all variables and relationships and only those functions and subroutines that are required.

Modeling software has been used to develop customized user and institution-specific models, as well as for the development of problem-specific "template models." Template models, like generic models developed using programming languages, are models that address a problem common to many organizations or individuals, e.g., enrollment projections, institutional financing, etc. The model supplies the structure, but context specific data must be supplied by the user. The significant difference is that a template model, built using a modeling system, incorporates the user-machine interfacing system and all operational procedures of the modeling software package into the model. For model builders this means that they do not need to deal with such issues as the organization and character of the

command structures used to manipulate the model and the character of on-screen displays. They thus may focus their attention on development and testing of the model proper. The advantage of the use of template models for users is realized in situations when more than one model is needed. A series of template models developed using the same modeling system can be easily manipulated by users familiar with the general structure and operating procedures of the modeling system, thus, in theory, reducing overall learning time and leading to the easier adaptation of models by users.

Like models constructed using programming languages, templates can make more sophisticated analytical models and techniques available to individuals and organizations that might not otherwise benefit from them. However, like programmed models, they too can take on an aura of magic and make very complex problems look simpler than they are and their solution appear as easy as a number change or a keypunch or two. Additionally, while less conceptually complex template models, can be modified without much difficulty, e.g., simple financial forecasting models, modification of more complex models, e.g. those containing many routines or specialized functions, can, like their programmed counterparts, require considerable skills.

A limitation of the use of modeling software for modeling in some situations lies in the considerable computer hardware resources required by some packages. Interactive, easy-to-use, and powerful modeling packages require a great deal of computer

memory. Most of the commands, functions, and subroutines that comprise the system normally reside in the computer's active or working memory space, whether they are used in a particular model or not. To use such systems may require the purchase and installation of additional memory and/or processing chips to increase the operating speeds of larger models; although the introduction of new technologies and decreasing costs are rapidly diminishing the seriousness of these concerns.

Selection of a specific modeling software package has become increasingly difficult with the proliferation of packages that have become available in recent years. McNeich (1982) suggests the use of six basic criteria for the evaluation of any software product: functionality (can it do what I need done), ease of use, documentation, the availability of support, the delivery system (computer resources required), and cost. The BRIDGES Project, an AID sponsored educational development project at the Harvard Graduate School of Education, has developed a more detailed set of criteria that elaborates on the categories of McNeish and includes specific attention to the utility of software for use in educational planning. The BRIDGES criteria, outlined in Appendix B-1.3, were the basis for the guidelines outlined in Appendices B-1.1 and B-1.2, upon which the more detailed reviews contained in Appendices B-2 through B-13, were based. The discussion that follows is general in nature and intended only to familiarize the reader with the various models and classes of modeling software that exist and to identify significant strengths and limitations.

Spreadsheet Modeling Systems

The introduction of VisiCalc in 1979 began a revolution in microcomputer use in general and microcomputer-based modeling in particular. VisiCalc brought to the microcomputer an easily understood and familiar concept, an accountant's spreadsheet.[31] Since VisiCalc was introduced, many new spreadsheet modeling systems have been introduced, all offering refinements of the original idea, such as the inclusion of additional functions and subroutines, enhanced graphics capabilities, and more visually attractive screen displays; but the basic concept of a spreadsheet-based system, as described in the first section of this paper, has remained the same. VisiCalc dominated among spreadsheet packages until the introduction of LOTUS 1-2-3 in 1983. What distinguished LOTUS most significantly was its integration of graphics capabilities and a database with a spreadsheet, its use of a sophisticated on-screen menu system, the addition of many new functions and subroutines, and a "macro" facility that permitted the user to develop and save functions and subroutines and to incorporate them into a model with only several keystrokes. Since the introduction of Lotus 1-2-3, many similar spreadsheet modeling systems have been introduced. Systems are generally distinguished from one another in terms of the range of functions and subroutines available, the variety of reports that can be generated, the amount of computer resources they demand, speed of operation, and ease of use. LOTUS 1-2-3 is

[31] Miller, 1985.

the most popular and as such is reviewed in more detail in Appendix B-5. Other notable spreadsheet packages include Multiplan (reviewed in Appendix B-6), SuperCalc, EXCEL (MacIntosh), VP-Planner (three-dimensional matrix capabilities and inexpensive), Framework, Symphony, and Jazz (Macintosh).

Although modeling software is in use in many developing countries, particularly in the areas of finance, agriculture, health, and energy, the use of modeling systems software for educational planning in developing countries (or at least reports of its use) has not been extensive.[32] However, several recent developments and plans for future development at the World Bank suggest this is changing. The World bank recently sponsored the development of a model for calculating the relative costs of alternative curricular mixes and individual subjects in set national curricula in developing countries. It is called the "Economies in Curricular Choice Model," ECC, and was designed for use on IBM computers using Lotus 1-2-3.[33] The ECC model is currently being field tested following which plans include the development of a version of the same model for use on Macintosh computers using the spreadsheet program, EXCEL. The ECC model is a template model that requires the input of country-specific data including a range of policy-related data such as the number of

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[32] Horn, 1986.
See Ingle, Berge and Hamilton, 1984; Brodman, 1985; and Munasinghe, Dow, and Fritz, 1985, for reports of the use modeling software in the fields of finance, health, energy and agriculture in developing countries.

[33] Nazareth. 1986.

class periods per day and per week, the length of school periods, the specific courses of study included in the curricula, the number of teaching periods per teacher, average teacher and support salaries, etc. Using this data the model then calculates a series of costs including costs per student per subject, total capital and recurrent costs, etc. The model can be used to test the effects of changing policies, e.g., adding courses to the curricular, increasing teacher salaries, etc. The model focuses on "relative" costs and was explicitly designed for exploring relative effects and facilitating policy dialogue. The ECC model is reviewed in more detail in Appendix B-7.

The BRIDGES Project (AID and Harvard University) has developed two models for use on IBM computers using LOTUS 1-2-3. The Schiefelbein/Cuadra Model calculates transition rates (promotions, repetitions, and dropouts) from an analysis of enrollment data and projects school enrollments for ten years from which resource requirements and costs can be forecast. The model is designed for use in developing countries. Schiefelbein/Cuadra is reviewed in more detail in Appendix B-9.

POPEX2 is a cohort-based population projection model that projects population for three, five-year periods out from a base year and includes the calculation of single-year age groups, using Sprague Multipliers, for use in enrollment projections. The model, designed for national level projections in situations when migration is not a major factor, requires only the input of

a base year population and the appropriate UN mortality level. POPEX2 is reviewed in more detail in APPENDIX B-8. Both the Schiefelbein/Cuadra Model and POPEX2 are currently being field tested.

In the U.S. the dominant use of spreadsheet modeling software in educational planning has been for projecting enrollments and for financial planning.[34] An exemplar application is a model developed by the Planning and Institutional Research Office at the University of Hartford.[35] Using Lotus 1-2-3 they developed an enrollment and financial planning model with eight integrated model components:

(1) Enrollment forecasting,
(2) Credit hours,
(3) Institutional pricing,
(4) Income,
(5) Financial aid,
(6) Higher education prices,
(7) Administrative positions and salaries, and
(8) Faculty positions and salaries.

The model is based on a five-year history of data trends and data for the current year. Forecasts are made for five years on the basis of user-specified assumptions regarding changes in key model variables. The model is used to generate alternative scenarios which are summarized in an executive summary model, the

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[34] Cause/Effect, the professional magazine for college and university computing, reports regularly on microcomputer applications, including modeling, in higher education. Enrollment and financial planning dominate the use of spreadsheet modeling systems.

[35] Glover, 1985.

specifications for which were developed by the end users of the model. The summaries are reviewed by the president and senior officers, the executive committee, the financial committee of the board of directors, and an ad hoc budget advisory committee appointed by the president. The model has reportedly been very successful as a strategic planning tool and has sparked interest in the development of a more comprehensive model that will be integrated with existing mainframe and minicomputer databases at the university.

Despite its apparent success, model development reportedly proved to be more complex, labor intensive, and costly than originally anticipated. The problem, according to Robert Glover, Director of Planning and Research at the University of Hartford, was that the project was too ambitious. Glover questions "the advisability of attempting to design and implement four major applications simultaneously." Glover's observation is typical of the comments of many college and university administrators. (Appendix A-3 contains an example of an institutional spreadsheet planning model.)

An alternative to the custom design of models in college and university settings is the Decision Support Series developed by the National Center for Higher Education Management Studies (NCHEMS). The series consists of seven template models and accompanying documentation, each designed to address a specific decision-related problem area and to be used independently. Use

of the same modeling system and the standardization of on-screen model formats facilitates ease of use by planners and decision-makers. Included in the series are models for projecting service area populations and enrollments, tracking faculty course loads, and developing short- and long-range financial plans. The DS Series is outlined in more detail in Appendix B-10.

Spreadsheet modeling is also increasingly common at the school and district level in the U.S. for the calculation of resource requirements based on current and projected enrollments. But the main use of spreadsheet systems in schools is for accounting and financial analysis not necessarily linked to model development. In particular the use of spreadsheet systems has become increasingly common for the rapid analysis of differing salary schedules and benefit packages during school/teacher negotiations.[36]

A modeling systems package that is based on a spreadsheet concept but is significantly different from other spreadsheet packages is Javelin. It is the first of a predicted forthcoming wave of next generation spreadsheet modeling packages.[37] In Javelin the spreadsheet is only one of eight possible and easily accessible "views" of the model and the data upon which it is built. The model and data can be viewed in a spreadsheet format,

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[36] See Gustafson, 1985; Little, Mackey, and Tuscher, 1983, and Dembowski, 1983 for discussion and examples of school level use.

[37] Foster, 1986; Casella, 1986.

as a diagram of variable relationships, in graphic form, or as tables of data. One view is even designed to hold user entered notes on particular aspects of the model, e.g., to detail model logic. A model can be developed or variables and relationships changed in any of the views with changes reflected in all other views. The benefit of the multiple views approach is the ability to select the most appropriate view for the task and to examine the model from multiple perspectives.[36] Although models using Javelin are not known in educational planning, Javelin is included in this review and reviewed in more detail in Appendix B-11 because of its high ratings by users in other fields and its potential for impacting model development in the future.[37]

Increasing memory capacities and operating speeds have made the conversion of some earlier mainframe and minicomputer software packages possible. IFPS/Personal is a microcomputer version of the same Interactive Financial Planning System (IFPS) that was formerly only available on mainframes and minicomputers. IFPS/Personal is a very powerful program containing extensive capabilities for data analysis, data smoothing and projection functions, a report generator, and use of a "case file" approach that permits easier storage and comparison of alternative scenarios than with the mainframe version. However,

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[36] Miller, 1985.

[37] See InfoWorld magazine, Nov. 1985, and PCWorld magazine, Dec. 1985.

IFPS/Personal does not contain all of the advanced model interrogation routines as the mainframe version. "What-if" testing and goal seeking are available; but sensitivity analysis, risk analysis, and impact analysis are not. This is presumably explained by the fact that such routines require enormous amounts of working area within the computer's main memory; and, in general,most microcomputers do not yet have sufficient capacity to take advantage of them. As microcomputers become more powerful we can expect to see upgrades of IFPS/Personal and the inclusion of more sophisticated interrogation functions in other modeling systems.

Like the mainframe version of IFPS, IFPS/Personal does not appear in typical spreadsheet modeling form, as do VisiCalc or Lotus, which use the characteristic matrix and allow models to be built directly on the screen by moving about the spreadsheet to define and change variable relationships and values. Using IFPS, a model is built as a series of command line statements that define variable values and relationships. It is only when the model is run that the model is organized and displayed on-screen in a row/column matrix format, which is its underlying structure.

Although designed originally and primarily for financial planning applications, IFPS/Personal and similar programs, such as Plan80 and Financial Planner, have a broad utility for use in target-setting and resource allocation models. As computer technologies advance and more advanced model analysis features are added their use will likely increase. IFPS/Personal is

reviewed in Appendix B-12.

Dynamic Systems Modeling Packages

Dynamics systems software packages permit modeling of the same types of problems modeled with spreadsheet-based software, but seem particularly useful in two settings: (1) for simple target-setting models, e.g., standard population projection and flow modeling in situations when there is a general idea of how systems "work" but not much good data, and (2) for modeling the exploration of teaching/learning dynamics when a general understanding of interactive processes are more central than are strict quantitative measurements. In systems dynamics models, as with spreadsheet models, variables can be related in order to explore ideas and theories by studying which variables and sets of variables affect and interact with other variables. However, instead of assuming effects that follow each other in discrete sequences and time intervals, dynamic models permit exploration of simultaneous effects among variables and focus on the relative significance of changes in variable values. The explicit concern in dynamic systems modeling is insight, not number crunching.[40] Dynamic systems software are well suited to the modeling of teaching/learning processes and interactions and for exploring issues of policy and program interventions, e.g., how time on task and motivation interact simultaneously to increase learning over time. The dominate dynamic system packages available for

[40] Teel and Ragade, 1984.

use on microcomputers are Microdynamo and STELLA.[41]

A dynamic systems model developed using Microdynamo to simulate relationships among female education and employment, health and nutrition services, family planning and population growth in Bangladesh illustrates the use of the dynamic systems approach.[42] The Bangladesh model was developed to simulate the interaction of various sectors of Bangladesh society and their effect on population growth. A dynamic systems approach was selected in the absence of accurate data and because the relationships between components of various sectors of Bangladesh society, e.g., employment and fertility, is not entirely clear. Using Microdynamo, relationships among the various sectors are mapped out using available data on population and school enrollments, the number of health care clinics, women in the labor force, etc. Where data was lacking, the opinions of knowledgeable experts on Bangladesh were solicited and approximated values used. The base year in the model was 1972 with data included for the years 1972 through 1980. Projections were made for a 30-year period. Assumed variable values and relationships among variables were tested, when possible, against available data. The effect of changes in variable values was tested by rerunning the model.

Over a 25-five year period the model indicates that

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[41] Structural Thinking, Experiential Learning Laboratory with Animation (STELLA).

[42] Teel & Ragade, 1984.

increased female schooling leads to increased levels of nutrition, general health and child survival, and decreased birthrates. The results suggest that policies designed to increase the level of education of women, i.e., reduce the number of female dropouts and increase the number of female entrants, will significantly reduce population growth. The model does not indicate what should be done, but the model does serve to indicate where more intensive research efforts might focus in Bangladesh.

STELLA, a systems dynamic model developed for use on Macintosh computers, is an easy-to-use, visually oriented modeling package. In a particularly interesting application Stella was used to model dynamic relationships in the teaching/learning process.[43] This model was developed by Carl Clauset at Boston University as a dynamic systems simulation model for studying the effects of alternative school improvement policies on the assignment of teachers, class size, the allocation of classrooms and instructional time, etc. The model then relates these more tangible elements of the educational system with teacher expectations of students and student aptitude and motivation to assess the overall effect of policy interventions on student learning and to help identify the more

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[43] The use of Stella for modeling the teaching/learning processes was demonstrated by Carl Clausett of Boston University at the Harvard Graduate School of Education, Spring 1986.

critical relationships in the process. Relationships among variables are defined in terms of direction, i.e., positive or negative, and magnitude relative to the magnitude of other relationships within the model. The model facilitates exploration of how the entire set of variables affect student learning, as well as how individual variables are themselves affected by specific policy interventions. The model points to areas of research that might be developed and demonstrates again the effectiveness of systems dynamic models for use in situations where data is incomplete or absent and relationships among system components are not always clearly defined.

STELLA has also been demonstrated to be effective for population projection and for modeling issues of time in educational systems, e.g., student time on task, teaching time, length of teacher training, etc. as they affect student learning.[44] STELLA is reviewed in more detail in Appendix B-13.

Linear and Nonlinear Optimization Modeling Systems

In optimization models the objective is the selection of an optimal solution from a set of possible solutions that are feasible. Objective functions, which state explicitly the relationships between benefits and/or costs, and activity levels and/or outputs, are set for maximization or minimization. A set

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[44] Use of Stella for population projection is well presented in the user documentation that accompanies the software. Use of Stella for time-related modeling was demonstrated by Medardo Tapia, Research Assistant, the BRIDGES Project, AID and Harvard University, Spring 1986.

of constraint equations that define the limits of feasible solutions are written. The model solves the set of constraint equations, and from the feasible solutions it selects the optimal.[45]

LINDO and GINO are two examples of optimization systems available for use on microcomputers. LINDO (Linear Interactive and Discrete Optimizer) is an interactive, quadratic and integer programming system.[46] GINO is a package for solving optimization problems and sets of simultaneous linear and non-linear equations and inequalities.[47] Although they are extremely powerful, because of their highly specific purpose -- the solution of sets of linear and/or simultaneous equations -- the range of system commands and built-in functions included in the system is small relative to other modeling software packages, making them relatively easy to learn and use. Models are built as a series of standard algebraic expressions entered by the user to define the objective function and all variable values and relationships in the set of constraint equations. Model solutions are calculated by the system and output in standardized formats.

Optimization modeling systems are most appropriate in problem situations characterized by a high degree of quantitative structure and where specific objectives are defined, e.g., determining the most efficient distribution of known resources

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[45] Schiefelbein and Davis, 1974; Davis, 1980.

[46] Schrage, 1985.

[47] Liebman, et al., 1986.

among a known population.[48] They are not likely to be of much use as "dialogue-generating models," but could be used to provide accurate analysis of aspects of more complex semi-structured problem situations. The results of the optimization model might then be used as input into the larger decision-making context and perhaps into other models. The conditions that determine optimal solutions can also be varied, and effects on the objective function simulated and analyzed.

An application which illustrates the use of linear optimization modeling techniques within a broader decision-making context is the use of the Productivity Analysis Support System (PASS) by The Educational Productivity Council (EPC), a consortium of 25 Texas school districts.[49] PASS is an optimization-based "decision support system" shared by the 25 participating EPC school districts. The purpose of PASS is the analysis of the relative efficiency and effectiveness of school districts and individual schools vis-a-vis others. "A unit [district or school] is efficient if it achieving outputs (services) that are as high as any other unit when its input levels (resources) are taken into account." "A unit [district or school] is effective if it is meeting targeted output levels."

Assessments of efficiency and effectiveness are accomplished

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[48] G. Davis and M. Olson, 1985.

[49] A. Bessent, E. Bessent, Clark, and Elam, 1986.
Note: All quotations re PASS are from this reference.

by "the sharing of student test data and information on resources such as expenditures, time allocations for instruction, and professional staffing patterns." Efficiency ratings for each district and school are calculated using a linear optimization model that is then compared with the results of models from appropriate comparison sets of schools or districts. The results are available to school administrators who may then use them "to search for and diagnose sources of inefficiency, to set output targets, to comply with mandated written operating plans, and to investigate the operations employed in more efficient schools." Use of PASS is not required of schools in the EPC; however, schools that have used the PASS system reportedly have increased both their efficiency and effectiveness.

Use of models in the broader context of planning and decision-making is an area that is receiving increasing attention by planners and administrators in education and many other fields. Work continues on the development of more powerful, "feature-loaded" modeling systems but the dominant thrusts are toward the development of more comprehensive computerized decision support systems -- systems that link users with large databases and sophisticated analytical tools and modeling systems thus permitting the development of more comprehensive models -- and the development of strategies that will insure that future models and decision support systems will address the specific needs of the users of such systems.

DECISION SUPPORT SYSTEMS, PROTOTYPING AND ITERATIVE DEVELOPMENT

Introduction

Interest and activity in microcomputer-based modeling in education is, in part, reflective of a broader interest and activity in the development of computer-based management information and decision support systems (MIS and DSS respectively). Interest in decision support and the development of decision support systems is generally considered "a natural result of the evolution in database management and in computer-based problem solving."[30] References to "decision support systems" were not widespread and virtually nonexistent in the literature on educational planning and administration prior to 1980. However, a significant body of literature has emerged since then. A review of the decision support literature is helpful to the extent that it provides a theoretical context for considering the past and future development and use of modeling in education.

Decision Support Systems

The term "decision support system" means different things to different people. To those who study the use and development of computing systems in organizations, it connotes a class of interactive computer-based information systems that help decision-makers utilize data and models to solve semi-structured

[30] Andriole, 1986; Brinkman, 1984.

and unstructured decision-related problems.[31] To many practitioners it refers to a class of software that supports modeling.[32] For still others DSS includes any system or software that is capable of supporting decision-making in any way.[33] What relates these alternative views of DSS is that all reflect a fairly recent concern for using the data processing power of computers to provide information to decision-makers that was not always readily available to them from earlier information systems.[34] The practitioner's definition of DSS as a class of software that supports modeling reflects the important role that modeling is given in the broader context of DSS. The notion of DSS as any system that supports decision-making in any way is useless as far as helping one understand the technical and organizational requirements that might support DSS development and use.[35] DSS, as interactive computer-based information systems that help decision-makers utilize data and models to solve semi-structured and unstructured decision-related problems, is the most useful and dominant definition.

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[31] Sprague and Carlson, 1982; Alter, 1980; Keen, 1980.

[32] For example, Masland, 1984.

[33] For example, Maclean, 1986.

[34] Keen, 1980.

[35] Sprague & Carlson, 1982.

The characteristics of DSS that have evolved from the work of Alter, Keen, and others are summarized by Spraque and Carlton (1982). DSS:

(1) Tend to be aimed at the less well structured, underspecified problems that upper-level managers face;

(2) Attempt to combine the use of models or analytic techniques with traditional data access and retrieval functions;

(3) Specifically focus on features that make them easy to use by non-computer people in an interactive mode; and

(4) Emphasize flexibility and adaptability to accommodate changes in the environment and decision-making approaches of the user;

Central to the notion of DSS is the underlying assumption that a DSS "must be built from the manager's perspective and based on a very detailed understanding of the decision process and organization context."[54] DSS are intended to support, not replace, the decision-maker's judgment. The application must drive the technology, not the reverse.[57]

Although most often associated with senior-level decision-makers and problems of a strategic nature, it is becoming increasingly recognised that DSS applications are appropriate in any situation involving semi-structured problems. For Sprague and Carlson (1982) DSS can have utility for all "knowledge-workers" -- people whose jobs involve the processing of information and the resolution of semi-structured problems,

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[54] Keen, 1980.

[57] Keen, 1980.

whether they are involved with operational or management control or higher level strategic planning.

A fully operational computerized decision support system is composed of three principal components: (1) a database management system (DBMS), (2) a model base management system (MBMS), and (3) a dialogue generation and management system (DGMS).[56]

Database management systems represent an evolutionary development of earlier electronic data processing systems (EDP) and management information systems (MIS). EDP involves processes and routines that facilitate data entry, storage, and maintenance of data pertinent to an organization's operations. An MIS adds to the EDP the capability for organizing data into information useful for assessing how well an organization is meeting its objectives. Generally, the information that could be retrieved by earlier MIS was pre-specified, and reports were pre-formatted. DBMS represent an advancement of EDP and MIS concepts. DBMS perform as earlier systems did and also permit easy generation of custom-designed reports and ad hoc data queries.[57] The primary purpose of the DBMS in a DSS is to supply the data and information needed for the development of decision supporting models.

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[56] Sage, 1985; Sprague and Carlson, 1982.

[57] Brinkman, 1984.
CBIS, EDP, MIS, DBMS are terms used widely and often interchangeably in the literature and daily speech. For more detailed distinctions, see Kanter, 1984 or Martin, 1983.

The role of the model base management system (MBMS) is to provide tools that support the construction of decision models. A well-developed MBMS would provide ready access to a variety of modeling techniques and analysis tools, i.e., statistical packages such as SPSS or SAS, and a broad range of analytical testing possibilities ("what-if"testing, sensitivity testing, feasibility analysis, goal-seeking, etc.)[40] A MBMS might also provide a series of pre-defined model formats or "decision model modules"[41] for quicker and easier use in analyzing recurring problems.

The dialogue generator and management system (DGMS) is the user-system interface component of the DSS. The DGMS is responsible for communicating the commands of the user to the DBMS and MBMS components and the production of output representations that are meaningful and useful to the user.[42] The DGMS is responsible for all aspects of communication between the user and DSS -- screen, keyboard, sound, printer, reports, graphs, etc. A graphical representation of a theoretically complete DSS is presented below.

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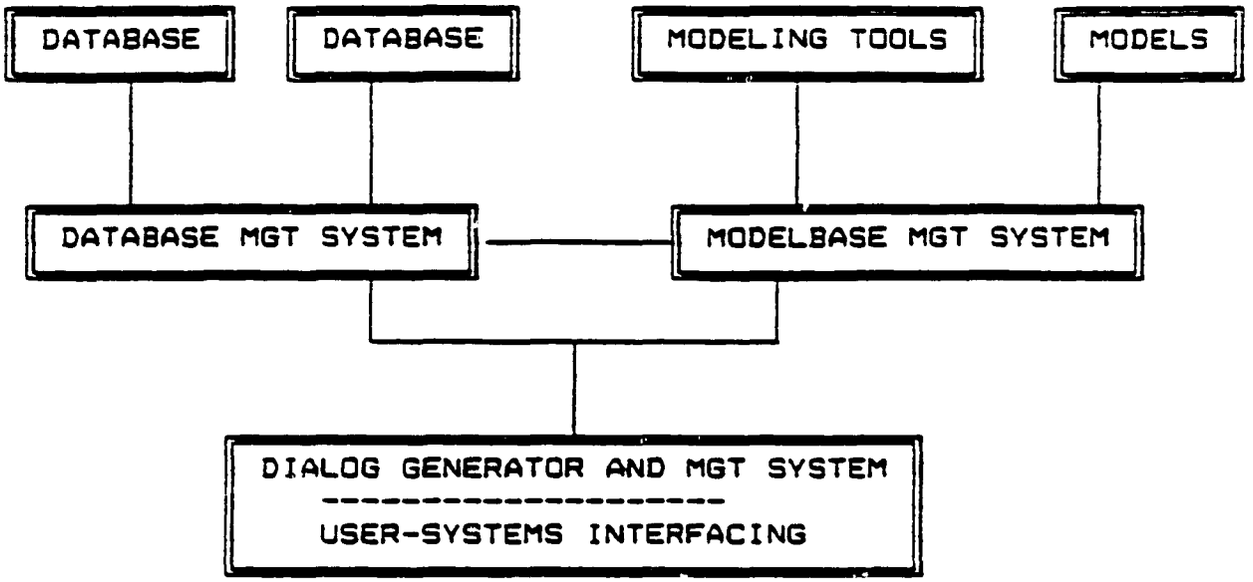
[40] Brinkman, 1984; Sprague and Carlson, 19982; Liang, 1985.

[41] Davis & Olsen, 1985.

[42] Brinkman, 1984; Sprague & Carlson, 1982.



A Theoretically Complete DSS

Liang (1985) notes that from a software design perspective, the model and data aspects of DSS management have evolved through three generations, but a fully operational, fourth generation DSS has yet to be realized. Examples of all three "generations" are in active use today.

A first-generation approach is one in which "models and data are integrated on the basis of individual application programs."[43] An application programmer uses a programming language to develop the computational procedures, define the data structures and input requirements, and specify the form of outputs.

Second-generation approaches use software packages that have been developed around a set of common computational procedures.

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[43] Liang, 1985.

The packages, or tools, are "problem domain independent"[44] and permit the user to specify only those computational procedures desired and to define data input requirements. Output reports are generally pre-formatted. The function of the software is to transform the inputs into outputs that may be used to solve decision-related problems.

Third-generation systems differ most significantl from first- and second-generation approaches in their ability to access existing databases, thereby, in many cases, reducing the potential for data input errors, eliminating redundancy, and permitting more timely review of th outputs of alternative modeling tools. Third generation systems also allow the user to develop customized output reports.

The advantages that fourth-generation integration of models and data are expected to provide include: (1) a further reduction in redundancy (the MBMS will handle the integration of models and data automatically), (2) an easy sharing of models among users, and (3) increased flexibility and communication across the system, e.g., changes made in one model might be automatically reflected in others.[45]

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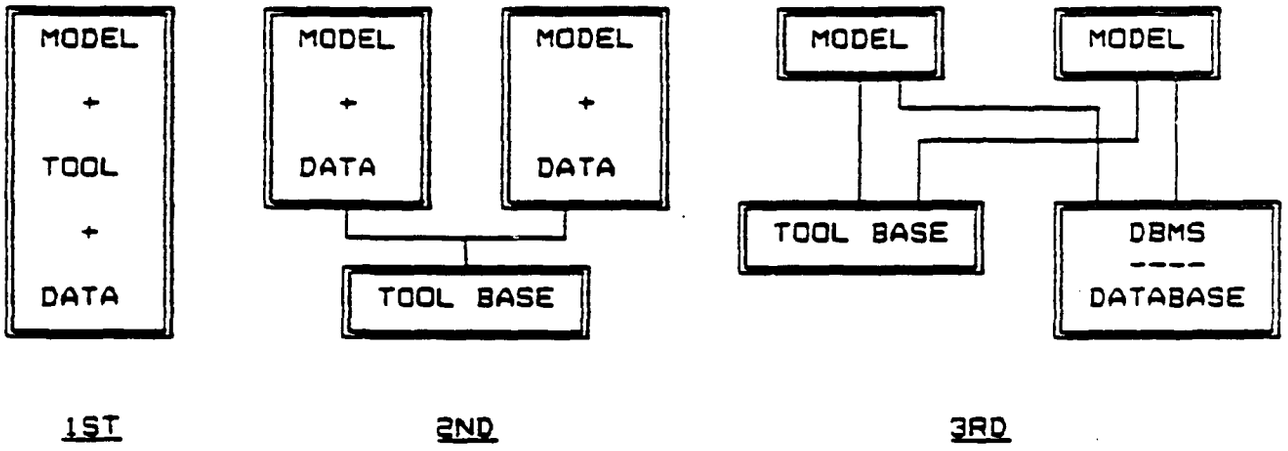
[44] Liang, 1985.

[45] Liang, 1985.



The Relationship Between Models and Data in First-, Second-, and Third-Generation DSS.

The development of dialogue generation management systems in DSS has benefitted greatly from the general microcomputer revolution. A broad range of user systems interface devices are now available to the systems designer -- user prompting, pull-down menus, touch screens, high resolution graphics, etc. An advanced DGMS would provide a user with a selection of alternative user interfaces. But such DGMS's are not widely available yet. In the absence of an advanced DGMS, system designers are forced to select a user interface for a system from among the familiar approaches, e.g., a Lotus-like menu scheme, Macintosh-like pull-down menus, a touch screen, etc. This is a most difficult task given that there is a gap in knowledge regarding the "best" ways to approach user system interfacing.** A DGMS that permits a user to select the user interface that he/she is most comfortable with might facilitate more effective

** MacLean, 1986.

use of DSS systems in general and modeling systems in particular.[47]

Efforts to develop systems and software that are sufficiently flexible to accommodate individual differences, respond to a wide variety of less well-structured problems, and reduce development and maintenance costs have led, in addition to technical developments, to an increased focus on strategies for applications development that include greater attention to the needs and desires of the end users of modeling and decision support systems.

Prototyping and Iterative Development

User involvement in model development has been encouraged by those working with models in education for almost 20 years and by virtually all who study and work with DSS. Most recently in the academic literature a call for "iterative development" or "iterative design" has dominated.[48] In the professional literature a similar approach is advocated but is most often

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[47] Note: The ECC model developed at The World Bank and discussed in this paper is reportedly being developed for use on Macintosh computers using the EXCEL spreadsheet program. One reason for this is the question of appropriate user/machine interfacing, specifically questions regarding the cultural relativity of user/machine interfacing in developing countries. The ECC model will be tested using both IBM screen/keyboard and MacIntosh graphic/mouse versions.

[48] Sprague and Carlson, 1982; Davis and Olsen, 1985; Bennett, 1983.

referred to as the "participatory approach" or "prototyping."[69] In general, a greater degree of user involvement is indicated and encouraged in the professional literature. For example, although Sprague and Carlson (1982) stress user involvement, a systems analyst is responsible "for implementing the required changes and modifications." Those advocating the participatory approach or prototyping give more of the responsibility for implementing desired changes to users. This, they argue, is possible given the highly developed applications generation tools that are currently available. A systems analyst is used to check their technical work, but not always to do it.

Prototyping and iterative design involve speeding up the typical development sequence of analysis, design, construction, and implementation and repeating it several times for the purpose of evaluating and modifying the system incrementally as needed.[70] The benefits of prototyping and iterative design include the early exposure of system users to the functional model which leads to more timely, and often less costly, changes, both in terms of what the model does and how it works and in how it looks. That is, prototyping and iterative design should lead to models that are more likely to be of use and less costly to maintain. The disadvantages of this approach include a possible increase in hardware and software costs, as the applications

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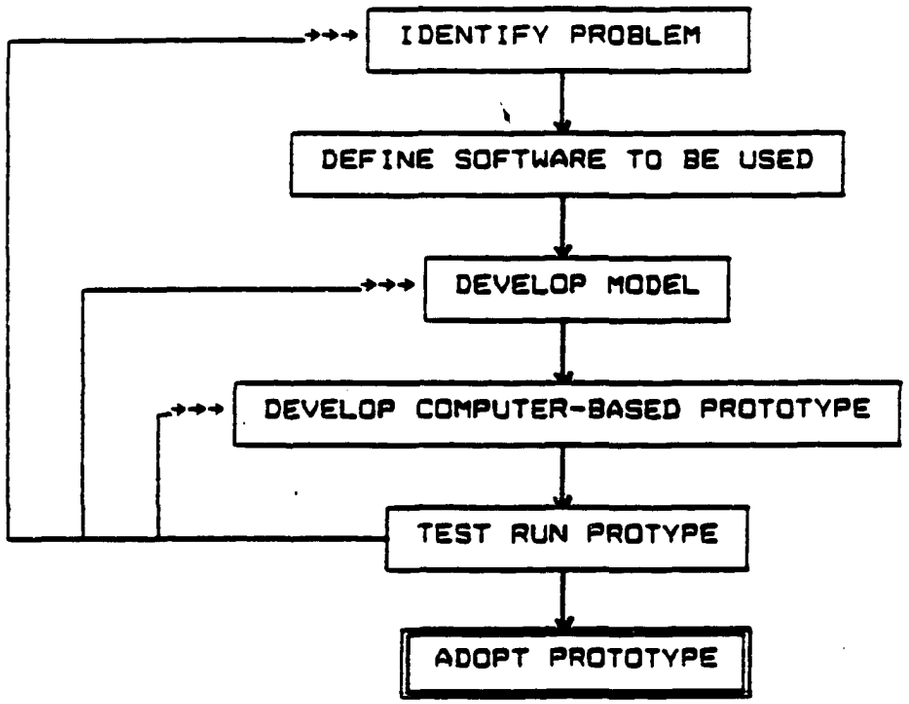
[69] Sholtys, 1983; Lowry & Little, 1985; Segall, 1984; Oppermann, 1984.

[70] Sprague and Carlson, 1982.

generations tools that support such development may need to be purchased; and these tools generally require additional operating and storage memory capacities.[71] Another reported disadvantage is the cost associated with training in-house staff in terms of both financial cost and time lost from other duties -- not insignificant in many social organizations where resources are limited.[72] Whether these associated costs are justified would depend on the extent to which skills developed would be used in the future.



The Prototyping Approach to Applications Development

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[71] Lowry and Little, 1985.

[72] Segall, 1984.

CONCLUSIONS

VisiCalc's introduction of spreadsheet-based modeling on microcomputers has been the singular most dramatic event in the evolution of microcomputer-based modeling to date. The spreadsheet format has proven effective for a wide diversity of modeling applications in educational planning. Following the introduction of VisiCalc in 1979 numerous similar programs appeared offering refinements of the original idea; but it was not until the introduction of Lotus 1-2-3 in 1983 that any significant advancements on the original VisiCalc approach were introduced. Lotus added to the basic spreadsheet, row/column matrix format a sophisticated modeling language that included English-like commands, an easy-to-use hierarchal menu structure, a wide range of available and easy to use functions and subroutines, and a "macro" facility that permitted the construction of user defined menus and subroutines. Many other spreadsheet systems have been introduced offering refinements to the Lotus approach, but the Lotus "look" and approach remains dominant among the spreadsheet systems; and the use of spreadsheet systems dominates modeling on microcomputers.

In terms of features that support the construction of models and assist decision-making through interactive dialogue, most microcomputer-based modeling systems are incomplete. Extensive error-checking capabilities, the tracking of the relationships

among variables, goal seeking, and impact and sensitivity analysis are missing from most all microcomputer-based spreadsheet systems.

The introduction of the most recent version of IFPS/Personal (Spring, 1986) was significant iin its range of easy-to-use built-in interrogation functions, e.g., goal seeking, that are used in planning. IFPS/Personal has the ability to track variable relationships, and there is now a case study feature that makes saving and comparing alternative scenarios easier. IFPS/Personal is not yet as complete as its mainframe version, but IFPS/Personal demonstrates that the inclusion of advanced model interrogation functions and other features that support planning analysis and policy decisions are possible on microcomputers; but such features require a lot of working memory, and operational speeds are relatively slow.

The "multiple views approach" introduced in Javelin (Spring, 1986) is significant in that permits the examination and alteration of a planning model from a variety of perspectives. Not everyone sees problems in the form of row/column matrixes. A multiple views approach may lead to a greater understanding of the structure and purpose of models and, in particular, may increase the usefulness of model templates in that the end user is not restricted to interacting with the model in only one way.

Not all problems are best solved using spreadsheet modeling systems. Dynamic systems and optimization-based modeling

software are extremely useful but much more specific in purpose than spreadsheet systems. Given their specific purposes, their development has been much less dramatic than that of spreadsheet systems. The only significant general feature introduced by any of these programs is the highly graphic/visual approach to model development that characterizes the STELLA systems dynamic modeling system. The graphic/visual approach is very engaging. It is particularly helpful when the generation of policy related dialogue, based on close-in analysis of the teaching/learning process, is required. The object of planning is education, and the heart of that is teaching/learning. Planners and high level policy analysts sometimes need reminding of that, and systems dynamic models can be effective tools for this objective.

Programming languages are also useful for the development of planning models. They are very flexible, although they have generally required more technical skill to design, compile, debug, and alter than have modeling systems. In addition to their applicability to a wide range of modeling applications, programming languages permit structuring the user interface component of models to accommodate the preferences of end users; and they are extremely efficient in terms of the computer hardware resources (memory) they use. Recently, more sophisticated programming languages have been introduced, e.g., Turbo Pascal and True BASIC, that are easier to learn and use and should make the construction and maintenance of models using

programming languages easier. These newer languages are also significant in that they are specifically designed to support the construction of models in a modular and integrated fashion, i.e., the integration of sub-models for population projection, enrollment projection, costing, etc.

Choosing the most appropriate or "best" approach to model development, i.e., whether to use a programming language or a modeling system and which one, is not at all a clear cut-issue. Strengths and weaknesses characterize each approach and each individual language or modeling system. In addition to questions of the functionality of a language or system for addressing a particular modeling problem, there are unresolved issues regarding what is the best user interface approach to take in any given situation. Continuing technological advances may resolve some issues and cloud others. The differences between programming languages and spreadsheet systems are becoming less significant. Rapidly increasing memory capacities and operating speeds reduce concerns about modeling systems being "memory hungary" and slow; and "sparse matrix technologies" facilitate the development of larger, more orderly, and easier to use spreadsheet models. The development of more sophisticated, easy-to-use programming languages reduces concerns about the ability of end users to either create new applications or modify generic models to meet end user requirements. Increasing memory capacities and operating speeds should also lead to the inclusion

of more sophisticated interrogation routines in both programming languages and modeling systems, making them both more useful and attractive.

Models developed on microcomputers recently have emphasized target-setting models, primarily population and enrollment projections, and models that support resource allocation and costing. Modeling of the processes of education, e.g., of teaching/learning relationship, is less common; but systems dynamic modeling with STELLA has brought this into the state of the art. The development of heuristic models on microcomputers is also not common, but should increase with advances in graphics and printing technologies.

A trend toward integrated modular, or component, construction of models has evolved from an earlier focus on smaller problem-specific models. In some U.S. institutions the number of components that are linked is so great that integrated models become more and more similar to the large-scale comprehensive models of the early 1970s. In these institutions modeling has thus evolved from large-scale comprehensive models to problem-specific sub-models to the integration of the sub-models and then back to large-scale comprehensive models.

In the U.S. the trend toward the integration of sub-models, for example, of the various tasks of planning in a large, complex

institution, is part of a broader trend toward the development of integrated decision support systems (DSS). DSS will link large databases with a number of modeling tools (programming languages and modeling systems) and analytical programs and may eventually offer a selection of user interaction and dialogue approaches. Hopefully, they will avoid the size, complexity, and rigidity problems that plagued mainframe computer models of the early and middle 1970s.

As large-scale integrated models and the development of DSS have become more prevalent, there has been a renewed call for the development of strategies that will ensure that these newer systems and models created within them continue to address the needs of end users and remain within their control. The use of prototyping, or iterative design, is generally considered the most promising strategy.

Few empirical studies exist that focus on the relative effectiveness of one approach to model development for planning over another. Even fewer studies focus on the use of microcomputer-based planning models. Fewer still focus on microcomputer-based models for use in educational planning. Personnel commentary and unstructured case studies appear, but detailed evaluations are rare. Reports of model use in agriculture, energy, and finance in developing countries exist; but here, too, detailed evaluations are rare. Significant needs

for research include: (1) studies to determine how significant the character of the user interface really is; (2) studies to identify the elements associated with successful modeling, specifically on microcomputers; and, perhaps most importantly, (3) studies that examine the effects of microcomputer-based models on decision-making, particularly in educational planning in developing countries.

MODEL	SUPPORTING SOFTWARE	PLAN DOMAIN	Population Projection	Enrollment Projection	Costing & Cost Effectiveness	Resource Allocation & Financial Planning	Educational Efficiency Measures	Heuristic Modeling	Teaching/Learning
EDSIM	BASIC	Nat.	x	x	*				
EDP MENU	BASIC	Nat.		x	x		x		
PETS	Turbo Pascal	Nat.		x			x		
ECC	LOTUS v.1A	Nat.			x	x			
POPEX2	LOTUS v.2.0	Nat.	x						x
Scheifelbien-Cuadra	LOTUS v.2.0	Nat.		x			x		
Decision Support Series	LOTUS v.1A/2.0	Inst.	x	x	x	x			
Teel Model	Microdynamo	Nat.					x		x
PASS	Unspecified Linear Prog.	Distr.			x		x		

* = limited capabilities

Summary Table of Models Discussed and Reviewed in Terms of Applicable Planning Uses

APPLICATIONS SOFTWARE	SOFTWARE CATEGORY	Population Projection	Enrollment Projection	Costing & Cost Effectiveness	Resource Allocation & Financial Planning	Educational Efficiency Measures	Heuristic Modeling	Teaching/Learning
LOTUS 1-2-3	Spreadsheet	x	x	x	x	x		x
Multiplan	Spreadsheet	x	x	x	x	x		x
IFPS/Personal	Spreadsheet	x	x	x	x	x		x
Javelin	Modified SS	x	x	x	x	x	*	x
LINDO/PC	Linear Prog.			x	x	x		
STELLA	Sys. Dynamics	x	x			x	*	x

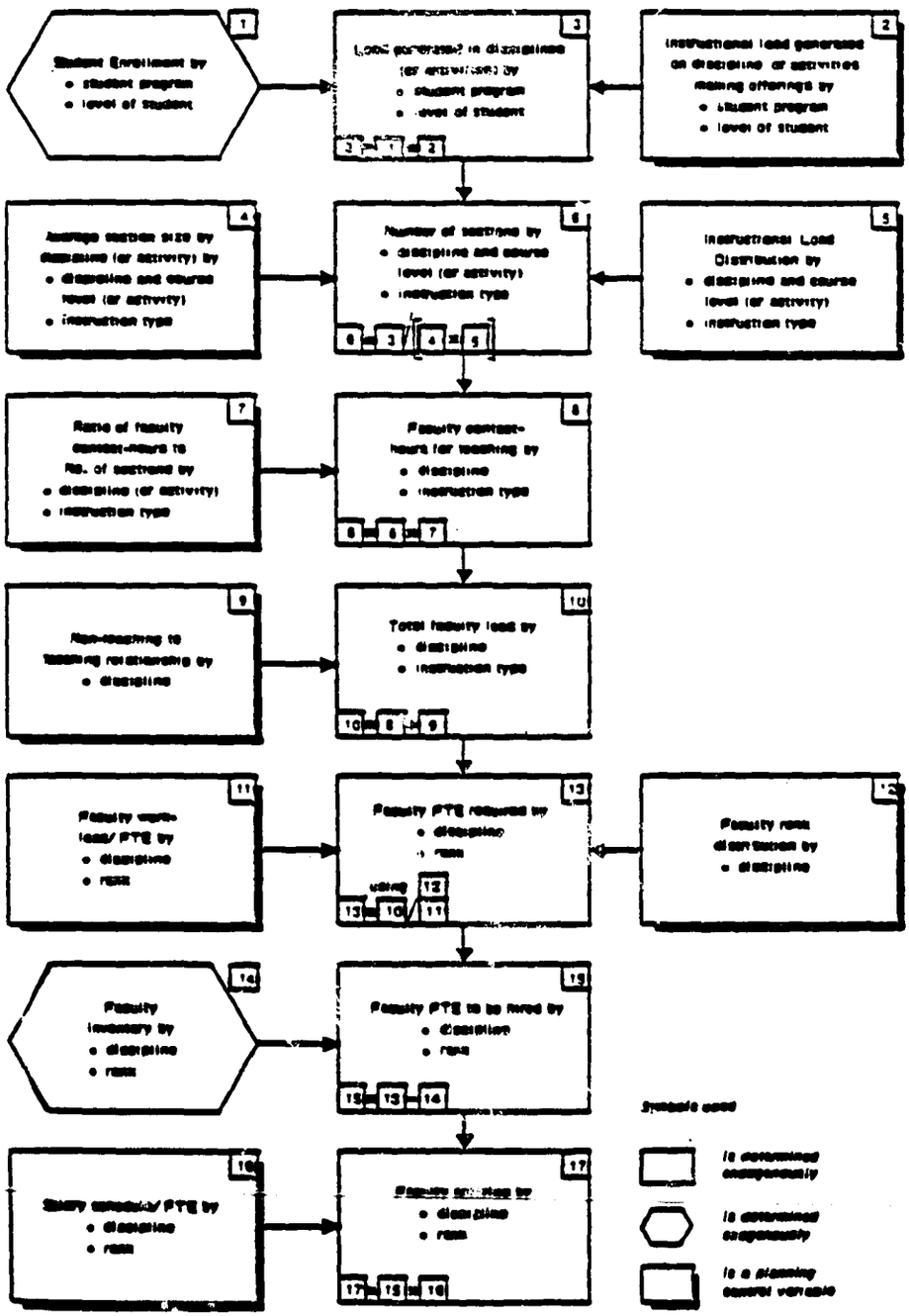
* = limited capabilities

Summary Table of Applications Software Discussed and Reviewed in Terms of Planning Uses Supported

APPENDIX A-1

Basic Logic for CAMPUS and RRPM Modeling Systems

BASIC LOGIC FOR CAMPUS AND RRPM



APPENDIX A-2

EFPM Command Tree Diagram

EFPM Tree Diagram

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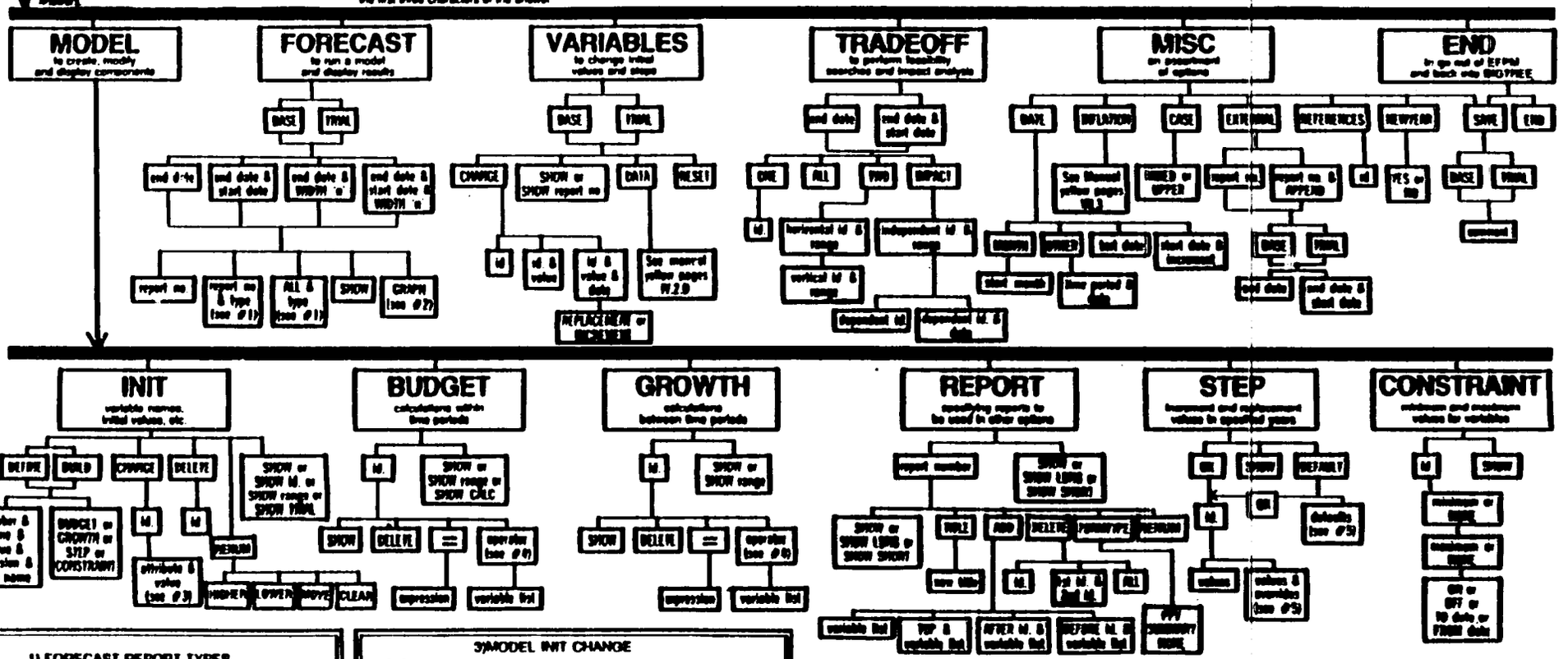
EDUCOM

ENTER OPTION

- Each valid answer moves you down the tree
- Type a ↑ to move up (or back out of a branch; enter several ↑'s to move up several levels
- Type a ? to get a help message that will explain possible answers
- At the end of a branch the last prompt will repeat until you either make another choice or enter an ↑ to move up the branch to another option
- All prompts shown in capital letters may be abbreviated to the first three characters of the answer



1) FORECAST REPORT TYPES

ROW%: Projected values for first time period and percent changes thereafter.
DELTA: Projected values for first time period and absolute changes thereafter.
GROWTH: Projected values for first and last periods, absolute changes, percent changes, and compound percent changes.
TOTAL: A one column report showing the row total for each variable.
ABSOLUTE: Absolute changes between BASE and TRIAL.
PERCENT: Percent changes between BASE and TRIAL.
SHORT: Variable numbers and names are used in place of longnames.
SHORT: (May be used in conjunction with other report types.)
COL%: Values shown as percent of column totals.

2) FORECAST GRAPH TYPES

ONE: Graphs one variable.
TWO: Graphs two variables.
RELATE: Graphs the relation of two variables.
COMPARE: Graphs BASE and TRIAL values of one variable.

3) MODEL INIT CHANGE

Attribute	Value
(Basic Attributes)	
NUMBER	New id number
NAME	New (short) name
VALUE	Initial value
PRECISION	Precision code (display format) 0-7: number of decimal places P: percentage to 0.1% %: percentage to nearest percent H,T: header
LONGNAME	Long name, for display purposes (up to 24 characters)
SHOW	Needs no 'value', displays basic attributes of current variable
(Variable-mode attributes, see yellow pages V.3.D.2)	
BUDGET	Budget function for this variable
GROWTH	Growth function for this variable
STEP	Step value(s) (and overrides) for this variable
CONSTRAINT	Minimum, maximum, and (ON, OFF, TO date, FROM date)

4) BUDGET and GROWTH FUNCTION OPERATORS

= (followed by arithmetic expression using any of +, -, *, and /)

A: Absolute value
B: Amortization
C: Ceiling (round higher integer)
D: Depreciation
E: Exponentiation and Logarithms
F: [illegible]
G: Additive growth (GROWTH function only)
H: Multiplicative growth (GROWTH function only)
J: Derived growth
M: Maximum
N: Nearest (round off)
P: Present value
S: Smallest
T: Truncate (round lower integer)
U-Z: User defined operations

5) STEP OVERRIDES AND DEFAULTS

BASE: Steps will be entered in BASE only.
TRIAL: Steps will be entered in TRIAL only.
BOTH: Steps will be entered in both BASE and TRIAL.
REPLACEMENT: Steps will be replacement steps.
INCREMENT: Steps will be increment steps.
FEEDBACK: To display all steps created or changed.
NOFEEDBACK: No display of steps created or changed.
TIME date: The first value entered will apply to period (date), the second to period (date + 1) etc.

STEP VALUES

OFF or NONE: Eliminates an existing step.
SAME or ': No change to be applied.

APPENDIX A-3

An Example of an Institutional Spreadsheet Planning Model

**** SMALL COLLEGE EXAMPLE -- MASTER PLANNING WORKSHEET****

REVENUE - EXPENSES	(BASE YR) 1983-84	1984-85	1985-86	1986-87	1987-88	1988-89
TOTAL REVENUES	2265440	2654110	2959796	3147820	3351311	3538836
TOTAL EXPENSES	2819446	2929655	2991584	3124642	3292419	3368008
BALANCE	-553006	-275545	-31788	23179	58892	170828

REVENUES	(BASE YR) 1983-84		1984-85		1985-86		1986-87		1987-88		1988-89
1. NET TUITION INC	764740		1111666		1370830		1532752		1713194		1894378
2. GOVT GRANT	1200000		1224000		1254600		1267146		1279817		1292616
GR GOVT GRT		0.020		0.025		0.010		0.010		0.010	
3. DIV & INT INC	2700		2795		2934		2949		3008		3038
GR D&I INC		0.035		0.050		0.005		0.020		0.010	
4. CONTRIB & SPEC APPL	275000		291500		306075		318318		327868		331146
GR CONTR & SP AP		0.060		0.050		0.040		0.030		0.010	
5. MISC INC	23000		24150		25358		26625		27424		27698
GR MISC INC		0.050		0.050		0.050		0.030		0.010	
*TOTAL REVENUES	2265440		2654110		2959796		3147820		3351311		3538836

EXPENSES	(BASE YR) 1983-84		1984-85		1985-86		1986-87		1987-88		1988-89
1. COMPENSATION-COL	385563		376283		432821		477172		533487		476232
2. COMPENSATION-GRAD	440423		522547		490394		533247		591603		526407
3. COMPENSATION-ADMIN	350500		364520		379101		394263		410035		426437
GR COMP-ADMIN		0.040		0.040		0.040		0.040		0.040	
4. COMPENSATION-SERVICE	300000		312000		324480		337459		350958		364996
GR COMP-SERV		0.040		0.040		0.040		0.040		0.040	
5. FOOD SERVICE COSTS	290000		292900		295829		298787		301775		304793
GR FOOD SERV		0.010		0.010		0.010		0.010		0.010	
6. UTILITY COSTS	175000		179375		183859		189375		193163		197026
GR UTIL		0.025		0.025		0.030		0.020		0.020	
~~7. MAINTENANCE COSTS~~	~~125000~~		~~125000~~		~~125000~~		~~127500~~		~~131325~~		~~136578~~
GR MAINT		0.000		0.000		0.020		0.030		0.040	
8. GEN OPERATING COSTS	403000		407030		411100		415211		419363		423557
GR GEN OPER		0.010		0.010		0.010		0.010		0.010	
9. EQUIP ACQUISTION	25000		25000		25000		25625		26650		27983
GR EQUIP		0.000		0.000		0.025		0.040		0.080	
10. MORTGAGE PAYMENTS	324000		324000		324000		324000		324000		324000
GR MORT		0.000		0.000		0.000		0.000		0.000	

STUDENT INCOME	(BASE YR) 1983-84		1984-85		1985-86		1986-87		1987-88		1988-89
TOTAL ENROLLMENT	226		262		294		316		344		363
RESIDENTS	179		206		220		220		220		229
GRADUATE	79		91		97		97		97		101
COLLEGE	100		115		123		123		123		128
COMMUTERS	47		56		73		95		124		134
GRADUATE	18		22		28		37		47		51
COLLEGE	29		35		45		59		76		83
GR RES GRADUATE		0.150		0.070		0.000		0.000		0.040	
GR RES COLLEGE		0.150		0.070		0.000		0.000		0.040	
GR COM GRADUATE		0.200		0.300		0.300		0.300		0.080	
GR COM COLLEGE		0.200		0.300		0.300		0.300		0.080	
STUDENT CHARGES											
TUITION & FEES	3540		3823		4014		4175		4300		4429
ROOM & BOARD	2300		2484		2608		2713		2794		2879
GR TUIT & FEES		0.080		0.050		0.040		0.030		0.030	
GR RM & BRD		0.080		0.050		0.040		0.030		0.030	
TOTAL STUDENT INC	1211740		1513966		1753015		1914967		2095379		2266523
INSTIT STU AID	447000		402300		382185		382185		382185		382185
GR STU AID		-0.100		-0.050		0.000		0.000		0.000	
NET STUDENT INCOME	764740		1111666		1370830		1532782		1713194		1884338

COMPENSATION - COLLEGE (BASE YR)

	1983-84		1984-85		1985-86		1986-87		1987-88		1988-89
ENROLLMENT	129		150		168		192		200		211
AVG CRSES/YR/STUDENT	9		9		9		9		9		9
TOT CRSE/YR/ALL	1161		1348		1515		1637		1796		1995
CLASS SIZE	16		20		20		20		20		20
TOT CRSE SEC REQ	72.6		67.4		75.7		81.8		89.8		94.7
FAC CRSE LOAD	5		5		5		5		5		5
FTE FAC REQ	14.5		13.5		15.1		16.4		18.0		18.9
AVG FAC COMP	23050		23972		24931		25679		26449		26449
GR FAC COMP		0.040		0.040		0.030		0.030			
TOT FAC COMP	334513		323191		377606		420300		474908		417654
DEAN & SECR COMP	51050		53092		55216		56872		58578		58578
GR D&S COMP		0.040		0.040		0.030		0.030			
TOT COMP - COLLEGE	385563		376283		432821		477172		533487		476232

COMPENSATION - GRADUATE (BASE YR)

	1983-84		1984-85		1985-86		1986-87		1987-88		1988-89
ENROLLMENT	97		112		125		134		145		152
AVG CRSES/YR/STUDENT	8		8		8		8		8		8
TOT CRSE/YR/ALL	776		900		1002		1070		1157		1219
CLASS SIZE	15		15		15		15		15		15
TOT CRSE SEC REQ	52		60		67		71		77		81
FAC CRSE LOAD	4		4		5		5		5		5
FTE FAC REQ	12.9		15.0		13.4		14.3		15.4		16.3
AVG FAC COMP	30110		31314		32567		33844		34550		34550
GR FAC COMP		0.040		0.040		0.030		0.030			
TOT FAC COMP	389423		469507		435232		478430		533142		467886
DEAN & SECR COMP	51000		53040		55162		56816		58521		58521
GR D&S COMP		0.040		0.040		0.030		0.030			
TOT COMP - GRADUATE	440423		522547		490394		535247		591663		526407

APPENDIX B-1

B-1.1 Guidelines for the Evaluation of Modeling Software

B-1.2 Guidelines for the Evaluation of Models

B-1.3 BRIDGES Project - Criteria for Evaluating Computer-based Modeling Systems

GENERAL GUIDELINES FOR THE EVALUATION OF COMPUTER PACKAGES USING THE NOTEBOOK PROGRAM FILE: PACKREV.

PNUMBER: BRIDGES assigned record number

PNAME: Software package being evaluated

VERSION(S)/DATES: Version of package reviewed. If review is compiled from several versions, identify differences and critical elements as appropriate.

COPYRIGHT FIRM: Company or person owning the rights to the package.

PRICE/COPY STATUS: Package cost. Include site licence costs, if applicable.
Is software copy protected? If so, specify details (# of copies, harddisk copy possible?).

AVAILABILITY: How easy or difficult to obtain? Give specific source, if appropriate.

TECHNICAL DETAIL: Hardware requirements (IBM, 512k,harddisk, etc.)
Companion software required or desireable, if any.

REVIEWS/PUB&DATE: List books, journals, newspapers, etc in which the package was reviewed.

OVERALL EVALUATION: Very general comment(s) synthesizing your and other reviewers observations re ease of use, performance and speed, improvements on earlier versions,comparison to similar packages, etc.

TASKS PERFORMED: Specify tasks and operations that were examined in reviewing the package.

* Creating a new application (formatting and defining the application, specifying relationships and/or writing formulas.
* Entering, editing and deleting data and/or existing application structures.
* Creating and printing reports and graphs.
* Importing/exporting data with other packages.
* Other.

TRIALEVAL DATE: When and where was the program field tested in an educational setting? (If known)

EVALUATOR: Of the field test.

OVERALL COMMENT: Of the field evaluator.

STRENGTHS:
WEAKNESSES: Comment as appropriate.

* General ease of use:
  - Creating new applications.
  - Entering, editing and deleting data.
  - Creating reports.
* Ease of learning.
* Programming/command language is understandable.
* Flexibility:
  - Degree to which structure of a created application can be changed.
  - Multiple forms of input/output possible.
* Available decision support features:
  - Sensitivity analysis (what if)
  - Goal seeking
  - Impact analysis
  - Comparison of alternative scenarios (ability to display simultaneously and/or to save).
* Graphing of output.
* Safeguards to protect against inadvertent destruction or modification of the application.
* Error checking and handling capabilities.
* Quality of online help.
* Quality of documentation.

DEMONSTRATED PLANUS:
POTENTIAL PLANUS: Comment as appropriate.

- Problem conceptualization (e.g. Heuristics).
- Systems conceptualization.
- Policy research and evaluation (quant. or qual.).
- Project/program design (scheduling & costing, work flows, etc.).
- Institutional program design.
- Operations mgmt. and control:
  - Costing and budgeting.
  - Resource scheduling.
  - Database.
- Strategic planning:
  - Forecasting - trend analysis, curve fitting, etc.
  - Projections - economic, population, enrollment, resource needs.
  - Resource allocation.
  - Comparison of alternative scenarios.

GENERAL COMMENT: Re the use of the package in educational planning and/or the potential for use in educational planning.
You might include a comment on why this particular package was reviewed if the reason is not obvious.

REVIEWED BY/DATE:

EDITED BY/DATE:

GENERAL GUIDELINES FOR THE EVALUATION OF PLANNING MODELS AND APPLICATIONS USING THE NOTEBOOK PROGRAM FILE: MODREV.

MODEL NUMBER: BRIDGES assigned record number

MOD NAME(S): Model being evaluated

SYSTEM/PACKAGE: The programming language or software package that the model was constructed with.

OWNERSHIP: Company or person owning the rights to the package.

PURPOSE & STRUCTURE: What is the purpose of the model - what problem(s) does it address?
What is the general approach that guide the model construction?

PRICE/COPY STATUS: Model cost, if applicable.
Is software copy protected? If so, specify details (# of copies, harddisk copy possible?).

AVAILABILITY: How easy or difficult to obtain? Give specific source, if appropriate.

TECHNICAL DETAIL: Hardware requirements (IBM, 512k,harddisk, etc.)
Companion software required or desireable, if any.

DATA REQUIREMENTS: What data is required by the model?

CREATE/DEVELOP/DATE: Where and when was the model developed?

PLACE/DATE USES: Where and when has it been used?

PLAN DOMAIN USES: What level (systems, institutional, program, project,...)?

PLAN TASK USES: What planning related tasks is the model designed to accomplish?

- Problem conceptualization (e.g. Heuristics).
- Systems conceptualization.
- Policy research and evaluation (quant. or qual.).
- Project/program design (scheduling & costing, work flows, etc.).
- Institutional program design.
- Operations mgmt. and control:
  - Costing and budgeting.
  - Resource scheduling.
  - Database.
- Strategic planning:
  - Forecasting - trend analysis, curve fitting, etc.
  - Projections - economic, population, enrollment, resource needs.
  - Resource allocation.
  - Comparison of alternative scenarios.

EVALUATION OF USES: Does the model accomplish what it sets out to? How effectively?

STRENGTHS:
LIMITATIONS: } Comment as appropriate.

* Clear specification of problem(s) addressed?
* Clear specification of data needs?
* General ease of use:
  - Entering, editing and deleting data.
  - Creating reports.
* Ease of learning.
* Programming/command language is understandable.
* Flexibility:
  - Degree to which structure can be changed.
  - Multiple forms of input/output possible.
* Clearly understandable outputs?
* Available decision support features:
  - Sensitivity analysis (what if)
  - Goal seeking
  - Impact analysis
  - Comparison of alternative scenarios (ability to display simultaneously and/or to save scenarios).
* Graphing of output? (multiple forms of)
* Safeguards to protect against inadvertent destruction or modification of the model?
* Error checking and handling capabilities.
* Quality of online help.
* Quality of documentation.

DEVELOPMENTS NEEDED: How could the model be improved?

GENERAL COMMENTS: Re the use of the package in educational planning and/or the potential for use in educational planning.
You might include a comment on why this particular package was reviewed if the reason is not obvious.

REVIEWED BY/DATE:

EDITED BY/DATE:

BRIDGES PROJECT

MODEL UTILIZATION

CRITERIA FOR EVALUATING COMPUTER-BASED MODELING SYSTEMS

CONCEPTUAL - THEORETICAL CHARACTERISTICS OF THE MODEL

A. Clarity of purpose

B. Relevance for stated purpose

C. Limitations of approach for achieving stated purpse

D. Objectivity: degree of (reflecting what biases)

E. Clear specification of assumptions underlying and supporting the model

F. Validity (does the model do what it is supposed to)

G. Verifiabilty (how easy is it to assess the models validity)

H. Reliabilty (is the model dependable, stable, and consistent)

I. Interpretability (how easy is it to follow and understand the processes driving the model)

J. Efficiency of the model

K. Flexibility (degree to which the model can be changed)

L. Clear specification of needed inputs

M. Clearly understandable outputs

RELATED TO THE PRACTICE OF PLANNING

A. Relevance and usefullness for:

1. Resolving major problems of planning

2. Serving real world need

B. Can be related to heuristic models and used in the context of a script to accomodate social concerns/processes and generate broad future scenarios

C. Data requirements are clearly specified

D. Ease of data input

E. Ease of data manipulation and modification

1. variable values easily changed?

2. coefficient values easily changed?

3. Relationships amoung variables easily changed?

F. Interfaces possible with other software packages?

1. Easy to import data files?

2. Easy to export data\/

G. Interfaces possible with other computing systems (hardware)?

H. Useful for decision-making?

1. Strong decision support features?

a. Impact analysis?

b. Sensitivity analysis? (what if)

c. Goal seeking?

d. Risk analysis? (probalistic modeling)

e. Ability to compare altenative scenarios easily?

2. Strong report generator?

a. Clear, easily readable reports?

b. Flexible report formats?

c. Variety of graphical supports?

I. Multiple levels of aggregation/disaggregation possible?

J. Easily demonstrated and explained to non-technicians?

1. Has some unique/creative features that engage the atention of planners and other audiences?

2. Example/demonstration applications available and easily accessed

K. Degree to which itis possible to engage decision makers and /or client beneficiaries in direct interaction with minimal instruction

MODEL STRUCTURES AND FEATURES

A. Model building and model use are integrated - requiring users to learn only one system (vs. seperate editor systems)

B. Commands are simple, clear and consistent?

C.. Major or primary variables clearly identified?

D. Relationships amoung variables are clearly defined

1. Functional forms clear?

2. coefficient values clear?

3. Equations relating variables clear?

E. If optimizing involved, objective functions are clearly stated?

F. If :ontrols, state and control variable relationships are clearly defined

G. Verification that equations are working correctly is possible?

1. Tracking of modeling process is possible?

2. Debugging is possible by technicians with moderate skills?

H. Reports are easily generated?

I. Graphs are easily created and integrated in reports?

J. Relatively easy to:

1. Get the program started

2. Load desired files

3. Save work whenever one wishes to

4. Exit the program

K. The results of changes in data and/or variable values can be saved for later use?

L. Adequate safeguards exist to protect against:

1. Inadvertant destruction of files

2. Inadvertant modifications of equations and or cell formats

M. It is impossible (or nearly so) to get 'dead-ended'

N. Technical assistance with software is available

1. By mail?

2. By telephone?

O. Regular revisions to the software are routinely available?

P. The programming language underlying the model is understandable to technicians of moderate sophistication?

Q. The program underlying the model is:

1. Efficiently written?

2. Able to be modified by technicians of moderate sophistication?

OMPUTER-BASED FEATURES

A. Documentation is:

1. Complete?

2. Clear?

3. Current to version in use?

4. Written for varying user levels?

5. In non-technical language?

B. On-line tutorial?

C. Error messages are:

1. Comprehensiv?

2. Clear and brief?

3. Non threatening?

D. On-line help is:

1. Available?

2. Designed for varying user levels?

E. Hardware requirements and system configurations are relatively modest?

F. System has a history of operating relatively reliably and trouble-free?

G. System set-up and general maintenance are possible by non-technicians

H. Maintenance beyond the routine is readily available

I. Disk-based diagnostic routines are available and easily used

J.. Installation of software is direct, well documented and accomplished by non-technicians

K. Hardware system required is compatible with other major/popular systems

L. The system may be easily integrated into:

1. A local area network

2. An extended network

M. The system is relatively portable.

N. Costs:

1. Initial purchase

a. Hardware

b. Software

2. Getting started

a. Consulting and training

b. Staff release time

3. Consumable supplies

4. On-going support

1. Hardware

2. Software

APPENDIX B-2

EDSIM, Education and Demographic Simulation Model

System/Package: Written in BASICA.

Ownership: The Futures Group, Glastonbury, Connecticut.

Purpose & Structure: Enrollment projections by age, level and sex. Some facilities for examining teacher, school, and expenditure requirements.

Price/Copy Status: Not copy protected.

Availability: The Futures Group, Glastonbury, Connecticut.

Technical Detail: Available for Apple and IBM microcomputers.

Data Requirements: School enrollment data; P, R & D rates.

Create/Develop/Date: Developed jointly by The Futures Group and the Population Reference Bureau, 1982. Revision in 1983. New versions through 1985.

Place/Date Uses: Projections developed for some 20 countries. Field tests in five countries (Egypt, Saudi Arabia, Sudan, Nigeria, and Peru) that involved use/demonstration with host country officials.

Plan Domain Uses: Primarily national level but adaptable to to large districts or areas of concerns (urban/rural) if data is available.

Plan Task Uses: Enrollment projections; instructional re: effects of demographic changes/shifts on school-age populations.

Evaluation of Uses: The model effectively generates enrollment data and presents understandable output in both table and graphical forms. Data sets may be saved (base pop. P, R & D rates, migration) permitting the construction of alternate scenarios which may then be printed for comparison. Options for examining teacher, school, and expenditure requirements are not well developed and of minimal help beyond giving a very broad picture of resource needs.

Strengths:

(1) Clean visual presentations -- data input and and graphic screens. Graphics are particularly well presented.

(2) Relatively east to use despite lack of step-by-step documentation. If one is generally familiar with microcomputers, does not deviate from the prescribed order for loading files and if you remember to write down the names of data sets you have saved.

(3) The program is extensively prompt and menu driven.

Limitations:

(1) Lack of self-guiding and on-line help utilities.

(2) Error handling is weak, particularly if you run into an error, a BASIC language error. What value is it to know the error is line 192 of the program code if you do not know BASIC?

(3) It would not be easy to reformat screen or graphics displays without knowledge of BASIC>

(4) No on-line display of available data sets.

Developments Needed:

(1) Display of data sets that could be used.

(2) Ability to compare alternative projection, at least graphically.

(3) Step-by-step instructional manual.

General Comment: Visually, EDSIM is well developed, making it a good presentation and dialogue-generation tool. The ability to display age, sex, and grade level data is impressive. The graphics are exceptional to the point of being, at times, a bit overdone, e.g., the use of sound in the enrollment flow display. The lack of a step-by-step manual is hard to understand for a program that has been around for four years and reportedly "used" in a number of countries.

APPENDIX B-3

EDP MENU

General: A package of programs for measuring school productivity and projecting enrollments.

System/Package: Programmed in MBASIC.

Ownership: Jose Dominguez-Urosa, World Bank Education Program, 1984.

Purpose & Structure:

(1) Generation of promotion and repetition (P&R) rates to fit given system efficiencies.

(2) Measurement of system efficiency given a set of P&R rates.

(3) Enrollment projections under varying efficiencies.

(4) Calculation of annual recurrent costs if unit costs are known.

(5) Simulation of the effects of improvements in efficiency.

Price/Copy Status: Not copy protected.

Availability: World Bank Education Program.

Technical Detail: Runs in MBASIC; versions available of IBM-PC/XT, K-Pro II, and Apple IIe. Program requires a printer.

Data Requirements: World Bank Education Program, 1984. Still under development.

Place/Date Uses: Currently being field-tested in 3-4 countries in Latin America.

Plan Domain Uses: System level.

Plan Task Uses: Enrollment projection and system efficiency measurement; policy research/comparison of alternative scenarios in the sense of informing policy-makers re the effects of improved efficiencies and increased enrollments.

Evaluation of Uses: Unless P&R rates are known, the primary value is in informing/teaching re the effects of varying P&R rates on enrollments and system efficiency. Generation of P&R rates from a general measure of system efficiency is done by random selection with questionable results. In a test of this aspect of the program using a six-grade system and an efficiency of

55%, seven runs produced wide variations in both individual year P&R rates and overall P&R rate changes from year to year with consequent results in individual year enrollments. When P&R rates, enrollments, and first grade growth rate are known, the program calculates efficiencies, projects enrollments, and prints and stores results fairly easily.

Strengths:

(1) Informative simulation of improved efficiencies.

(2) Instant printed results.

(3) Well-presented printed output.

(4) Relatively easy to use; extensive prompting for operational function and data input.

(5) Efficiency measure includes calculation of number of student years invested per graduate.

Limitations:

(1) Not at all transparent. Program has a "black box" magic about it; assumptions and operational structures not explicit.

(2) Requires data (P&R rates, enrollments, growth rate, and unit costs) that is often difficult to get.

(3) Random generation of P&R rates yields widely varying and, at times, implausible results.

(4) On-screen visuals are cluttered and distracting at times.

(5) Enrollment projections cannot be viewed on the screen; they must be printed.

(6) P&R rates are often displayed/printed in scientific notation.

Developments Needed:

(1) Improved on-screen visuals, including consistent formatting of numerical outputs.

(2) Improved documentation, including an explanation of underlying structures and assumptions.

(3) measure of the average years to complete a cycle might be included in the output.

General Comment: Program is probably best used by someone quite

familiar with enrollment projection and school efficiency measurement. As an instructional tool, informing re the effects of varying P&R rates, etc., it could also be useful. Reportedly, the program is being tested against date in Latin America, and program modification is expected.

APPENDIX B-4

PETS [Test Version]

General: The Primary Education Tracking System.

System/Package: PETS operates within a modeling package developed by The Research Triangle Institute of No. Carolina. HOST is referred to as a modeling 'shell' by its developers and was developed using the programming language Turbo Pascal.

Ownership/Developers: L.Crouch & S.Moreland, Research Triangle Institute under The BRIDGES Project, AID and Harvard University.

Purpose & Structure: PETS is designed to calcualte transition rates and project enrollments in primary level education systems based on a times series of enrollment data and population projections. The model has four distinct components:

(1) The calculation of transition rates (promotions, repetitions, and dropouts).

(2) The projection of transition rates into the future.

(3) The projection of student enrollments.

(4) The calculation of a set of eduational efficiency measures (input-output ratios, % of graduates, avg. years in school, avg. years to graduate, and # of 'ontime' graduates).

PETS is structured in a modular fashion that permits users to work with each of the above components independently.

Two methods for projecting transition rates are available, Standard and Schiefelbein, and a set of choices is possible for guiding the projection, rates fixed at some historic value or at the levels of historic means, rates that follow a logistic curve or linear trend, or rates that converge on user defined target rates..

Data entry and editting, model execution , and the displaying of model results is through the HOST modeling shell.

Price/Copy Status: May be copied.

Availability: Contact RTI, Raleigh, NC or The BRIDGES Project, Graduate School of Education, HArvard University.

Technical Detail: Developed for use on IBM computers and compatibles. Requires: 256K minimum RAM, 3MB of hard disk storage space, and a math coprocessor. A printer is optional but recommended.

Data Requirements: Data requirements vary depending on the module used and user choices made regarding the approach to the calculation of transition rates that is undertaken by the model.

(1) Population by single-year age groups for the historic period upon which calculations are to be based and for as many periods into the future as the user wishes to project enrollments.

(2) Enrollment in the aggregate (last) age group by grade.

(3) Enrollment by grade and single-year age groups.

(4) Number of repeaters by grade (for use with standard method of estimating repetition rates).

(5) The repetition rate, number of dropouts, and the age distribution of enrollments (for use with the Schiefelbein Method of estimating transition rates).

(6) Age of entrance and entrance rate for the first grade.

(7) Oldest 'legal' school age.

(8) Target rates specified by the user for target setting projections.

Create/Develop Date: June-July, 1986.

Place/Date Uses: Currently in field testing in Honduras and other countries involved with The BRIDGES Project.

Plan Domain Uses: National level, but could also be used at the district or school levels if sufficient data available.

Plan Task Uses: See Purpose & Structure section, above.

PETS generates data and efficiency indicators that are very useful but the model itself is not likely to be useful for interactive policy dialogue among planners as operation is relatively complex and extensive data changes require some time to accomplish. Neither is the model a very good pedagogical tool for introducing computer-based modeling or demonstrating the procedures for the calculation of transition rates. (Although a section of the User's Guide does a nice job of introducing the methodolgies employed in the model.)

Evaluation of Uses: The model accomplishes what it sets out to and provides a broad set of useful output tables but is not easy to use by the uninitiated. Data requirements are extensive. The relationship between HOST and PETS is unclear and awkward initially. With only the model and "Draft Users Guide" at hand, one must work quite hard to work through the model, i.e., to understand commands and structures, and the relationship between HOST and PETS, and to be able to enter, edit and run ones own data.

Strengths:

(1) User's Guide describes model components and data requirements, installation procedures, and the technical details of estimation and projection methodologies well. (see Weaknesses, #1)

(2) Utility for saving sets of assumptions and the results of calculations and projections in output files and a utility for comparing two sets against each other is very useful. (see Weaknesses, #2 & 3)

(3) Choice of approaches to the calculation of transition rates.

(4) It is possible to set target transition rates and have the model calculate required changes over time.

(5) The range of output tables and efficiency measures is helpful.

(6) A special function, "?", exists that provides onscreen listings of all available entries when the user is prompted for data by the model.

(7) A special function, "INCLUDE", exists that permits easy exclusion of data from periods that are a typical and likely to distort results unrealistically.

(8) A special feature, "INSTRUCT", exists for keeping online notes regarding model structure and operations.

(9) Descriptions of all variables used in the model are available online.

(10) The "DIMENSION" feature permits review of data by user selected parameters, i.e., enrollments by age by period, sex by period, etc.

(11) Onscreen descriptions of PETS components is well developed. (see Weakness #)

(12) A two-level protection system helps to protect underlying model structures from inadvertant user modifications. (This also made it impossible to examine the model structures for this review).

(13) Menus are well structured. (see Weakness #)

Weaknesses:

(1) "How to"-type instructions not well developed in the users manual. Some instructions re the use of HOST, but little on PETS itself.

(2) No section in the manual details how to create new data sets/files.

(3) Sensitivity and impact analysis are not available.

(4) Data requirements are extensive.

(5) Online descriptions of PETS modules although very good are not "upfront" enough. They are presented only as background once one has set a projection running.

(6) Manual assumes user knowledge of LOTUS 1-2-3 commands and structures.

(7) Formatting of some data tables makes reading tables awkward, e.g., why are there 5 decimal places in some population tables.

(8) A number of functions are not yet active - most notably graphics and data file creation.

(9) Error messages appear that are quite disconcerting and not very helpful - most notably when one begins using the model and the model was not properly exited at the conclusion of the previous session, although the procedure for "proper" conclusion of a work session is not clearly specified. Another error message that occurs when one attempts to run an incomlete data file informs the user that the "HOSTERR.TXT" file contains error messages, and kicks the user out of PETS and HOST with no explanation. These messages would be disturbing at any time but coming so early in ones use of the program they are particularly troublesome.

(10) A number of menu items and other onscreen messages and prompts are not clearly explained in the manual; e.g., What are system environment files? In general the terminology used does not always clearly indicate what the user would be electing to do by selecting one or another menu item.

Developments Needed: In general developments needed are those that will make the model easier to understand and somewhat more "friendly", particularly for those users who may have had little or no experience with computer-based models in the past. The model appears to accomplish what it sets out to, although it was is difficult to check this aspect of the model because access to the model structures was locked.

(1) Error messages should include more detailed information or indicate the source of such information.

(2) Protection from inadvertant user errors that kick the user out of the program with no explanation should be built into the program.

(3) More "how to"-type instructions and examples in the users guide.

(4) A map of menu structures and selections should be included in the manual.

(5) A map of the overall structure of the PETS model and its relationships with the HOST "shell" should be included in the manual.

(6) Entry into PETS directly with access to online descriptions, and perhaps a step by step example availble for first time users, would simplify ones initial encounter with the model.

General Comments: PETS and the accompanying User's Guide are currently in development and field testing. Hopefully many of the difficulties experienced by this reviewer (and others) will be cleared up. As it currently exists mastery of the model requires considerable effort. Those wishing to benefit from its use would almost have to secure the services of experienced users to master both its use and structural underpinnings most quickly. The use of a separate editor complicates the model somewhat and is curious given that those invloved in earlier modeling efforts in the U.S. reported that users found seperate editor systems more difficult to follow than the full-onscreen editting that characterize more recent spreadsheet systems.

~~Reviewed By/Date: T.Cassidy~~

Edited By/Date:

APPENDIX B-5

Lotus 1-2-3

Versions and Dates: Version 2.0, December 1985.

Copyright Firm: Lotus Development Corporation, 455 Cambridge Parkway, Cambridge, Massachusetts 02142.

Price/Copy Status: List price, $495; Key disk protection.

Availability: Widely available.

Technical Detail: For IBM's and all compatibles. Requires 256K and one disk drive minimally, but 512K and a hard disk are recommended for applications of any size. The program itself requires approximately 180K. Requires PC or MS-DOS 2.0 or later. Integrated spreadsheet, data base, and graphics. Overall worksheet size is 256 columns by 8192 rows. Print-graph disk for customizing printed graphs. Utility disk for converting files for transfer and exchange with other programs. Tutorial disk.

Reviews/Pub. & Date: Personal Computer, February 1985; PC World, January 1986; InfoWorld, December 1985.

Overall Evaluation: Easy to learn and use. Popular over wide range of novice to expert users worldwide. Version 2.0 permits the construction of much larger models than earlier versions, is faster and contains many more features, including the ability to do regression analysis, work in a number of currency formats, and create much more complex, but easier to use, application templates using macros. Receiving and transporting data to other systems is relatively easy. Processing speed can be increased significantly by the addition of a math co-processor. The only real problem is that more complex applications created with Version 1A do not run under Version 2.0.

Tasks Performed: Basic population/enrollment forecasts; institutional modeling; graphing of output; creation of macro driven applications. Attempted to convert and run existing 1A applications.

Trial Eval. Date: January-June 1986 used with Schiefelbein enrollment projection model in Central America; spring 1986, cohort-based population template developed by BRIDGES project; spring 1986, institutional model developed for a small private college. Additionally, 1984-86, user responses to

Lotus 1-2-3 Version 1A observed by evaluator in teaching/laboratory settings.

Overall Comment: Impressed educators in Central America, BRIDGES staff, and college administrators with ease of use and utility for planning. Use by novice users enhanced by the creation of user menus using macros. Version 2.0 much faster than 1A. Documentation and tutorials (written and on-line) have been improved. Lotus 1-2-3 is a widely known and used spreadsheet applications generator.

Strengths:

(1) Ease of learning and use by users who wish to develop their own applications. However, while a new user could be creating simple applications in a fairly short time, the commands and processes required for creating more complex applications can be overwhelming at first. Finding and correcting mistakes can be particularly troublesome and anxiety-producing. (See Weakness No. 1)

(2) Extensive programming capabilities using macros permits the creation of templates for use by novice computer users.

(3) The larger worksheet size and use of "sparse matrix technology" permits better organization of applications. It is no longer necessary to jam all components of a complex application into the upper left-hand corner of the worksheet to minimize the amount of disk storage or random access memory required. More complex models can be formatted onscreen in a more orderly and less awkward manner than was possible with Version 1A.

(4) On-screen graphics is quick and easy and may be automated using macros. Printing of graphs is also possible but requires use of a supporting utility program.

(5) Printed copy of part or all of a worksheet is easily and quickly accomplished. It is possible to embed printer control codes in spreadsheet cells. Thus, if a worksheet is structured with some thought given to the type and form of reports needed, reports can be generated easily. However, the printing of customized reports requires the use of a supplemental program, 1-2-3 Report Writer, purchased separately from Lotus for $150.

(6) There are easy-to-use ways of protecting parts or all of an application from inadvertent alteration by locking cells. This is particularly useful when crating application templates.

(7) Input errors that involve the structure of 1-2-3 commands are virtually impossible to make, but the specifics for most warnings are not given.

(8) 1-2-3 supports some database functions and is particularly good for keeping all kinds of lists. Sorting, selecting, editing records, and performing simple mathematical and statistical functions are quite easy. Version 2.0 is better at database management than 1A.

(9) On-line help is extensive and available at all times.

(10) Documentation is complete and fairly easy to use.

(11) Written and on-line tutorials are available. The written tutorial contains many examples and is quite helpful. The on-line tutorial, while it gives a sense of what 1-2-3- is capable of, is somewhat tedious.

(12) Files are easily imported from and exported to many other programs.

(13) Lotus 1-2-3 has attracted a wide following and resulted in a significant cottage industry of supporting documentation, user groups, and add-on supplemental software. Some of the third-party user manuals are quite good, and several software packages have been developed that address some of 1-2-3's weaknesses. (See below)

Weaknesses:

(1) Tracking of relationships among variables becomes difficult in more complex applications. There is not built-in tracking system. Thus, changing the structure of an application can result in unanticipated and unnoticed significant changes. (A supplemental program, Cambridge Spreadsheet Analyst, reportedly addresses this concern. It costs $90 and is available from The Cambridge Software Collaborative, University Place, Cambridge, MA).

(2) While it is possible to do "what-if" type testing, comparison of alternate scenarios requires either that you alter the existing application, print or save the alternative, and then either revise the alternative back to "normal" or recall the original worksheet. This can become a slow process with more complex applications.

(3) Version 1A programs that contain formulas built of cell label references will not run under Version 2.0. To make them run you must edit all cells containing such formulas. In complex applications, this can be very tedious and time consuming.

(4) Other reviewers report a major problem resulting from the 1-2-3 protection scheme employed when working from a hard disk. Before running a complete hard disk backup, it is necessary to uninstall Lotus. Failure to do so results in a 1-2-3 program that will not run.

Demonstrated Plan Use: Population and enrollment projections; economic projections, costing and budgeting, and resource allocation modeling. Limited database use.

Potential Plan Use: Some data analysis, including multiple regression on up to 16 independent variables.

General Comment:

(1) Lotus 1-2-3 has been tested for some years now and its usefulness in financial applications well established. Its use in other areas relevant to educational planning seems promising. The National Center for Higher Education Management (U.S.) has promoted its use and developed a series of decision support templates for use in colleges and universities. (These are reviewed separately under The Decision Series.) Use for national level planning seems equally promising in light of enhancements made in Version 2.0 and recent and continuing advances in microcomputer memory and operational hardware. Development and field testing is currently in progress at the World Bank and in several AID sponsored projects.

(2) Effective use of 1-2-3 is accomplished in one of two ways -- building one's own applications, or using applications templates. Building simple applications is fairly easy. Well-designed templates, even those addressing complex problems,

can also be quite easy to use. The greatest difficulties seem to arise in either case when the user becomes prematurely over-confident in the use of 1-2-3, or is not familiar with the problem being addressed. The result can be an improperly constructed application, a template that is altered incorrectly, a template that goes unused because of suspicions regarding its intent, or an application that is misused.

APPENDIX B-6

Multiplan

Versions and Dates: Version 2.0

Copyright Firm: Microsoft Corporation, Bellevue, Washington.

Price/Copy Status: Version 2.0 costs $195 for new purchases or $50 from the company for users of earlier versions.

Availability: Widely available or from Microsoft in Washington. Discounts to students and educational organizations available from Chamber Associates, Florida.

Technical Detail: Version 2.0 is 128K (Vers.1.1 required only 64K). A single floppy drive is adequate but dual floppies are recommended. Multiplan is available for use on most well known, and many lesser known, computers - all Apple computers and clones; IBM and compatibles; MacIntosh.

Reviews/Pub & Date: INFOWORLD. Nov.11, 1985 & March 28, 1983. The Book of IBM Software. Mellin & Hayes, 1985.

Overall Evaluation: Multiplan has been a popular spreadsheet program since 1983. It is easy to learn and use. Hardware requirements are modest. Version 2.0 improvements, including the use of sparse matrix technology, an ability to utilize support of an 8087 processor, a larger spreadsheet area (4095R x 255C), the use of macros, and an ability to work with a mouse, make it an attractive alternative to LOTUS 1-2-3 for some users; when applications are not very complex and/or hardware limitations exist. Its only limitation is its very limited graphics capabilities.

Tasks Performed: Version 1.10 has been extensively tested by this reviewer in all task areas (creating applications, entering and editing data, linking models, printing results, etc.). Version 2.0 was examined to verify reports re increased processing speed, macro ~~capabilities, increased spreadsheet size, and new~~ utilities for exporting and importing data files to/from other packages.

Trial Eval Date: Fall/Spring 1985-86, Hellenic College, Brookline MA
Fall 1985 - Office of Financial Affairs, Harvard Graduate School of Education
Spring 1986, conversion of earlier applications to

Ver. 2.0s

Overall Comment: Multiplan has been in use at Hellenic College for 3 years. It is the backbone of the financial mgmt. operations of this small college (300 enrollment) and is used in the finance offices off many schools and smaller colleges. Only the calculation and storage of financial aid applications was outside its capabilities at Hellenic College, primarily because of worksheet size and processing speed limitations. An institutional planning model has been used extensively by both officers and board members. For this type of modeling in a smaller and relatively less complex institution, Multiplan has been more than adequate. Additionally, MP has been used for limited record-keeping (personnel). Vers.2.0 should make Multiplan more attractive to larger institutions, but lack of graphics and any advanced decision support features may limit its appeal as users become accustomed to newer, more sophisticated packages.

Strengths:

(1) Ease of learning and use.

(2) Ability to "link" up to 8 worksheets, i.e., you can create submodels easily to support one or more common master models.

(3) Speed of processing in V.2.0 has been increased and can be further enhanced by the use of an 8087 math coprocessor.

(4) Macro abilities of V.2.0 permit the simplification of more complex and/or repetitive operations.

(5) Easy to restructure models and worksheets provided you can locate problems(see weaknesses).

(6) "What if" type queries are possible but require that you change elements of the existing model. You may print these but to save them you must rename the file, save it, and then either recall the original file or change the altered file back. This can be a bothersome procedure.

(7) Ability to import and export ASCII and DIF files in V.2.0 (earlier versions do not read or write in DIF).

(8) Cells and/or formulas can be locked to prevent

accidental loss.

(9) Extensive error-checking improved further in Vers. 2.0, but specific explanations often not given for error warnings.

(10) Extensive on-line help.

(11) Clearly written and presented documentation including a straightforward tutorial.

(12) V.2.0 capability for using mouse makes input easier for some users.

(13) Modest hardware requirements.

(14) Low cost.

(15) Excellent user support record.

Weaknesses:

(1) Minimal graphics capabilities.

(2) No formal decision support features.

(3) Complex formulas limited vs. LOTUS 1-2-3 e.g., only 5 "if-then" tests could be nested in one cell vs. 12 or more in Lotus.

Demonstrated Plan Use: Primarily in operations management and control-costing and budgeting.
Very limited database capabilities- primarily sorting data that can be kept in row/column format.
Institutional Modeling (resource allocation - revenue/expense).

Potential Plan Use: Use will likely remain the same with the added power with V.2.0 improving overall performance. Population and enrollment projections in regional planning and smaller institutions should also be possible. The ability to link worksheets is an easy-to-handle method for dividing complex models into smaller, more manageable components. This same feature could serve in institutional and project management, allowing separate units to be modeled and tied to a single master sheet.

General Comment: Multiplan has been among the most popular spreadsheet programs since its introduction. In settings where graphics capabilities are not critical and with the improvement in V.2.0, it is as good a

functional spreadsheet as there is. In situations where hardware upgrading is not possible Multiplan might be made to serve many of the same uses as LOTUS 1-2-3. Microsoft is rumored to be introducing "expert system-like" templates for use with Multiplan. These templates which would prompt the user for input sound very much like the complex templates it is possible to build with LOTUS 1-2-3.

Multiplan on the MacIntosh has been particularly well received, hence the introduction of "mouse support" for V.2.0. Cost and relative ease of use will continue to make it an attractive product.

APPENDIX B-7

ECC, Economies in Curricular Choice [Test version, May 1986]

System/Package: A simulation model template for Lotus 1-2-3, version 1A.

Ownership: Anita Nazareth, EDIET, The World Bank, 1986

Purpose & Structure: Calculation of resources required (facilities, teachers, equipment, and instructional time) and capital and recurrent costs associated with providing a desired curriculum. Allows examination of the effects of adding/eliminating subjects, increasing/decreasing class sizes, shortening/lengthening class periods, etc.

The model is divided into 7 distinct sections:

(1) Summary information: user input that includes: (a) definition of system norms, e.g., avg. class size, # of weekly school periods, etc., (b) assumptions made re: avg. teacher salaries, non-teaching related recurrent costs, avg. equipment and facilities life cycles, etc.

(2) Curriculum: descriptive data re: levels, grades, mode/stream, # of classes at each level, subjects taught, etc.

(3) Facilities: including: (a) an inventory of special classroom facilities and teaching spaces needed, and (b) calculation of total space requirements and usage factors.

(4) Capital costs: Calculates cost of constructing and equipping facilities required by specific curriculum.

(5) Teachers: Calculates two scenarios of teachers required per subject (specialized subject teachers vs. multiple-skilled teachers.)

(6) Maximum recurrent costs: Calculates recurrent costs per student/subject/year assuming use of specialized teachers and totals recurrent and capital costs to yield total cost/subject/year.

(7) Minimum recurrent costs: Calculates recurrent costs per student/subject/year assuming use of multiple-skilled teachers and totals recurrent and capital costs to yield total cost/subj/year.

Price/Copy Status: No cost data available; not copy protected.

Availability: Education and Training Division, The World Bank Washington, D.C.

Technical Detail: Operates under Lotus 1-2-3, Version 1A only. Requires DOS 2.0 or higher. Currently requires IBM PC/XT/AT or compatible with 512 K minimum. Needs graphics adaptor card/board to take advantage of built-in graphics. Printer capable of graphics printing also desirable. Also, requires three or more blank formatted disks to use built-in disk backup utility upon first use. As developed, requires utility program for sideways printing.

Data Requirements:

(1) General background: Average class size, weekly school periods, school days per week, number of periods per week, teaching periods per week, average teacher salaries, non-teaching recurrent costs/period/year, number of classes per grade, subjects taught, number of meetings/subject/week, and facilities required per subject/week.

(2) Capital costs: Average size of facilities in sq. meters, construction costs in $U.S. per sq. meter, average equipment costs in $U.S., and average furniture costs in $U.S.

Place/Date/Uses: Currently in field testing; illustrative examples available based on data from Malaysia, Jordan, Barbados, and China.

Plan/Domain Uses:

(1) National level systems when decisions regarding curriculum and facilities are highly centralized.

(2) Institutional level for more localized study of costs relating to curriculum.

(3) By development agencies for studying/assessing needs in demand-driven situations or determining limits in resource constrained situations and/or for assessing the effect of policy changes.

Plan Task Uses: The model is designed for the specific purpose of calculating relative recurrent and capital costs associated with alternative curriculum mixes. The model developers stress the concept of "relative costs" noting the difficulty of obtaining actual cost data.

Thus, the primary purpose of the model is teaching/learning and policy dialogue generation.

Evaluation of Uses: The model does exactly what it has been designed to do and does so in a straightforward manner.

Strengths:

(1) Supporting documentation (manual) clearly specifies the purpose of the model.

(2) Model itself is designed in a modular/sectional format that is easy to use and permits examination of sub-components.

(3) Between the documentation and labeling on the model itself, assumptions and relationships among variables are made explicit.

(4) Extensive, easy to understand user menus facilitate ease of use.

(5) Tutorial outlined in the manual is clear and simple facilitating quick understanding of the model.

(6) Graphic displays of cost and facilities use.

(7) Model is protected for inadvertent alteration, but modifications are possible with knowledge of Lotus.

Weaknesses:

(1) Somewhat cluttered on-screen appearance (primarily the result of Version 1A, which requires compact design to conserve memory).

(2) No facility for on-line comparison of the outcomes of alternative scenarios.

(3) Built-in macro printing utility requires creation of an output file and use of an auxiliary printing program. There are no macro utilities for printing all or sections of the model directly.

(4) Printing of graphs requires creation of an output file and use of Lotus Print-Graph utility program (a limitation of Lotus, not the model).

Developments Needed:

(1) Conversion to Lotus 2.0 would allow separation of model sub-components and speed calculations (through the use of Version 2.0 macros).

(2) A diagram of the model's structural flow would be helpful.

(3) When starting the program, the user is required to go through a backup procedure. This should be made optional.

(4) The built-in menu structures are very helpful and well developed, but it is still possible to inadvertently enter the Lotus environment. Procedures for returning to the main model menu and escaping from unanticipated problems should be presented at the beginning of the documentation and/or available on screen. These instructions are currently buried in the documentation.

General Comment: Overall, the EEC model is well constructed, direct in its purpose, and easy to use. As the developers note, its primary utility is most probably as a teaching/learning and policy dialogue generating tool. Its use may facilitate not only a greater understanding of the effects of policy decisions on curriculum-related costs, but should also help with the identification of data required by decision-makers and the encouragement of the development of underlying databases.

Conversion to Lotus 2.0 (Version 1A is not completely compatible with Version 2.0 at this time) would allow for some minor changes as outlined above, which would improve the model's look and performance.

The EEC model is reportedly being developed in a MacIntosh version using the EXCEL spreadsheet program. One reason for this conversion revolves around the question of appropriate user/machine interfacing, specifically questions regarding the cultural relativity of user/machine interfacing in developing countries. Comparison of IBM screen/keyboard and MacIntosh graphic/mouse versions is worth watching.

APPENDIX B-8

POPEX2 [Test Version]

General: A cohort-based population projection template model.

System/Package: A template model for use with LOTUS 1-2-3, version 2.0

Ownership: T. Cassidy, R. Davis; The BRIDGES Project, AID and Harvard University.

Purpose & Structure: Cohort-based population projection and the calculation of age-sex specific groupings for ages 1-19. The model is divided into the following component sections:

(1) Base year data input - population and fertility and mortality assumptions.

(2) Population projection tables by projection period, age, and sex.

(3) Calculation of births.

(4) Calculation of age-sex specific groupings using Sprague Multipliers.

Price/Copy Status: No cost. May be copied.

Availability: The BRIDGES Project, Graduate School of Education, Harvard University, Cambridge, MA.

Technical Detail: For use with LOTUS 1-2-3, Version 2.0 on IBMs and IBM compatibles. Requires 512K RAM. Processing speed enhanced by a math coprocessor. Graphics card and printer required to take advantage of all program outputs.

Data Requirements: (1) Base year population data by cohorts.

(2) Fertility rates for women ages 15-49.

(3) Identification of the appropriate 'mortality level' from the UN Life Tables.

(4) Male/Female birth ratio.

(5) Migration data, if applicable.

Create/Develop Date: Spring 1986. Currently being field tested and development continuing.

Place/Date Uses: Demonstrated in Egypt, Hondurasa and Sri Lanka. Currently being tested in the Bahamas and Korea, and at the Harvard Graduate School of Education by students of educatonal planning.

Plan Domain Uses: National level but could be used for regional projections if data is available.

Plan Task Uses: Population projection and the calculation of age- sex specific groupings for use in school enrollment projections and for comparing enrollments against populations. The relatively straight forward process involved in cohort-based projections also serves the models intended purpose as as a teaching device for introducing spreadsheet-based modeling to planners and policy-makers unfamiliar with computer-based modeling.

Evaluation of Uses: The model computerizes standard cohort-based population projection. The UN Life Tables and Sprague Multiplier Panels are built into the model making projections and distribution to age-sex groupings quite easy. The model is structured in component sections that can be viewed by moving throughout the spreadsheet randomly or by using a set of menus designed to facilitate easy input of data and viewing of population tables. The model has impressed users for its ease of use and straight forward approach. Responses from users unfamiliar with computer-based modeling report that the model does provide a good working introduction to computer modeling.

Strengths:

(1) Problem addressed is clearly presented and handled in a straight forward manner.

(2) Data needs are clearly defined.

(3) Generally easy to learn and use although some users have difficulty moving about the model because components are to closely bunched on the spreadsheet.

(4) Documentaion, although limited, is available onscreen.

(5) User command menus created with LOTUS macros make inputtting data and viewing tables easy.

(6) Tables of outputs are clearly presented and easily read.

(7) Sensitivity analysis is present but for only limited use, i.e., testing the effect of improved quality of life during the projection periods as measured by an increase in applicable UN Life Table Levels.

(8) Graphic output is available for projecting populations and enrollments.

(9) Data may only be entered in data input cells -all other cells are locked to protect against inadvertant alteration of the model. (Cells are easily unlocked using LOTUS commnds).

Weaknesses:

(1) Except for limited capabilities for sensitivity analysis no other interrogationfeatures are available. 'What if' testing is possible but requires changing data and then rerunning the model. There is no utility for onscreen comparison of alternative scenarios, e.g., using different assumptions re fertility - this a limitation of LOTUS as well as other spreadsheet software.

(2) While graphic output is formatting of the output has been jumbled when the model is run on some systems. This is presumably because of diffences in the graphic boards in some systems.

(3) Some output tables are larger than the size of a single screen and row/column headings are not always visible when viewing parts of some tables.

Developments Needed:

(1) Versions for use with varying computer system configurations should be created to eliminate graphing problems.

(2) Printer user documentation to accompany on screen information.

(3) Component sections should be seperated further from each other.

General Comments: POPEX2 has proven a good device for introducing spreadsheet modeling to planners and students of planning in initial tests. For a group of approximately 40, about 1 hour was required to familiarize people with the model to the point that most felt comfortableexploring the model on their own. In smaller groups of from 1-3, twenty to 30 minutes has been sufficient to introduce the model and get people working on their own.

Reviewed By/Date: T.Cassidy, October 1986.

Edited By/Date:

APPENDIX B-9

SCHIEFELBEIN/CUADRA [Test Version : under development]

General: A model for calculating transition rates and projecting enrollments at the primary level (grades 1 - 6).

System/Package: A template model for use with LOTUS 1-2-3, version 2.0 on IBM computers and compatibles.

Ownership: E.Cuadra, E. Schiefelbein; The BRIDGES Project, AID and Harvard University.

Purpose & Structure: Calculates transition rates (promotions, repetitions and dropouts) from an analysis of enrollment data and projects school enrollments for ten years from which resource requirements and costs can be forecast.

The model is divided into four major sections:

(1) Data Worksheet for age-grade matrices.

(2) Historical Transition Rates Worksheet

(3) Calculation and projection of transition rates by trend fitting with an asymptote as a constraint.

(4) Enrollment Projection

Price/Copy Status: No cost. May be copied.

Availability: The BRIDGES Project, Graduate School of Education, Harvard University, Cambridge, MA

Technical Detail: For use with LOTUS 1-2-3, version 2.0. Requires 512K RAM.

Data Requirements: (1) Age-grade matrices, grades 1-6.

(2) First grade entrants

(3) Assumption re rate of repetitions.

Create/Develop Date: Spring 1986. Development continuing.

Place/Date Uses: Used in Honduras and Guatemala, Fall 1986. Demonstrated in Egypt, Summer 1986.

Plan Domain Uses: National Systems level but could be used at the district or school levels if sufficient data available.

Plan Task Uses: Calculation of transition rates and enrollments; flow analysis.

Evaluation of Uses: The model is large and at this time somewhat difficult for new users to follow but as a tool for the calculation of transition rates and enrollments it is impressive. It has impressed planners and policy makers in Central America and Egypt. In initial tests the results of the model when compared to actual data, i.e., visiting schools and checking school registers, as well as literally counting heads, have proven to be more accurate than 'official' in-country projections.

Strengths:

(1) Problem it is addresses is clearly defined.

(2) Calculation routines have been thoroughly tested in real planning contexts.

(3) Model outputs are extensive and useful for other planning related activites and analysis, i.e., for projecting resource requirements and costs, and measuring school efficiencies.

(4) All underlying structures are discernable to users familiar with LOTUS 1-2-3 although a complete understanding would take some time to accomplish.

(5) Output tables of transition rates and enrollments are well presented and extensive.

Weaknesses:

(1) Model use requires the assistance of someone very familiar with the model. At this time only several people have the knowledge required to operate the model effectively.

(2) Data requirements are extensive.

(3) Calculations are complex and operation is slow on some machines.

(4) Advanced interrogation routines are not available. 'What-if' testing is but comparison of the results of alternative scenarios onscreen is not possible. (A limitation of LOTUS).

Developments Needed:

(1) Special menus to aid data input and the locating of model components should be developed.

(2) A users manual that includes an outline of the models components and operation at both user-friendly and more technical levels.

(3) Indicators of outputs in more graphcs form.

General Comments: This model although conceptually not too complex appears so because of the volume of data and calculations required. The response of those who have worked with the model and other potential users has been very positive. The model has proven to be quite good at what it has been designed to accomplish. Criticims/weaknesses of the model at this point are perhaps somewhat premature as the model is still under development. To date the emphasis has been on ensuring the integrity of the models internal calculations and in this regard the model appears to be very sound. Efforts are currently beginning (Oct. 1986) to accomplish the tasks defined in the section above, "Developments Needed" in an effort to make the model easier to use.

Reviewed By/Date: R.Davis, Spring 1986.

Edited By/Date:T.Cassidy, October 1986.

APPENDIX B-10

Decision Support Series, Simulation Model Templates for Planning and Management in Higher Education

System/Package: Templates available for use with Lotus 1-2-3, Version 1A or Version 2.0

Ownership: Vantage Information Products, Inc.; National Center for Higher Education Management Studies, Boulder, CO.

Purpose & Structure: The Decision Support Series is designed to aid decision-making and planning in higher education. The series consists of seven templates and accompanying documentation, each designed to address a specific decision-related problem area. Although each template is problem-specific and operates independently, all have been developed around a standardized format in an effort to facilitate ease of use by planners and decision-makers. Each template could be reviewed individually; however, our focus here is the series, and consequently the review is general in nature.

The seven templates include:

(1) POPULATN: Population-based enrollment forecasting model. Relates the population of an institution's service area to enrollment prospects based on a causal model of historical data. It is designed to permit investigation of the effects on enrollments of varying assumptions about future populations and/or changing participation rates of various age cohorts.

(2) ENROLLEE: Enrollment forecasting. Projects undergraduate and graduate enrollments based on a causal model of historical trends. Focus is on transitional flow rates and enrollment quotas for graduate programs.

(3) STUFLOW: Student flow model. Used to estimate enrollments and track student flow by identified characteristic-based cohorts, e.g., by academic ability, by divisions within the institution, by sex, by race, etc. Allows analysis of the potential impacts of policy changes on the mix of students enrolled in future years.

(4) FACULTY: A faculty database. A database of information pertaining to faculty characteristics, e.g., age, rank, status, salary, hire date, date of next leave, retirement date, etc. Permits analysis

of basic statistical data and provides a method for tracking faculty availability.

(5) FINOVIEW: Financial overview model. For analyzing an institution's current and future situation at a high level of aggregation, e.g., revenue and expenditure statements, balance sheets, etc. Built around a five-year time frame -- two historical, one current, two future.

(6) FINPLAN: Long-range financial planning model. Allows adjustment of revenue and expenditure items over a five-year projection period in an effort to reach a balanced budget. Major policy variables considered are tuition, unrestricted scholarships, endowment payout, salaries, and expenditures for improvements.

(7) FINTRADE: Financial trade-off model. Facilitates examination of the relationships among a number of variables critical to an institution's financial situation, e.g., enrollments, tuition, faculty compensation, etc. Includes sensitivity analysis.

Price/Copy Status: Approx. $150 per template or $850 for the entire set. Not copy protected.

Availability: Vantage Information Products, Inc., PO Drawer P, Boulder, CO 80302. Tel. 303-497-0386.

Technical Detail: Requires IBM PC/XT/AT or compatible with 256K minimum; MS or PC DOS 2.0 or higher; Lotus 1-2-3, Version 1A or 2.0 depending on the version of the Decision Support Series. Printer is optional. Processing speeds enhanced by the addition of a math coprocessor.

Data Requirements: Varies by template, but generally data is available in the admissions, planning, and finance offices of most U.S. colleges and universities.

Create/Develop Date: December 1985 by various developers working for NCHEMS.

Place/Date/Uses: Various templates are in use at many small to medium size colleges and universities throughout the U.S.

Plan Domain Uses: Institutions of higher education. Both public and private institutions, although some modifications may be necessary. Generally not as appropriate for larger institutions in which research and development

activities contribute significantly, although theoretically these could be accommodated as well by modifying the templates.

Plan Task Uses: See Purpose & Structure Section above.

Strengths:

(1) Standardized design of templates facilitates ease of use across the range of applications.

(2) Individual templates are developed in a modular/sectional format that is easy to follow.

(3) Written documentation is thorough, very well presented, and easy to read.

(4) Most necessary documentation is also available on screen.

(5) What model templates do and do not do and situations for which they are most appropriate are explicitly stated.

(6) Very well-developed user menus aid movement around the template, ease data input, facilitate printing and viewing of graphs and other material, etc.

(7) Graphic representation of key variables and analyses are available.

(8) Extensive printing macros facilitate easy printing.

(9) Input only allowed in certain cells. All others protected.

(10) A telephone support service is available at no charge.

(11) Upgrades and new releases are free of charge.

Weaknesses:

(1) On-screen visuals can be distracting as modules literally reside one next to the other. Movement throughout the model can be awkward and confusing as onscreen displays often include segments of two different modules.

(2) While templates are 95% standardized, there are a few places where they are not consistent. This is a minor problem, but disconcerting when you have

been lulled into a rhythm of use and feeling of security.

Developments Needed: Separation of sub-component parts to ease viewing.

Comments: The Decision Support Series represents a well thought out concept for providing a set of related tools to planners and decision-makers in a specific decision-making environment. Problem-specific application templates, standardized formats, specific instructions, explicit detail regarding limitations, customer support, etc., suggest a model for others desiring to develop and distribute decision supporting templates within well-defined decision environments.

APPENDIX B-11

JAVELIN

Versions and Dates: V. 1.0, Spring 1985.

Copyright Firm: Javelin Software Corporation, Cambridge, MA.

Price/Copy Status: $695.

Availability: Generally available or from Javelin Corporation, One Kendall Square, Building 200, Cambridge, Ma 02139.

Technical Detail: IBM - PC/XT/AT and compatibles; 512K; Dual floppy or hard disk systems.

Reviews/Pub & Date: InfoWorld, Nov. 1985; PCWorld, Dec. 1985 (Not full reviews).

Overall Evaluation: InfoWorld's software product of the year and rated a promising potential frontrunner by PCWorld. Javelin is not a spreadsheet bu uses a spreadsheet-like matrix as one of 10 "views" on a central model database. These views provide a variety of ways (tables, graphs, charts, formula maps, diagrams, etc) to construct and keep track of model construction, to enter, edit and examine data, and to analyze results of model simulations. Changes made while using one view are automatically updated in the central model database and reflected in all other views. Designed for numerical analysis over time, the program comes with a lot of knowledge built-in (AI) that makes it particularly will suited for any kink of projections. Formulas are constructed using names/symbols that theprogram keeps track of in several ways, including an audit trail-like system that maps variable relationships. While giving up none of the power of the leading spreadsheet programs - 78 mathematical functions are built-in, including all standard Boolean logic functions - the multiple "views" approach make Javelin a very flexible program. ASCII files may be imported from other programs. The program runs reasonably fast and is well equipped with error messages. Javelin is fairly easy to learn if you can escape the constraints of a spreadsheet mind set.

Tasks Performed: Two applications were created, an enrollment projection and an institutional allocations model, and sample reports and graphs printed.

Trial Eval Date: "Laboratory" tested, no known use in education.

Overall Comment: For population and enrollment projections, the

program worked very well, although a well thought out work plan was even more necessary than with LOTUS. Javelin is not for the casual user, but seems more appropriate for the creation and viewing of application templates. The very systematic manner in which variable relationships are defined and the multiple views approach permit you to look at data in a disaggregated form and in several ways quickly. It is, for example, easy to obtain definitions of all variables and formulas, either by listing them or displaying them in graphic form.
The program was less effective for constructing an institutional planning model. While offering the same advantages re multiple views, I was unsuccessful in creating a single full-screen model, which often is desireable with these type of models.

Strengths:

(1) The "multiple views" approach allows you a number of ways to build the model and enter data, but its greatest value is in the multiple ways you can view and analyze the results of simulations.

(2) The capability of diagramming data/variable relationships.

(3) Built in artificial intelligence re time periods, days, weeks, months, etc., makes time projections easier/quicker to organize. (System "knowledge" can be redefined).

(4) The "diagram" view is particularly useful in describing or formulating a conception of a problem.

(5) Extensive online help and documentation.

Weaknesses:

(1) While the added features in Javelin are attractive for more complex models, they get in the way somewhat when trying to use the spreadsheet for simple accounting tasks.

(2) While not very difficult to learn, the package is more complex than conventional spreadsheets and I would expect it to take people some time to learn. The use of packaged application templates would not be much more difficult to master than similar templates in Lotus, but with advantages in terms of making assumptions and logic more

transparent.

(3) The program does not have any of the standard, even if limited, database features common to more advanced spreadsheets.

Demonstrated Plan Use:

Potential Plan Use:

(1) Problem and system conceptualization using diagrams and block views for the generation of policy dialogue.

(2) Projections and forecasting.

(3) Resource allocation.

(4) Costing and Budgeting.

(5) Some data analysis including regression.

General Comment: Javelin was reviewed on the basis of its potential for use in modeling in education. The program was developed by a demographer and econometrician with time-oriented projection as an underlying structure. Hands-on testing I did confirmed what others have written re the uniqueness and potential usefulness of the multiple views approach. This approach may be very appropriate when the model is being used by groups of people for some of whom one or another way (view) of looking at a problem or interpreting data makes more sense.

APPENDIX B-12

IFPS/PERSONAL

Versions and Dates: Version 2.1

Copyright Firm: EXECUCOM Systems Corporation, 3410 Far West Blvd., Austin Texas 78731 tel. (512) 346-4980

Price/Copy Status: $700/$200-Educational. Upgrades are $35. Key disk protection. One hard disk installation.

Availability: EXECUCOM, Austin, Texas Tel. (512) 346-4980

Technical Detail: Dual floppy and 512K minimum, but 640K and a hard disk is recommended. For all IBMs and compatibles.

Reviews/Pub & Date:

Overall Evaluation: IFPS/Personal (Interactive Financial Planning System) is a micro version of the mainframe IFPS. It is compatible with the mainframe version. It is easier to use than the mainframeversion because of its full-screen, interactive editing and onscreen LOTUS-like menu structures. Not all of the features of the mainframe version are available in the micro version. What-if testing and goal seeking are, but notably absent are the more advanced impact, sensitivity, and risk analysis functions available on the mainframe. It is well tructured for the specific purpose of creatingfinancial systems and institutional models and includes features that facilitates easy tracking of variable relationships and easy storage and examination of alternative scenarios.

Tasks Performed: Creation of an institutional model based on an existing small college model - creation of alternative scenarios, goal seeking, reformatting, graphic output, and printing of reports.

Trial Eval Date: July 1986. "Laboratory" tested only.

Overall Comment: IFPS/Personal is quite easy to understand and use. The system is structured around a series of command menus called "modes" that are organized as a set of hierarchal levels and uses natural language mnemonics that make keyword and command structures easy to follow. Onscreen formats are neat and uncluttered. Models are built as a series of statements that define variable values and relationships. Once the model is constructed, it is compiled by the system and produced in the row-column matrix spreadsheet format. This contrasts with systems such as LOTUS 1-2-3, Multiplan, and others in which the model is structured in a row-column matrix step-by- step as it

is built. Although modifying the model is not too difficult, IFPS rewards careful planning prior to computer development. IFPS/Personal contains several more advanced model interrogation features than do most other spreadsheet-based systems such as the analyze and goal-seeking features. IFPS/Personal is significant in demonstrating that such features are possible on microcomputers. Plot and graphic outputs are fairly easy to generate. Automatic scaling is built in to the system or may be user defined. Output reports may be user defined. The construction of template models is supported by features that support the construction of user defined menus, the creation of input prompts that ask/remind the user to enter specified data before the model will run, and the creation of user defined complex functions. 16 template models come with the most recent version of the system - 7 are industry-specific (education not included), 7 are functional specific (finance, marketing, human resources, etc), 1 is a corporate DSS case study, and 1 is a presented as a managers "game," i.e., an overview of a five year company plan that is used to play out alternative strategies for balancing the budget over a five year period.

Strengths:

(1) Easily understood menu commands and structure support easy model construction.

(2) Full-screen editing and a set of error tracking and editing commands makes the building and altering of models relatively easy.

(3) 20 user definable functions possible.

(4) An "analyze" feature that supports the tracking of variable relationships.

(5) A "goal seeking" feature that has the system calculate the value of a specified required to achieve a desired value in another specified variable.

(6) Facility for the creation of user-defined menus and a feature that allows the creation of input prompts support the construction of template models.

(7) A "case study" feature that supports easy storage and comparison of alterative scenarios involving changes in variable ~~values or structural relationships~~

(8) User defined split screen facility.

(9) 30+ built-in functions and processing routines.

(10) Extensive on-line help utility.

(11) Very good and complete documentation.

(12) IFPS/Personal is compatible with the mainframe version.

(13) The system supports the use of data files for the storage and use of alternative sets of input data in models.

Weaknesses:

(1) Fewer built-in functions and routines than other spreadsheet-based modeling systems. Probably the result of the systems explicit focus on financial modeling.

(2) Larger models run a little slowly. The system requires a lot of operating memory.

(3) The protection scheme used could result in very bothersome delays should hardware systems fail and the one permitted hard disk installation is corrupted. Replacement requires returning the system disk to EXECUCOM for an exchange.

Demonstrated Plan Use: IFPS/Personal is nicely structured for supporting target setting and flow modeling. The mainframe version of IFPS is widely used in colleges and universities for financial planning applications at the institutional and departmental levels and for managing all auxiliary enterprises (housing, dining, etc.). The system is also used for enrollment planning and faculty tenure planning. The micro version could support these same uses and is easier to use, but does not yet contain all of the advanced interrogation features of the mainframe version. EXECUCOM reports the micro versions use in colleges and universities but no specific

Potential Plan Use: As above. IFPS/Personal is like its mainframe version best suited for operational management and control applications in particular for costing and budgeting. It is also useful in strategic planning for economic and enrollment projections and projecting resource needs. It is also very well designed for supporting comparison of alternative scenarios of all of the above applications.

General Comment: IFPS/Personal was reviewed because of the enormous popularity of the mainframe version. Easier to use than the mainframe version and visually much more attractive, it could serve very well in situations that do not require the advanced interrogation features of the mainframe version. Should future versions include sensitivity, risk, and impact analysis IFPS/Personal will easily become the most powerful of the spreadsheet-based microcomputer modeling systems.

Reviewed By/Date: T.Cassidy/ September 1986.

APPENDIX B-13

STELLA

Versions and Dates: Fall 1985.

Copyright Firm: High Performance System, Dartmouth, NH.

Price/Copy Status: ?/Copy protected.

Availability: High Performance Systems, Dartmouth, NH.

Technical Detail: MacIntosh Computer, 512K min recommended

Reviews/Pub & Date:

Overall Evaluation: A remarkable easy to use systems dynamics modeling program Stella's major contribution may be in aiding the processes of problem definition and system conceptualization. Its graphics/visual orientation makes it easy to follow model structures by encouraging "system thinking".

Tasks Performed: Three models were created: a demographic and enrollment projection, a heuristic model of the dimensions of time-on-task, and a scaled down resource allocation model similar to the EEC model.

Trial Eval Date: "Laboratory" tested by BRIDGES project staff/ Spring 1986.

Overall Comment: Ease of use and appreciation for the visual approach dominated responses to STELLA. Also noted was how quickly discussion of the problem(s) being modeled is generated. Stella is a very engaging package that supports heuristic modeling very well. It's greatest value is likely teaching/learning and policy dialogue generation. It is much less effective for more straight forward financial and resource allocations problems.

Strengths:

(1) Ease of use/accessibility.

(2) High quality graphics (a MacIntosh standard).

(3) Excellent, clearly written and well presented documentation.

(4) Flexible - both data and structures can be easily changed.

(5) Good error handling.

Weaknesses:

(1) Larger models run slowly.

(2) No import/export of data files possible.

(3) No macros to minimize data entry or model construction.

(4) No advanced decision support features.

(5) Comparative analysis on screen not possible.

Demonstrated Plan Use:

(1) Problem/System conceptualization. Stella promotes thinking and discussion.

(2) Population and enrollment projection.

Potential Plan Use:

(1) Any flow modeling problems.

(2) Policy dialogue generation.

General Comment: Facilitation of thinking, discussion and debate seem clearly to be the advantage of Stella. For problems involving more routine calculations in the areas of costing and budgeting spreadsheet programs are more straightforward, although Stellar can accomplish these.

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