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ABSTRACT

The first report of an ongoing case study examining the impact of using a laboratory of microcomputers as a tool for teaching science and social science courses in a high school, this paper reports on a sociological investigation of the organizational change in the structure and functioning of the school brought about by the introduction of the microcomputer laboratory. Introductory materials include a brief introduction to the systems thinking approach which underlies the STACI (Systems Thinking and Curriculum Innovation) project and a brief review of the sociological research literature on the impact of technology on formal organization with particular reference to schools. The participating high school where the study was conducted--the Brattleboro Union High School in Vermont--and the methods employed are then described. The report concludes with discussions of the organizational changes resulting from the introduction of systems thinking as detected to date, and policy implications of these findings that are appropriate for promoting effective use of computer based technologies in schools. (21 references) (EW)

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WHAT HAPPENS WHEN A SCHOOL STARTS USING A MICROCOMPUTER LABORATORY? THE IMPACT OF A SCIENCE AND SOCIAL SCIENCE MICROCOMPUTER PROGRAM ON THE STRUCTURE AND FUNCTIONING OF A HIGH SCHOOL

Technical Report

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What Happens When a School Starts Using a Microcomputer Laboratory? The Impact of a Science and Social Science Microcomputer Program on the Structure and Functioning of a High School

January 1989

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INTRODUCTION

This article is the first report of an ongoing case study examining the impact of the use of a laboratory of microcomputers as a tool for teaching science and social science courses in a high school. The research reported here is undertaken from a sociological perspective which emphasizes organizational change in the structure and functioning of a school. However, this sociological investigation is a part of the larger project, Systems Thinking and Curriculum Innovation (STACI), which is a multiyear research effort intended to examine the cognitive consequences of learning from a systems thinking approach to instruction.[1] Systems thinking is a problem solving technique that uses modeling on microcomputers to simulate the behavior of complex systems. A software program, STELLA, (Richmond, 1985) which runs on the Apple Macintosh microcomputer, makes model building and problem solving both engaging and educationally productive activities.

The purpose of the STACI Project is to test the potentials and effects of using systems thinking in existing secondary school curricula to teach both content knowledge and general problem solving skills. The research focuses on the content knowledge learning outcomes and transfer of problem solving skills that result from using a software package that enables students to learn from making abstract representations or models of

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[1]The STACI Project is directed by Dr. Ellen B. Mandinach of Educational Testing Service. It is carried out under the auspices of the Educational Technology Center at Harvard Graduate School of Education. Financial support was provided by both Office of Educational Research and Improvement of the U.S. Department of Education (OERI Contract 400-83-0041) and Educational Testing Service. Apple Computer Inc. generously provided a laboratory of fifteen Macintosh Plus microcomputers for the high school. The opinions expressed in this article are those of the author only and do not reflect the positions of the funding or supporting agencies.

scientific, mathematical, and historical phenomena. The STACI Project provides opportunities and support for teachers to learn systems thinking as well as to use their own initiatives in developing new curricular materials and teaching strategies.

The organizational case study reported in this article is a substudy conducted within the framework of the STACI Project. The objective of the substudy is to contribute to an understanding of the role of technology in organizational change as well as to inform educational policies intended to facilitate the use of computer based technologies in teaching and learning activities in schools throughout the nation.

In the next section of this article a brief introduction to systems thinking will be presented to provide a broader context within which to understand the substantive and technological innovation introduced in the school. A brief review of the sociological research literature on the impact of technology on formal organizations with particular reference to schools will be presented next. Then a description of the high school participating in the STACI Project and the methods employed in the case study will be presented. The article will conclude with a discussion of the organizational impacts resulting from the introduction of systems thinking as detected by the case study research to date. This discussion will point out policy implications where appropriate for promoting effective use of computer based technologies in schools.

SYSTEMS THINKING

Systems thinking is an analytic technique that provides a means of understanding better the behavior of complex phenomena over time. Systems thinking uses modeling to focus on the interrelations of system components over time and thus facilitates the analysis of change. In systems thinking simulations in the form of computer based mathematical models are used to represent dynamic relationships among variables over time (Forrester, 1968).

Systems thinking posits that it is possible to understand better the behavior of complex systems by constructing models and examining the cause and effect relationships among components expressed as variables. Because no one can monitor cognitively the many variables in a complex interacting system, computer models are ideal for these kinds of analyses. To build a model, it is necessary to hypothesize the major variables that comprise the system. These variables taken together then form a set of dynamic feedback loops that are expressed in a series of simultaneous equations. Thus, systems thinking focuses on the connections among the variables and provides a means to understand how they contribute to change over time (Roberts, Andersen, Deal, Garet, & Shaffer, 1983).

The basic concepts in systems thinking are not new. Indeed, the origins can be traced to antiquity. However, in the early 1960s the advent of the general purpose digital computer gave new impetus to systems thinking. It became apparent that complex models of dynamic systems could be represented and simulated on computers. Forrester and his colleagues at the Massachusetts Institute of Technology (MIT) developed a computer language, DYNAMO, which could be used to create and run a variety of models (Forrester, 1961, 1969, 1971).

The models of industrial production, urban development, and worldwide patterns of natural resource consumption received widespread attention and eventually much severe criticism, for they attempted to use the models as the basis for making predictions about the future. Because many of the models painted such bleak pictures of the future, systems thinking and modeling temporarily fell into disrepute among both the policy making and the social science communities.

In recent years greater appreciation has developed for the heuristic value of systems thinking. The creation and manipulation of models is increasingly recognized as a powerful teaching methodology. Frequently the computer models uncover startling and unanticipated consequences. It is precisely such examples that can often be most useful for teaching purposes. In the STACI Project simulation models are used to enable teachers and students to examine the structure of dynamic systems in high school science and social science courses. The approach to teaching embodied in the STACI Project then consists of three interdependent and therefore inseparable elements: systems thinking, the theoretical formulation; STELLA, the software package; and the hardware, the Macintosh computer. This organizational case study examines how the introduction of systems thinking using STELLA on a laboratory of Macintosh microcomputers affected the structure and functioning of the high school.

RELEVANT LITERATURE

The study of complex or formal organizations has for many years been a major subfield within the discipline of sociology. Dating back to the early writings of the major social theorists, Weber, Durkheim, and Pareto, the study of formal organizations has been a continuing object of theory formulation and empirical research. The sociological literature is filled with organizational case studies including: restaurants (Whyte, 1948), labor unions (Lipset, Trow, & Coleman, 1956), business offices (Elizur, 1970), mental hospitals (Stanton & Schwartz, 1954), industrial plants (Gouldner, 1954), government agencies (Kaufman, 1960), quasi-government agencies (Selznick, 1966), maximum security prisons (Sykes, 1958), academic libraries (Cline & Sinnott, 1982), and secondary schools (Cline, Bennett, Kershaw, Schneiderman, Stecher, & Wilson, 1986). No category or aspect of formal organization in our society has escaped sociological investigation (Katz, Kohn, & Adams, 1980).

The study of organizational change has also been a major intellectual focus among sociologists. Indeed, the assumption that organizations are microcosms of the larger society in which they are embedded has lead many to believe that the study of organizational change can shed some light on the dynamics of societal change. A recent collection of original essays dealing with the methodology of organizational change is one volume in a major publisher's series of research monographs (Seashore, Lawler, Marvis, & Cannann, 1983). The methodologies employed in studying organizational change include: surveys of attitudes and behavioral characteristics of members, participant observations of activities, job analyses, and program evaluations. The lists of topics and methodologies are extensive.

Focusing particularly on educational organizations, there is also a large literature devoted to the consequences of technology and change in schools and colleges. This literature might conveniently be categorized into three divisions:

(1) studies of learning outcomes resulting from the application of technology based systems;

(2) "how to" statements, which prescribe the steps and caveats

relevant to promoting widespread and effective use of computer based learning systems; and

(3) expository, and frequently hortatory, papers encouraging scholars and practitioners alike to engage in new and divergent research and development activities which will capitalize upon the inherent, yet unrealized capacities of computers to revolutionize teaching and learning activities.

The organizational case study presented here does not fit any of these categories, for it provides an account of observed reactions among teachers, administrators, students, school board members, and parents to the innovation of a computer based modeling system designed to enhance science and social science course offerings. From this perspective, it is a unique empirical study. An earlier study which is comparable focused on organizational changes in high schools resulting from the introduction of microcomputers (Pondy & Huff, 1981). This case study describes the strategies employed by a superintendent's office to facilitate effective introduction of microcomputers in the district high schools. Another comparable study is the collection of reports of computing activities and organizational change at Carnegie Mellon University (Kiesler & Sproull, 1987). This volume examines the impact of the distribution of networked microcomputers throughout the university campus. The organizational impact of the computer intensive environment is examined in the library, administrative offices, and among student and faculty uses of the computing resources.

Although the literature on organizational change prompted by technology is vast, there is very little in the way of case studies of schools which document structural and functional changes resulting from the introduction of microcomputers. The case study reported here is an attempt to begin the accumulation of such knowledge.

BRATTLEBORO UNION HIGH SCHOOL (BUHS)

The Brattleboro Union High School District was created in 1957 by a vote of the citizens in the town of Brattleboro and four smaller, contiguous and previously independent school districts. Three of the five communities maintain their own elementary schools with grades kindergarten through eight. They send their students to the unified high school in Brattleboro. The elementary school in one of the communities includes only grades kindergarten to six. Consequently, a small junior high school immediately adjacent to BUHS serves the students from this community as well as those from Brattleboro. However, the STACI Project involved only students in the high school grades nine through twelve.

BUHS is governed by a fifteen member school board. Members are elected by their communities at the rate of one member per one hundred students. At the time of the study, the community of Brattleboro had ten members on the board. The remaining five members came from the smaller surrounding communities. School board members are elected for three year terms. However, reelection is common. On average there is less than one-third annual turnover in membership. The board operates through a committee structure. The four standing committees include: teacher/curriculum, planning, finance, and building. The full board meets twice a month on Monday evenings. The committees meet frequently on an as needed basis.

The school board annually appoints the superintendent of schools. The superintendent exercises jurisdiction over all elementary schools, the junior high school, and BUHS. The combined jurisdiction is known as the Windham Southeast Supervisory Union. The superintendent's staff consists of himself, an assistant superintendent, a business administrator, and appropriate support personnel. In addition, there is a special education coordinator who serves approximately 250 students with special needs in grades K through 12 throughout the district. BUHS offers a program for developmentally retarded and emotionally disturbed students.

Total annual expenditures for the school district are approximately $15 million dollars. Expenditures for BUHS alone are just over $6.5 million per year. At BUHS there are three senior administrative staff members, a principal, an assistant principal, and a director of vocational education. The principal assumes overall responsibility for the functioning of the school. The assistant principal is accountable mainly for student activities and disciplinary matters. The assistant principal also takes primary responsibility for operation and maintenance of the physical plant

The vocational director oversees a program of occupational programs offered to the high school students. In addition, he conducts a large vocational and continuing education program for community members. These classes meet in the evenings or on weekends, and everyone agrees that this is an important service which the school offers to its constituents. Normally small fees are charged for the administration of the adult courses, thus generating a revenue stream for the school.

There are nine departments at BUHS. Five correspond to academic fields: mathematics, science, social studies, english, foreign language, and physical and driver education. The other three are special services including: academic guidance, vocational guidance, and special education. There are over 130 teachers assigned to the school. All teachers belong to the union which negotiates with the superintendent's office for operating contracts. There is one union for all teachers in the Windham Southeast Supervisory Union District. There are a total of 285 members in the larger bargaining unit. Contract negotiations are carried out at the district level. For the most part, negotiations have been effective, and relationships between the union and management are cordial. The president of the union is a member of the BUHS faculty, and he exercises considerable influence on school policy formulation by virtue of his union position.

There are approximately 1,300 students enrolled at BUHS. The breakdown by class is approximately 300 each in the ninth and tenth grades and 250 each in the eleventh and twelfth grades. Approximately 900 students come from Brattleboro, the remaining 400 are distributed rather evenly across the other four communities. Enrollments at BUHS have been relatively stable in recent years. The ratio of students to faculty is approximately eleven to one, a rate that is indeed favorable by most standards.

The students at BUHS can be characterized as coming from quite heterogeneous socioeconomic backgrounds. The southeast corner of Vermont is primarily rural and agricultural. Particularly, the students from the smaller communities surrounding Brattleboro tend to come from families that are engaged in farming occupations and therefore are rarely affluent. The students who come from Brattleboro are somewhat more heterogeneous in terms of socioeconomic backgrounds, for a number come from families with professional and managerial parents.

There are also several small, but influential elements in the population of Brattleboro. First, there are the younger people who moved to Vermont during the 1960s to get away from the urban areas in New England and the middle Atlantic states to enjoy what they perceived to be a less complicated and pressured life style in Vermont. Some of these people are now members of BUHS staff and have children enrolled in the school system. Another small segment of the population served by BUHS are the children of parents who have achieved notable success and financial reward in business, artistic, or entertainment fields. Many of these individuals have taken a form of early retirement and moved from the greater New York City area to southeast Vermont and have their children enrolled at BUHS. In sum, the socioeconomic composition of the communities served by BUHS is indeed quite heterogeneous.

The academic achievements of the students are also quite mixed. BUHS frequently has several National Merit Scholarship finalists in its graduating class. Each year it sends a dozen or so students to highly selective colleges and universities. On the other hand, fifty percent of the graduates of BUHS never attend a post secondary educational institution. It is into this quite varied high school environment that systems thinking was introduced in 1985.

Systems thinking first was imported into the Brattleboro community by a graduate of MIT who worked for a local corporation. He had been exposed to systems thinking in courses and extracurricular activities while an undergraduate. He and his wife moved into the Brattleboro area about ten years ago. Their children were in the school system, they began talking to teachers and other parents about the potential heuristic value of systems thinking. Up to that time all the work with systems thinking at MIT had focused mainly on research activities involving graduate students.

This particular couple was interested in exploring the utility of systems thinking at the secondary school level. They invited a member of Professor Jay Forrester's MIT research staff to come to Brattleboro to conduct an informal seminar for parents, teachers, and administrators. Since the wife in this family was teaching in a local elementary school, she already had some professional ties with the educational community. About a dozen people attended the first seminar conducted in the home of this couple. All the participants expressed an interest in pursuing the matter further.

In the academic year of 1983-84 the senior chemistry teacher at BUHS received a sabbatical leave and spent part of the year at Dartmouth College taking courses in chemistry and other fields. During this time, he audited a course in systems thinking offered by a Dartmouth junior faculty member who had done his doctoral dissertation under Forrester At MIT. This assistant professor was creating a microcomputer version of the DYNAMO language created by Forrester and his colleagues. This was the origin of the STELLA software, which incorporates most of the basic concepts of systems thinking into a software package that runs on a Macintosh computer.

The chemistry teacher returned from his experiences at Dartmouth interested in pursuing the possibility of introducing systems thinking at BUHS. In the spring of 1985, a weekend workshop was organized by the Brattleboro couple who were promoting systems thinking. It included six students, ten faculty members, and several members of the school board. It was conducted by an MIT staff member and served to generate additional interest.

The following summer a week long course in systems thinking was offered by the same MIT staff member. Again, school board members, students, faculty, and parents attended this workshop. A fee of $100 for students and $300 for adults was levied to offset the cost of the course. In this summer workshop, STELLA was first introduced to the people in Brattleboro. There were four Macintosh computers available for the workshop. The couple were the driving force in organizing this summer workshop, and it clearly was the turning point for the implementation of systems thinking at BUHS. The summer workshops were repeated in 1986 and 1987. Again, students, faculty, school board, and community members attended. Several BUHS faculty have now attended each of the summer seminars seeking to improve their understanding and skills in systems thinking and modeling with STELLA.

Following the first summer workshop in 1985, four teachers decided to join efforts and conduct a systems thinking project at BUHS. The chemistry teacher, who had taken the courses at Dartmouth during his sabbatical year, became the chair of this group of four. The second member was one of the biology teachers. The third member teaches physics, as well as some sections of general physical science; and the fourth member of the group was a mathematics teacher. This individual usually teaches advanced courses in calculus and statistics. He is particularly interested in systems thinking and had broad eclectic interests in both the sciences and social sciences.

For the two years of the STACI Project, this mathematics teacher conducted an experimental seminar type course for a small number of students entitled War and Revolution. Each student chose a particular historical or contemporary conflict situation. They did independent, in depth research on their topics and then used systems thinking concepts to develop STELLA models of the conflicts. Topics chosen by students during the two years included such events as: Falklands War, Peloponnesian War, Iranian Revolution, Philippine Revolution, conflict in Sri Lanka, and the like. Using a wide variety of sources, students developed their models over the course of the school year. Class meetings were used to review progress reports presented by students on their research and the development of their models.

In 1986 the group of four teachers applied for and received a grant from the Secretary's Discretionary Fund of the U.S. Department of Education. This grant provided release time and stipends for the teachers involved in the systems thinking project to develop models and curriculum innovations for use in their courses.

During the two year STACI project at BUHS, substantial numbers of BUHS students were exposed to systems thinking in the classes taught by these four teachers. Approximately half the ninth grade students were introduced to systems thinking in general physical science; about half the tenth grade students were learning systems thinking in two units in biology; again almost half the eleventh graders were using systems thinking in a major unit in chemistry. In the second year of the project all seniors enrolled in physics had substantial exposure to systems thinking. In addition, a small number of students, mostly seniors, worked extensively with modeling in War and Revolution. In each of the three science courses in the ninth, tenth, and eleventh grades, some students were learning via systems thinking using STELLA on the Macintoshs, and the remaining students were being taught in the traditional manner.

Thus, a naturally occurring quasi-experiment was taking place at BUHS, because of the patterns of exposure to systems thinking in the different courses. The STACI Project examines the impact of the introduction of systems thinking within this design. A report on the curricular innovations and their impact upon student learning outcomes is reported elsewhere (Mandinach, Thorpe, & Lahart, 1988). More information on the impact on the school will be presented below.

METHODS

The methods employed in the organizational case study are those typically used in such research. The case study methodology is particularly fruitful for stimulating insights and for suggesting hypothesis for future research. It is also an especially productive methodology for identifying major consequences of organizational change. The case study is a frequently used but much maligned method in social science research. Clinical psychologists have produced many rich case studies of individuals. Sociologists and political scientists use the method effectively in studies of organizations, and the anthropological literature is replete with countless ethnographies.

During each of the two years of the STACI Project, visits were made by the author to the school at three different times. One visit occurred during the summer of each year, and extensive interviews were conducted with administrators, faculty, and school board members. Two visits were conducted during the school year. Again, interviews were conducted with the same people, and observations were made in all the classes in which systems thinking was being introduced. In addition, documents describing school operation, course offerings, annual reports, departments reports, minutes of committee meetings, and the like were all collected, assembled, and reviewed for background information on the school and accounts of the systems thinking project.

The chairpersons of every department within the school were interviewed at least twice. Senior members of each department also were interviewed, as well as several faculty members who were new to the school. In total, over 100 interviews were conducted with 28 different individuals. Interviews were repeated to collect information on the changing perceptions of individuals over the two year period of the project.

Since interviews were the major data collection method of the project, careful attention was paid to selecting topics. Each interview explored the following issues:

1. the history of the systems thinking project;
2. the organization and division of labor in each department;
3. each individual's academic and nonacademic assignments;
4. perceptions of the impact of the systems thinking project on students, faculty, administration, and the community; and
5. expectations concerning the future of systems thinking at BUHS.

Interviews were conducted in an open ended fashion. General topics were raised with the interviewee, and then specific issues were pursued and followed up as they emerged in the responses. Interviews tended to be more like informal discussions, rather than question and answer sessions. Most interviewees appeared to be quite comfortable and relaxed, and there is very little reason to suspect that anyone felt threatened or intimidated by the experience. There were few occasions during the project that the author perceived that an interviewee was withholding information. For the most part, everyone at BUHS had a positive attitude toward the project and were therefore quite willing to speak openly about their perceptions.

There were a few indications that some faculty members were envious of the attention and equipment being showered on the science department. This was perhaps exacerbated by the fact that during the first year of the project the science department moved into a new wing, recently added to the building specifically for housing laboratories, classrooms, and offices for the science faculty. In addition to the new quarters, the laboratory of fifteen Macintoshs donated by Apple were also given to the science department. To somewhat counter an over reaction, the computer laboratory was initially housed in the older, main part of the building. However by the second year of the project, it became clear that the laboratory of Macintoshs needed to be placed in the science laboratories and classrooms

As in any case study, there are always problems concerning the generalizability of the findings. Because a case study is an indepth investigation that requires a substantial commitment of time and resources, it is usually expensive to conduct. Therefore, case studies are usually done one at a time, and the extent to which findings can be generalized to other organizations is always questionable. A convincing case for the replicability of the results can never be made completely in a case study.

ORGANIZATIONAL IMPACT

It became very clear from the repeated interviews with teachers and administrators that the work activities carried out by the four teachers participating in the STACI Project underwent substantial transition during the two year period. The change started slowly at first and gradually escalated. The teachers first identified segments or modules of their courses in general physical science, biology, and chemistry which they felt might be appropriate for teaching from a systems thinking perspective. This included topics in which there were changes in variables over time, for example; acceleration in general physical science, osmosis in biology, and reaction rates in chemistry. All three science teachers found themselves engaged in the task of identifying these segments of their courses and creating new teaching plans incorporating the introduction of systems thinking and the use of STELLA on the Macintoshs for creating and running models.

The teachers identified two basic strategies for using modeling in their teaching. The first entailed the teacher creating the model of a particular phenomenon; for example, reaction rates. The teacher builds the model using STELLA and establishes the initial values for variables. Copies are then made of the model for each of the fifteen Macintoshs. When the students come to class and work in pairs on the Macintoshes, they load the models and run them according to a set of instructions provided by the teacher. The students then make and record observations on the changing parameters in the model. These observations are subsequently turned in to the teacher for grading.

Teachers and students alike reported that these exercises were very useful. The students found the models engaging, and the teachers felt that they had achieved their learning objectives. However, the teachers spent a great deal of time in creating the models and the teaching plan, certainly much more time than would have been necessary to prepare a traditional lesson plan for the same material. Nevertheless, once the lesson plan and model are completed, they readily can be used in subsequent years.

The second basic strategy in using modeling was employed frequently by the physics teacher. Here students are given a problem; for example, a typical acceleration problem in physics. The students then create their own models to assist in solving the problem. In the former case the students manipulate the models created by the teacher; in the latter case the students create and subsequently modify their own models.

In both instances students can change initial parameters in the models and observe the effect over simulated time. When they build their own models, they can modify them by changing the equations and observe how the model obtains under different structural conditions. Initially, teachers felt that only advanced students would be able to create models. However, the teacher successfully had students in the ninth grade general physical science class constructing and operating their own models on simple problems. This method of organizing and presenting course material is a significant departure from that done in traditionally taught classes.

The three teachers in the science department found that it was useful for them to consult with one another periodically in developing their teaching strategies and models. They were able to be of some assistance to one another in these tasks. The three science teachers operate within a science department of 13 members. Work on the STACI Project served to consolidate the three science teachers on the one hand; but on the other it tended to decrease their interaction with the other science teachers who were using traditional means in their classes. This pattern tended to isolate the project teachers within the science department.

The teachers involved in the STACI Project emerged as an operating unit during the period of time in which the proposal was written for the federal grant. This solidarity among the group gathered strength over the two year period. However, the fourth teacher in the group operated in relative isolation, especially in the second year of the project. The course he taught, War and Revolution, was not formally listed in any academic department. The social scientists had considered the course, but later indicated that they were unwilling to accept it for credit in their department. Since this faculty member was located in the mathematics department, teaching a course partially under the auspices of the social studies department, and frequently interacting with members of the science department, his status became that of an individual marginal to the traditional organizational units within the school.

Furthermore, the students who applied for and were accepted into the War and Revolution course tended to be the most able in the school. The course and the teacher, therefore, were perceived as being highly academically oriented, elitist, and exclusionary. On the basis of classroom observations and interviews, it was clear that the teacher and students in War and Revolution were all quite comfortable with this perception. On the other hand, many people in the school resented the special status accorded to these individuals. Increasingly suspicion grew as to the quality of academic work and achievement in this course. During the second year of the project the students in the class also shared this concern for the quality of the course.

The role of the science department head was particularly interesting during the course of the STACI Project. In the academic year immediately preceding the establishment of the project, he was granted a leave of absence to complete his doctoral degree. When the science department chair returned the next year, the four teachers had already organized themselves and were writing their proposal for federal support. The chairman of the science department felt excluded from the systems thinking activities. Consequently, he never rendered adequate support for the activity. Although the project was clearly supported by the principal, superintendent, and school board, the chair of the science department was quite neutral and even somewhat skeptical concerning the potential utility of systems thinking. STACI Project members and other faculty perceived this as somewhat of a "sour grapes" attitude on the part of the science department chair.

Toward the end of the first year of the project, the science department chair accepted a position as science curriculum coordinator in a large district in another state. The reaction of most members of the science department and administration was one of relief at having him move on. A replacement was found from a nearby New England school district. This individual came into his new job at the beginning of the second year of the STACI Project with a great deal of interest and enthusiasm for curriculum innovations. Although he did not participate during his first year as science department chair in using systems thinking in his own teaching, he was a strong supporter of the activities of the three science teachers and wished to preside over future deliberations in the science department concerning possible expansion of systems thinking into other areas of the curriculum.

The three science teachers participating in STACI were greatly relieved and most appreciative of the position and attitude of the new department chair. It is interesting to note however, that other than good will and verbal support, no one could point to any specific consequence of the new chair's attitude, which either helped or promoted the program. However, in the long run, they suspected that having the support of the chair would ensure the continuation and success of the program.

It is clear from the interviews that most teachers and all administrators at BUHS were keenly interested in and supportive of the STACI Project. Not all were uniformly supportive of the activities, but every person interviewed was clearly aware and interested in learning more about it. One immediate consequence of the project was to increase the amount and flow of information throughout the school on this topic. It was in the words of one informant, "a major event" and therefore, a topic of a great deal of inquiry and exchange of information. It was also clear that decision making with respect to the project was placed squarely in the hands of a very few individuals.

When ETS first approached BUHS to participate in the STACI Project the principal's immediate reaction was that he would be interested in exploring the possibility. Nevertheless, he made it very clear that the final decision as to the school's participation would be made by the four teachers involved in the project. Fortunately, the teachers readily agreed to participation. They quickly recognized that in return for their allowing ETS to conduct research, they would receive hardware and financial support for their activities.

All matters pertaining to the design, conduct, and execution of the project were left in the hands of the project director and the three participating teachers. Hence, the STACI Project operated as a completely autonomous unit independent of the formal departmental structure at BUHS. It is important to recognize that there is a tradition of relative autonomy in terms of how courses are taught in high schools. Although the content may be specified by the state and or district, the actual method of teaching is usually left to a teacher's discretion. Therefore, the introduction of systems thinking into these courses did not represent a major departure from the usual method of conducting business in the schools.

This organizational case study is particularly limited in shedding light upon the fiscal impact of the introduction of systems thinking. With funds from the discretionary grant from the Department of Education and the funds provided by ETS through the Educational Technology Center at Harvard and the donated hardware by Apple, the fiscal aspects of the STACI Project at BUHS are quite artificial. Most of the financial resources needed to introduce and sustain the project were provided by outside agencies. This type of project does shed light on what direct and indirect expenses can be involved in a project of this type. They include hardware, software, teacher training, maintenance, security, laboratory preparation, etc. A subsidized project of this sort is limited in the extent to which it can shed light upon effective strategies that might be used by other schools employing technological innovations.

Nevertheless, it has become necessary for BUHS to make accommodations within its budget to provide for the project. For example, when the support from ETC and ETS ends, BUHS needs to determine its interest in sustaining or expanding systems thinking in the science or other departments. The BUHS School Board has already decided to allocate funds from its budget to provide for paraprofessionals to cover some nonacademic assignments that teachers normally perform. This assistance will allow them free time to work on systems thinking models and curriculum innovation.

This article is the first report of the organizational case study being conducted at BUHS. The investigation is being expanded in two ways. First the research at BUHS will be continued, and a longitudinal design is being implemented to trace the organizational impacts of introducing systems thinking over several years. Changes in the structure and functioning of the school will continue to be monitored as more teachers and departments start using systems thinking. Second, the project is being expanded to include additional schools in which similar curriculum innovations are taking place as a result of using systems thinking on a laboratory set of Macintosh computers. In addition to BUHS, the STACI Project now includes four high schools and two middle schools in California. It is expected that more schools will be added in future, and the case study design can be expanded further to permit comparisons among schools over time.

Reference List

Cline, H. F., & Sinnott, L. T. (1982). The electronic library: the impact of automation on academic libraries. Lexington, MA: Lexington Books.

Cline, H. F., Bennett, R. E., Kershaw, R. C., Schneiderman, M. B., Stecher, B. & Wilson, S. (1985). The electronic schoolhouse: the IBM secondary school computer education program. Hillsdale, NJ: Lawrence Erlbaum Associates.

Elizur, D. (1970). Adapting to innovation: a facet analysis of the case of the computer. Jerusalem, Israel: Jerusalem Academic Press.

Forrester, J. W. (1961). Industrial dynamics. Cambridge: MIT Press.

Forrester, J. W. (1968). Principles of systems. Cambridge: MIT Press.

Forrester, J. W. (1969). Urban dynamics. Cambridge: MIT Press.

Forrester, J. W. (1971). World dynamics. Cambridge: Wright-Allen Press.

Gouldner, A. W. (1954). Patterns of industrial bureaucracy. New York: The Free Press of Glencoe.

Katz, R., Kohn, R. L. & Adams, J. S. (1980). The Study of Organizations. San Francisco: Josey Bass.

Kaufman, M. (1960). The forest ranger. Baltimore: John Hopkins Press.

Kiesler, S. & Sproull, L. (Eds.) (1987). Computing and Change on Campus. New York: Cambridge University Press.

Lipset, S. M., Trow, M., & Coleman, J.S. (1956). Union Democracy: the internal politics of the international typographical union. Glencoe, IL: Free Press.

Mandinach, E. B., Thorpe, M. E., & Lahart, C. (1988). The impact of the systems thinking approach on teaching and learning activities. Princeton, N.J.: Educational Testing Service.

Pondy, L. R., & Huff, A. S. (1981). Drama and Routine in the Public Schools. Urbana, IL, Department of Business of Administration.

Richmond, B. S. (1985). STELLA [computer program]. Lyme, NH: High Performance Systems.

Roberts, N., Andersen, D., Deal, R., Garet, M., & Shaffer, W. (1983). Introduction to computer simulation: A systems dynamics modelling approach. Reading, MA: Addison/Wesley.

Seashore, S.E., Lawler, E. E., Marvis, P.H., & Cannann, C. (1983). Assessing Organizational Change: A Guide to Methods, Measures, and Practices. New York: John Wiley & Sons.

Selznick, P. (1949). TVA and the grass roots: a study in the sociology of formal organization. New York: Harper & Row.

Stanton, A. H., & Schwartz, M. S. (1954). The mental hospital: a study of institutional participation in psychiatric illness and treatment. New York: Basic Books.

Sykes, G. M. (1958). The society of captives: a study of a maximum security prison. Princeton: Princeton University Press.

Whyte, W. F. (1948). Human relations in the restaurant industry. New York: McGraw-Hill.