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ABSTRACT

To examine the problem of widening gaps in reading achievement between initially low-achieving children and other students as they move through elementary school, the authors first reviewed the literature on school effectiveness. Using a form of systems analysis called "system dynamics," they formulated a model and a set of hypotheses explaining the differences between effective and ineffective schools. Among the variables included are teacher skills and expectations, time factors, instructional intensity and appropriateness, principals' intervention and support, class size, feedback between reading achievement and teacher perceptions of a learning gap, and student behavior, motivation, and aptitude. A survey of educational practitioners' reactions led to adjustments in the model. The authors then constructed a mathematical computer simulation of the model, showing the flow of students through grades 1-6, to test the hypotheses and to evaluate four possible school improvement policies that involve changes in school characteristics, instructional intensity and appropriateness, or student behavior. Based on their results, the authors conclude that ineffective schools can be made effective by increasing teacher skills, raising teacher expectations, and maximizing instructional time. (Author/RW)

IMPROVING SCHOOLS FOR LOW ACHIEVING CHILDREN: A SYSTEM DYNAMICS POLICY STUDY

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INTRODUCTION

The Problem

The current emphasis on basic skills and minimal competency testing in U.S. elementary and secondary schools underscores a belief in and a concern for public education. The belief is that all but clearly exceptional students should be able to acquire a repertoire of basic skills and minimal competencies during the course of their schooling. Both educators and the public are concerned that elementary and secondary schools are not achieving this goal. It is in the nation's urban schools where the problem seems to be the worst. The continued failure of most urban elementary schools to educate students effectively has been well documented (cf. Edmonds, 1979; Kozol, 1967; Silberman, 1970; Weber, 1971).

There is repeated reference in the literature to a widening gap in reading achievement between poor and middle class children. By and large, poor children enter elementary school at a lower level of reading readiness than do middle class and upper middle class children. As these children move through elementary school, the gap persists and widens. The percentage of poor children who drop out of school by the time they reach age sixteen is far greater than that of middle class children (Dearman & Plisko, 1981, pp. 30,33). The problem can be viewed, then, as a discrepancy between the actual patterns of reading achievement for initially low-achieving students in urban elementary schools and a desired level of achievement for all students.

This problem can be conceptualized from the perspective of cohorts of students moving through an elementary school or from the perspective of the school monitoring patterns in reading achievement for successive cohorts over a period of years. From the cohort perspective, if students entering the first grade in a given year are divided into

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[1] This paper constitutes a summary report. The work is fully reported elsewhere (Clauset, 1982; Clauset and Gaynor, in preparation). Major reactors to working drafts have included Don Davies and Bernard S. Phillips, Boston University, and Edward B. Roberts, Massachusetts Institute of Technology. Editorial assistance was provided by Giansanto Lombardo and Owen Heleen. Final responsibility for the text remains with the authors.

initially low, average, and high achievers, based on indicators of reading readiness, the graph of cohort achievement in reading over the six years of elementary school would show a widening gap between the low and average achievers. The initially high achievers who began first grade above grade level maintain or increase their gap relative to the average achievers. In other words, differences in achievement among groups of students do not disappear at later grade levels. As Bloom (1976, p. 9) points out in his review of the few longitudinal research studies in this area, "there is a substantial relation between achievement differences among a group of students at one time and their achievement differences several years later."

From the school perspective, if one examined the reading achievement scores of sixth graders who were initially high-, average-, and low-achieving students, one would find that initially low-achieving sixth graders would maintain a pattern of achievement one to three years below the average achievers and the initially high achievers would be one to two years above the average achievers.

The existence of these reference behaviors is not well documented in the literature. There are two reasons for this. The first is the tendency on the part of school administrators to report average grade level achievement scores. Above average scores of the initially high achievers mask below average scores of the initially low achievers. The second reason for a lack of clear research evidence is the dearth of longitudinal studies that track the achievement patterns of students identified as initially low, average, and high achievers. However, few deny that the problem exists. Debate on the problem has been concerned with the relative contributions of schooling, family background or socioeconomic status (cf. Bridge, et al., 1979).

Coleman, et al. (1966) argued that "schools bring little influence to bear on a child's achievement that is independent of his background and general context." Since then there have been numerous critiques of Coleman's work and more recently a growing body of empirical work which suggest that schools do make a difference and that the problem described above need not exist (e.g., Averch, et al., 1974; Barr and Dreeben, 1977; Edmonds, 1979; Fowler, 1980; Rutter, et al., 1979). A relatively small number of "lighthouse" effective schools have been identified throughout the country. These are schools in which students, often minority and/or poor, achieve far better than home and SES variables would predict. Much of the literature on these schools has been in the form of case studies (Benjamin, 1980; Brundage, 1980; Phi Delta Kappa, 1980; Salganik, 1980; Weber, 1971).

Other research has focused upon the operative dimensions of effective schooling. This research has taken two directions. Most of the extant research, some of it experimental in design, has studied teaching processes and their effects upon basic skills achievement. This body of work, characterized for example, by the Beginning Teacher Evaluation Study in California (Fisher et al., 1978), has identified a number of process variables which are associated with basic skills learning, especially for traditionally low-achieving students (cf.

Berliner, 1979; Bloom, 1976; Medley, 1979; Rosenshine, 1979).

Of the various processes studied, it is the management and use of time that seems most important. This importance is underscored by the work of educational researchers and economists on resource allocation to and within schools (Dreeben & Thomas, 1980; Harnischfeger & Wiley, 1977; Thomas, 1977). A smaller body of research is beginning to emerge which focuses upon the organizational context of effective instruction. This research attempts to describe the organizational properties of the effective school (cf. Brookover, 1979; Edmonds, 1979; Rutter et al., 1979).

A variety of causal models have been developed to explain student achievement at the school, classroom, and individual levels. Broadly speaking, these models can be classified as input-output models or process-product models (Averch, 1974).

Much of the school effectiveness research has been of the input-output type. The goal of this type of research is to produce an "education production function" which describes, usually in the form of a multiple-regression equation, the relative impacts of student, background, and school inputs on achievement. Most of this work has focused on the school as the unit of analysis and has emphasized linear, non-feedback relationships (c.f. Bridge, et al., 1979). In recent years, there have been efforts made to develop educational production functions that focus on resource allocation within classrooms.

The work of Brown and Saks (1980), Harnishfeger and Wiley (1977, 1980), Thomas (1977), and Wiley (1976) represent research aimed at explaining why most of the variance in school achievement occurs within schools (Cohen, 1979). The limitations that we see in input-output research are that it is essentially: (1) atheoretical (Cohen, 1979), where large numbers of variables are "sifted" for statistically significant relationships; (2) linear, where important non-linearities are ignored; and (3) uni-directional, where important feedback relationships and interactions among variables are not included.

The process-product models of school achievement have focused more closely on what happens in classrooms to individual students. These models have traditionally been concerned with teacher and student characteristics and instructional methods (Averch, 1974; Bloom, 1976; Centra and Potter, 1980; Fisher, et al., 1978; Leinhardt, 1980; Peterson & Walberg, 1979).

More recently, research has included a focus on the organizational context within which classroom learning takes place. This has been the focus of the "school effectiveness" research (c.f. Brookover, et al., 1979; Edmonds, 1979). Although these models have had a stronger theoretical framework, they still tend to emphasize non-feedback, linear relationships and shed little light on how teachers make instructional decisions. The dynamic theory of schooling described in this paper is our attempt to address these deficiencies.

Research Objectives

The current work has sought to achieve two goals: (1) to develop a causal theory for understanding the problem of a widening reading achievement gap for initially low-achieving students; and (2) to use the theory to evaluate the likely consequences of policies, implemented by school administrators to ameliorate the problem. The methodology chosen to achieve these goals was System Dynamics. [2]

To develop a theory about effective and ineffective schooling, we focused on the interactions among a mutually interdependent set of variables that, over time, produce the patterns of reading achievement already described. This set of variables represents a causal structure of the problem system. The growing evidence that schools do have an impact regardless of family and socioeconomic background factors implies a focus on the constellation of variables within the boundaries of the school setting. Focus was on understanding the problem and on evaluating the likely impacts and trade-offs associated with school improvement policies. Our perspective in approaching this problem closely parallels Bloom's in his development of a theory of mastery learning. He states:

> Implicit in the entire work is the attempt to regard school learning as a causal system in which a few variables may be used to predict, explain, and determine different levels and rates of learning. This causal system makes explicit the notion that the present learning is an outgrowth of previous learning and learning conditions and that, in turn, the present learning will have consequences for future learning (italics in the original). (Bloom, 1976, p. 202)

In addition, we have developed a computer simulation model--the School Effectiveness Model--which is designed to address the following question: What mix of strategies available to administrators at the school or district level is most effective in closing the achievement gap for initially low-achieving students? The policy options examined with the model cluster in four areas: (1) changes in the school's student population; (2) changes in the quantity, or intensity, of instruction delivered to initially low achievers; (3) changes in the quality, or appropriateness, of instruction; and (4) changes in the school climate.

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[2] System Dynamics is a particular form of systems analysis which was developed at M.I.T. during the late 1950's and has been refined in a variety of applications over the last quarter century. It includes a set of tools and techniques for developing computer simulation models of dynamic causal structures. For a more detailed introduction to System Dynamics see Forrester (1968) or Richardson & Pugh (1981).

In the present stage of policy analysis we have made the simplifying assumption that policy interventions can be directly implemented. In the next stage of work, we plan to incorporate in the model organizational characteristics that often thwart implementation (e.g., limits on principal time and skill, and staff resistance to change).

Research Method

System Dynamics was chosen as a framework for theory-building and policy analysis. We did so for four main reasons (see also, Gaynor and Clauset, 1981). First, System Dynamics has an internal perspective. It assumes that the problem behaviors are not the result of discrete events arising within or outside the system. Rather, it assumes that the problem behaviors arise from the structure of the problem system. System elements are organized and interrelated in ways which produce the problem behaviors over time.

Second, System Dynamics focuses on feedback structures. Feedback structures [3] are inherent in the idea that system behavior is produced by a set of mutually interdependent and interacting elements. There are no independent variables and dependent variables as in the case of correlation or regression analysis.

For example, in traditional input-output studies of schooling, student achievement is considered to be the dependent variable and various student and school characteristics are considered to be independent variables. From the system dynamics perspective, achievement is a variable which impacts upon student characteristics such as behavior, motivation, and the ability to learn new material and upon school characteristics such as teacher expectations, and teacher emphasis on various achievement groups. Causal theories developed from the system dynamics perspective emphasize the interactive effects of multiple feedback loops and the idea that shifting dominance among feedback loops produces variations in system behavior.

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[3] Feedback structures are of two general types. "Positive" feedback structures include causal relationships among variables which are mutually self-reinforcing. The relationship between wages and prices operates within the dynamics of inflation and depression to illustrate the concept of positive feedback. "Negative" feedback structures are characterized by their goal-seeking behavior. A thermostat system, for example, is a negative feedback system. In such a system, the effect of one variable on another is the opposite of the counter-effect of the second variable upon the first. In the thermostat system, the heater goes on as the temperature goes down and off as the temperature goes up. Whereas positive feedback systems are characterized by runaway behavior such as inflation, negative feedback systems tend to stabilize values around a goal, such as the thermostat setting.

Third, an important characteristic of System Dynamics is the ability to translate one's causal theory about a problem system into a computer simulation model. The ability to model one's theory enables one to test the internal consistency and robustness of one's theory in a manner which is impossible with mental models. Furthermore, the computer simulation model allows one to search systematically for important policy levers in the problem system and then to test a range of potential policy solutions for ameliorating the problem. One can evaluate the likely consequences of different policies before investing large amounts of time, money and human resources on a particular policy option in a real school or school district.

The final advantage of System Dynamics lies in the rigor of the process. In order to write a set of mathematical equations for computer simulation, one must be explicit about one's assumptions and the relationships among system variables. The process draws on the existing research literature and on the experiental, qualitative knowledge that practitioners have. It encourages dialogue and debate about assumptions and relationships. The process is iterative. Trying to write equations to express a relationship may force one back to the literature for more information or may force one to reconceptualize the relationship completely. It is this circular process of moving between the knowledge base, the theory, and the simulation model that leads to deeper and deeper understanding of the problem.

System Dynamics has been used by several scholars to study important educational issues. Roberts (1974, 1975) used the methodology to understand factors affecting the academic performance of an elementary school student. She focused on the amount and quality of teacher-student interactions and on the influence of parents. Her work and ours are similar in the emphasis on teacher-student interactions, but there are also important differences. Our work places the individual student-teacher relationship in the context of the classroom, where other students compete for teacher time and emphasis, and in the context of the school, where school climate and school-wide administrative policies affect classroom instruction. Finally, our work focuses on school improvement policies at the school level while Roberts focused on the interactions between one teacher and one student.

Most of the other work applying System Dynamics to education has concentrated on policy issues. Garet (1979) and Gaynor (1979, 1980a, 1981) have studied the processes of innovation and the implementation of innovations in public schools. Weaver (1982) sought to understand the "causes of a persistent century-long gap in the educational resources and educational attainment favoring the advantaged" as these are distributed by the American educational system. Andersen (1977) and Andersen, et al., (1980) have focused on public school finance issues and on special education.

Research Stages

In applying System Dynamics to a problem of interest, the analyst is involved from time to time in a number of stages of work (Gaynor, 1982; Richardson and Pugh, 1981). These include: (1) Empirical Data Analysis; (2) Model Formulation; (3) Structural Policy Analysis; and (4) Empirical Policy Analysis. The analyst moves through these four stages somewhat sequentially, but also reiteratively. It is often necessary at each succeeding stage to continue activities associated with earlier stages.

Empirical Data Analysis

Policy analysis inevitably focuses on a specific set of perceived problems. A problem in the policy context constitutes a perceived discrepancy between an observed (or projected) trend and a desired trend. Therefore, the earliest stage of policy analysis work is directed toward clarifying as precisely as possible the empirical nature of the problem. Every effort is made to mine all feasible sources of data for information about the problem.

As the analyst develops clarity about the parameters of the problem, trend data are established and graphs are drawn to depict the problem as a continuing one over time. Such trends are called "reference behavior modes;" the graphs are referred to as "reference behavior graphs." Reference behavior modes represent crucial anchors for the ensuing study. They guide the choice of model variables, helping the analyst to determine what variables to include and which to leave out. They also constitute benchmarks against which to evaluate the behavior of the emerging model during later stages of the work.

The success of the work is rooted ultimately in the ability of the analyst to understand the processes, the systemic patterns of response and counter-response, which give rise to the focal problem(s). These understandings require a grounding in empirical reality, as best one can know it. In the final analysis, they derive from the fruitful interaction of knowledge and intuition (Gaynor, 1980; Polanyi, 1969). Thus, empirical analysis is a necessary foundation for clarifying the problem and for grounding understandings about the causal structure of the problem system. The analyst typically uses a variety of data sources, primary and secondary, quantitative and qualitative, in this search for understandings.

Model Formulation

Emerging understandings are depicted during various stages of the work in words, diagrams and equations. Actually, the earliest understandings take the form of mental representations--words and visual images. Throughout the analytic process, there is an interplay between ideas that are emerging through internal cognitive processes and those that have already been represented graphically, verbally and mathematically. As new understandings take theoretical form and are tested logically in a variety of ways, conceptual difficulties are

exposed. Here, again, data sources become crucial. Emergent ideas must be exposed to the light of relevant research findings as well as to the critical minds of persons believed to be especially knowledgeable about the problem(s) upon which the analysis is focused. Thus, in the model formulation stage the analyst reaches back constantly to empirical as well as logical analysis. For the system dynamicist, the special value of the computer lies in its unique ability to pursue rigorously and rapidly the logical implications of a set of ideas and understandings which have been cast in equation form.

Structural Policy Analysis

Once the model has been formulated, tested and adequately refined, it can at last be used to do what it was designed to do. The fruit of the process of policy analysis is to evaluate alternative policy proposals. It is difficult to evaluate adequately how specific policies are likely to play themselves out in a complex social system when one's understandings about the nature of the problem system are represented only in verbal or graphic form. But when one's theory of the problem is represented mathematically as in a system dynamics model, the computer is able to perform the many necessary calculations, to maintain in memory the results of these calculations, and thus to simulate the behavior of the system over time as a logical projection of the theory represented in the model.

The unique value of casting one's understandings in this form is that it then becomes possible to examine systematically the effects of specific structural changes on the behavior of the problem system. One can quite simply and directly alter either the values of specific variables at particular points in time, alter the causal relationships among variables, or introduce new variables and relationships into the model structure. This kind of structural policy analysis is the third stage of the modeling process.

Empirical Policy Analysis

The final stage of the policy analysis process is essential if one's interests transcend mere theoretical speculation. In this stage the analyst works with knowledgeable others to give empirical substance to policies which structurally have shown promise for ameliorating the focal problem(s). The problem is a real-world problem; the solution must be a real-world solution. That is, the policy conclusions must ultimately be expressed in practical terms, not simply "theoretically."

A DYNAMIC THEORY OF SCHOOLING

The Dynamic Hypothesis

The problem behaviors described earlier in this paper suggest the existence of a multiplier effect in the ineffective school that operates to reinforce the initial achievement differences among entering students. We argue that the fundamental difference between schools which

are effective and ineffective for initially low-achieving children lies in the relationship between Observed Achievement and the Appropriateness and Intensity of Instruction which the school delivers to different achievement groups. Based upon considerable research on "Direct Instruction" [4] and "Mastery Learning" (Bloom, 1976), it is assumed that in all schools, effective and ineffective, there is a direct causal relationship between the appropriateness and intensity of instruction and the rate at which children, especially poor children, learn to read (Benjamin, 1980; Medley, 1979; Rosenshine, 1979; Salganik, 1980). We hypothesize that effective schools provide instruction to low-achieving students which is appropriate and more intense in order to bring their reading achievement up to grade level. In these schools, grade level performance is the norm for all but clearly exceptional children. By contrast in the ineffective school, instruction is most intense and appropriate for children whose achievement is already at grade level or above and increasingly less intense and appropriate for children who read further and further below grade level.

Thus, effective schools are characterized by "negative feedback" between observed achievement and appropriateness and intensity of instruction (where lower achievers get more intense instruction) and ineffective schools are characterized by "positive feedback" (in which lower achievers get less appropriate and intense instruction). (see footnote [3], Supra, p. 5.) We are arguing that it is differing expectations of teachers for low-achieving students that determines different patterns of appropriateness and intensity of instruction in the effective and ineffective schools. This is our dynamic hypothesis.

This difference is found repeatedly in the literature (Benjamin, 1980; Brookover, et al., 1979; Brophy & Good, 1970; Edmonds, 1979; Phi Delta Kappa, 1980; Rosenthal & Jacobson, 1968; Salganik, 1980; Silberman, 1970; Weber, 1971). In an effective school, teachers and the principal maintain high expectations for the achievement of all but clearly exceptional students. They assume that, regardless of family background or social class characteristics, all but clearly exceptional children can learn at a normal rate and can achieve standard levels of performance during their years of schooling. In an ineffective school, expectations for achievement are neither high nor fixed. Children who enter school with a lower level of reading readiness or who are from lower socioeconomic classes (Rist, 1973) are categorized as low achievers. It is assumed that there is little the school can do to offset the impact of pre-school, family, and environmental conditions.

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[4] Direct instruction has been defined (c.f., Rosenshine (1979)): as being (1) academically focused, (2) teacher directed instruction using sequenced and structured materials, (3) grouping students for learning (where appropriate and where close monitoring and supervision can be provided), (4) emphasis on factual questions and controlled practice, and (5) careful management of students during seat-work.

According to this hypothesis, appropriateness and intensity of instruction constitutes an institutional response to a perceived learning gap. The perceived learning gap is the difference between expectations teachers and principals hold for students and their perceptions of how well students are actually achieving. It is the perceived learning gap which exerts pressure on teachers and principals to accept professional responsibility for low-achieving students and to work institutionally to increase the appropriateness and intensity of instruction for them.

In the ineffective school, teacher and principal expectations for students regress toward actual achievement, a dynamic which has the effect of "writing off" initially low-achieving children from the very beginning as students who cannot keep up. This dynamic in ineffective schools obviates any perceived learning gap and any institutional responsibility for improving instruction. Thus, ineffective schools are dominated by a positive dynamic which amplifies over time the initial differences in student achievement. This positive dynamic centers around the interactions between student achievement and motivation. As achievement rises or falls below grade level standards, student motivation to learn is increased or decreased. Changes in motivation affect the current learning rate which affects achievement.

In effective schools, the teachers and principal maintain their belief that all but clearly exceptional children can learn at grade level standards. In these schools, teachers and principal perceive a learning gap for low-achieving students, accept institutional responsibility for closing this gap, and work to do so by improving the appropriateness and intensity of instruction for low-achieving students. Effective schools exhibit goal seeking behavior where grade level standards are the performance goals for initially low achievers. Bloom (1976, p. 212) characterizes effective schools as "self-correcting" systems where feedback to teachers and students can reveal the errors in learning shortly after they occur and where appropriate corrections are introduced.

The Basic Feedback Structure

To understand the factors affecting achievement, one must focus on the student's learning rate. The student's learning rate for any subject is directly dependent on the amount of time the student is successfully engaged in instructional activities related to that subject [5]. This focus on time and learning draws heavily on the work of the Beginning Teacher Evaluation Study (BTES) in California (Fisher, et al., 1978).

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[5] Although variations in student aptitude are important, they do not change the institutional responses to achievement patterns. In this study, we have assumed that students with different levels of initial achievement have the same aptitude for learning.

Central to this concept is the notion of "engaged time" in instructional activities, or what the BTES study refers to as "academic learning time." Engaged time is a function of the amount of time available for instructional activities in a subject and the student's engagement rate in those activities. In this discussion, engaged time is student time. It is the amount of time students are engaged in learning activities.

The amount of time available for instruction in a particular subject area is a function of school policies, teacher effectiveness and student behavior. The student's engagement rate in learning activities depends both on student motivation for learning in that particular subject area and on the appropriateness of the activities planned and presented by the teacher. Activities are appropriate if they are at the right level of reading comprehension, culturally and topically relevant, and properly sequenced with reference to prior learning (cf. Bloom, 1976).

Thus, appropriateness of instruction depends heavily on teacher skills. It is also affected by class size since class size mediates the effects of skill [6]. Another way to think about appropriateness of instruction is to think about a teacher's "instructional efficiency", or how efficient a teacher is in converting time available for instruction into student engaged time. In the theory and model developed here, we have used the concept of instructional efficiency.

A teacher's instructional efficiency for a given achievement group may vary considerably from his or her general instructional efficiency. These variations are a function of teacher expectations for the group and teacher emphasis on the group. The effect of expectations on appropriateness of instruction (and, therefore, on cohort instructional efficiency) is largely a function of the perceived learning gap for the cohort. This gap is dependent on the level of teacher expectations and current achievement.

There is also a relationship between the appropriateness and intensity of instruction and student motivation. The literature on achievement motivation indicates that more appropriate and more intense instruction has a positive impact on student motivation to learn, while less appropriate and less intense instruction has a negative impact (Atkinson et al., 1976; Kolesnik, 1978; Russell, 1971; Watson, 1963).

Teacher expectations also affect student motivation. High teacher expectations for presently low-achieving students reinforce learning and help to raise student motivation. Students pick up the verbal and non-verbal signals from a teacher which say "you can do it." There is no such positive reinforcement in an ineffective school.

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[6] Workload pressures also affect a teacher's instructional efficiency. The present stage of research treats workload as an exogenous variable. In the next stage, it will be endogenous.

In addition, there are two interaction effects which mediate the impact of appropriateness and intensity of instruction and engaged time on the learning rate: the effect of the current level of achievement and the marginal return on highly concentrated instruction. In most learning situations, where a set syllabus and time line are followed, a below-normal current level of achievement negatively affects the learning rate. Students with lower achievement levels have not mastered the necessary precursor concepts and skills for the present learning activities and learning is more difficult. The learning rate is less than the amount of engaged time and student aptitude would indicate. This retardation of the learning rate increases as the gap between current achievement and grade level standards widens.

The impact of achievement on learning rate is affected by how the teacher teaches. As Bloom (1976) argues in developing the concept of Mastery Learning, a low level of achievement need not retard learning if the teacher designs instructional activities that build on the foundation of concepts and skills that the student already possesses or if the teacher spends more time with the students. This is, in fact, what we call appropriate and intense instruction. On the other hand, the negative effect of low levels of achievement is strengthened if the teacher's skills are below average.

The second interaction effect is the marginal return on highly concentrated instruction. It represents a saturation effect where increases in instruction no longer produce corresponding gains in engaged time because students have reached their limits of attention and concentration. The effect only becomes noticeable for significant increases in the intensity of instruction.

Time Available for Instruction

There is still more to the theory. As its name suggests, appropriateness and intensity of instruction is a two-dimensional construct. Engaged time in reading is increased both by more time spent in reading activities and by more appropriate reading activities. These are the companions - quantity and quality of instruction.

The quantity of instruction depends on a number of variables. First, it is a function of school policies which determine how much time is to be spent in the classroom on instructional activities and how much time is to be spent in other activities in or outside the classroom. Both the BTES study (Fisher, et al., 1976) and the work by Harnischfeger and Wiley (1980) report wide variations in time allocations both between and within schools.

Second, quantity of instruction is a function of how classroom time is apportioned among the different subject areas. Often there are school or district level guidelines for the number of minutes per day or per week for instruction in each academic subject.

Also, the amount of time available for reading instruction can be eroded by time teachers spend in transitional and classroom management activities. This time is dependent on classroom student behavior and on teacher effectiveness. The more highly skilled a teacher is in classroom management and in dealing with behavior problems, the greater the fraction of time allocated for instruction that can actually be spent in instruction.

The Appropriateness of Instruction

The quality or appropriateness of instruction can vary from achievement group to achievement group. Ethnographic studies such as Rist (1973) show that the quality of instruction provided to students in different achievement groups within the same classroom can vary considerably. These variations stem from differences in the teacher's instructional efficiency for the different achievement groups. Although a given teacher has a general level of instructional efficiency, his or her efficiency for a cohort depends on the teacher's emphasis on that group. Teachers who place more emphasis on a group are more efficient in their use of time for that group and more effective in their instruction. Students who receive greater emphasis have more time-on-task and higher engaged time than students who receive less emphasis.

It is central to our theory of schooling that the perceived learning gap between teacher expectations for achievement and present level of achievement is a major determinant of teacher emphasis for a particular achievement group. A teacher will devote more emphasis to the group if the teacher perceives a gap in reading achievement for that group (i.e., the teacher perceives that reading achievement is below the teacher's expectations for the group). If, because of low expectations, there is no gap in achievement, the teacher will make no effort to increase the emphasis on the group.

Teacher expectations also have a direct impact on teacher emphasis. There is research to suggest a systematic bias against those students for whom the teacher has below-normal expectations (cf. Rist, 1973). The effect of the bias (to reduce instructional emphasis) increases as the gap between grade level standards and teacher expectations widens. The teacher who has below-normal expectations for a particular achievement group will place less emphasis on them and the teacher's instructional efficiency for that achievement group will be less. Therefore, the appropriateness and intensity of instruction and the engaged time for that achievement group will decline. [7]

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[7] The assumption used here in estimating the impact of a relationship is "ceteris paribus" - all other things being equal. That is, that none of the other variables affecting appropriateness and intensity of instruction or engaged time are changed. This mental test

Motivation and Behavior

Student motivation and behavior are important contributors to achievement patterns. They are also affected by achievement patterns and the instructional process. They are embedded in a set of positive feedback relationships that increase or inhibit achievement (Bloom, 1976, p. 103). Motivation to learn in a given content area directly affects a student's engagement rate in learning activities. The lower the level of motivation, the lower the student's interest in and involvement with instruction. Motivation also has a direct effect on behavior.

Motivation

Motivation, itself, is primarily a function of environmental, rather than hereditary, variables (Watson, 1963). Although scholars agree that home and pre-school experiences are important determinants of a child's attitude to school and general achievement motivation, school experiences are also important (Bloom, 1976; Kolesnik, 1978; Russell, 1971; Watson, 1963). Children tend to become success- or failure-oriented, and, as Russell describes in the passage below, these patterns tend to be set early in the schooling process (Russell, 1971).

> Out of the milieu of early school experiences, the child develops a 'way of school life' which he is prone to continue for many years. If school turns out to be a place where success is encountered and pleasure is felt, it follows that positive expectancies are created and perpetuated. If, to the contrary, failure, embarrassment, and discomfort are the predominant themes, it is natural that negative expectancies arise. Whatever the child comes to expect, his own perceptions and behaviors tend to fulfill. In the school program or in his relations with teachers, he may find cause to change his expectancies. On the other hand, there is the strong possibility that the child who expects difficulty somehow conveys this feeling to the teacher in nonverbal communication, and that the teacher reacts in ways which make the child's expectations become fact. (pp. 53-54)

What school factors directly affect motivation? Clearly, feedback on achievement is important. Success reinforces success; failure reinforces failure. Students measure their own work against standards of performance set for them. Bloom argues (1976, p. 140) on the basis of macro- and micro-level studies

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of a causal link between two variables is often used by system dynamicists to clarify a relationship.

that "the student's perception of his competence in school learning" is the major factor influencing motivation to learn. Kolesnik sees the quantity and quality of instruction as particularly important (1978, pp. 249-250) and both Russell (1971, pp. 97-98) and Singer and Donlan (1980, p. 476) underscore the importance of teacher expectations. In addition, Kolesnik suggests that an unruly and disruptive atmosphere (where levels of student behavior are low) exerts a negative influence on motivation for learning.

Consistent with the literature, then, the theory of schooling described here includes the effects of achievement, teacher expectations, appropriateness and intensity of instruction and behavior on motivation. These factors exert pressure on students to change their level of motivation. The pressures may reinforce or neutralize each other. Changes in motivation do not occur instantaneously, but rather emerge over the course of time as the pressures for change continue.

Behavior

The case study literature on effective schools emphasizes the importance of good behavior and an orderly, quiet atmosphere conducive to learning (Benjamin, 1980; Phi Delta Kappa, 1980; Salganik, 1980). Students who are motivated to learn and who are experiencing success in their work are less disruptive and unruly. Achievement motivation is an important determinant of student behavior in school. In addition, a student's behavior is influenced by the behavior of peers. Classmates have the greatest influence since most of the student's time is spent in their company, but the general level of school-wide behavior is also important (cf. Duke, 1980; Kozol, 1967).

The size of a cohort in the classroom also affects its level of behavior. Teachers have long been aware of the effects of a "critical mass" of disruptive students. When the number of disruptive students is large enough, each student's unruly behavior is reinforced by peers and the general level of cohort behavior is lower than it would ordinarily be (cf. Duke, 1980; Kozol, 1967; Ryan, 1970). The same phenomenon occurs for exemplary behavior but the effects are not so noticeable, probably because the difference between "good" and average behavior is not as great as the differences between "bad" and average behavior.

This description of the influences of behavior highlights the difficulties in trying to maintain a high level of student behavior when motivation is low. Efforts by teachers and administrators to enforce strict discipline in an environment where the instructional process feeds feelings of failure and low motivation will only be met by resistance on the part of students. Under such conditions, the level of behavior desired

by the staff is inconsistent with the level of behavior indicated by motivation (which is a direct effect of the learning environment). As with changes in motivation, changes in behavior do not occur instantaneously, but rather emerge in response to the net effect of pressures from motivation and peer groups.

Interactions among Cohort Groups

The depiction of the theory thus far implies that decisions about reading instruction for a particular achievement group are made in isolation without considering the presence of other achievement groups in the classroom. This is not so. In heterogeneous classrooms typical of elementary schools, other groups can have a profound impact on the group's behavior and learning.

Interactions Affecting Behavior

Each achievement group's behavior is affected by its motivation to learn in each content area and by the general level of classroom and school-wide behavior. Each cohort's behavior also affects the general classroom behavior. Larger cohorts have a greater effect than smaller ones. The general level of classroom behavior directly affects the amount of time available for instruction to all students in the classroom and, through out-of-class interactions, affects the behavior of students at other grade levels throughout the school.

Competition for Teacher Emphasis

Teacher emphasis is a finite commodity. Students in various achievement groups compete for teacher emphasis. The desired teacher emphasis for a given achievement group and the actual teacher emphasis for the group may differ. While a teacher may wish to devote a great deal of his/her time to a particular achievement group, realities dictate that time must also be spent with the other groups. The teacher's instructional efficiency for a given achievement group is affected by the presence of the other achievement groups in the classroom.

The Theory

Figure 1 is a comprehensive picture of the relationships between achievement and instruction. It represents our dynamic theory of schooling.

A word of explanation is necessary about the lower left-hand part of the figure that deals with the formulation of teacher expectations. There are three ways one can form expectations.

First, expectations can be based on a fixed set of standards as in an effective school. Second, teachers can have no standards on which to base their expectations, as in an ineffective school, and base their expectations solely on a student's current level of achievement. Third, teachers can be somewhere in between these two extremes, where they base their expectations partly on a set of fixed standards and partly on current achievement.

The concept "teacher weight for standards" is used to indicate where a faculty falls on the range of choices for formulating expectations. A high weight for standards means that teachers have expectations firmly rooted in standards (an effective school). A low weight means expectations vary with achievement (an ineffective school). This "weight for standards" concept is important, even though it is not a familiar one. In the next section, we will show how teacher weight for standards can change and thus change the basis for forming expectations. This represents a potentially potent avenue for school improvement.

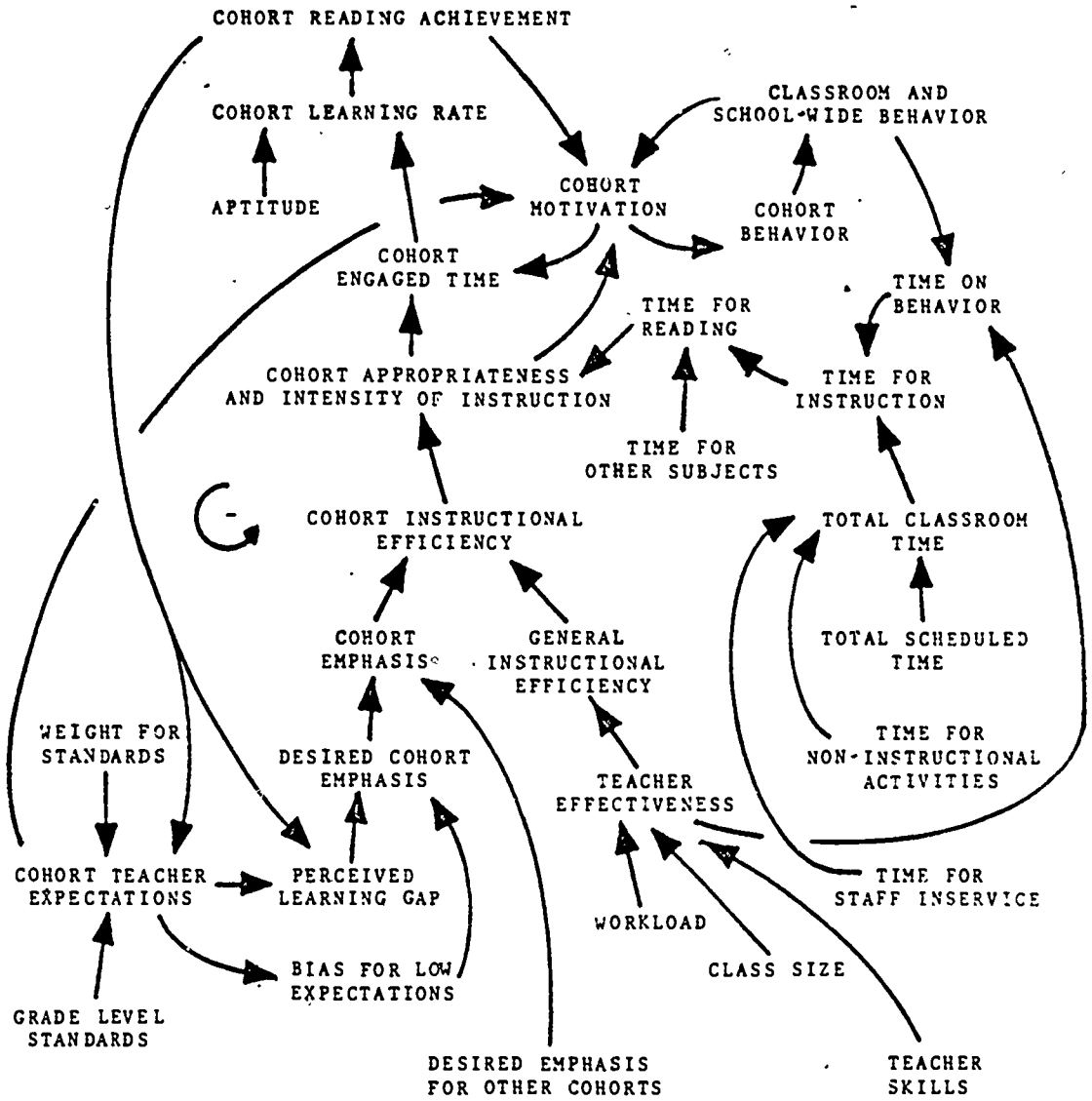

Figure 1. A Dynamic Theory of Schooling.

The diagram highlights a series of positive feedback loops which can operate to reinforce improving or declining achievement. The impact of these positive feedback loops is mediated by the negative feedback loop which operates through the perceived learning gap. In the ineffective school, this negative feedback loop disappears. There is no perceived learning gap because teacher expectations are the same as present achievement. Consequently, ineffective schools reinforce high achievement for initially high achievers, average achievement for initially average achievers and low achievement for initially low

achievers.

The absence of school administrators from this causal theory of instruction is purposeful. School administrators are not directly involved in the instructional process. In a McBer & Company study of superior principals in Cleveland, Burruss (1979) states:

> The role of the principal which emerges from this analysis is that of a facilitator and maintainer of the system. The major goal of this role is internal (e.g., to reduce conflict). Principals achieve this goal through building norms and establishing consistent policies. The teacher goal, in contrast, is external (e.g., to get kids to learn), and this goal is achieved through use of technical subject matter and teaching methods. The principal's role is not one of direct involvement in the educational process but rather one of maintaining a strong institution in which education can take place. Superior principals respect and support their staff, help them feel strong and confident. They develop very clear norms and procedures. They cultivate belief in the institution by speaking on its behalf and organizing activities that build team spirit. (p. 18)

In the policy analyses presented later in the paper, we assess the impact of various strategies a principal may employ in trying to change an ineffective school into an effective one.

Transition to Effectiveness

The causal loop diagram in Figure 1 does not indicate how schools can move from a state of ineffectiveness to a state of effectiveness. The dynamics of this transition process are captured in Figure 2.

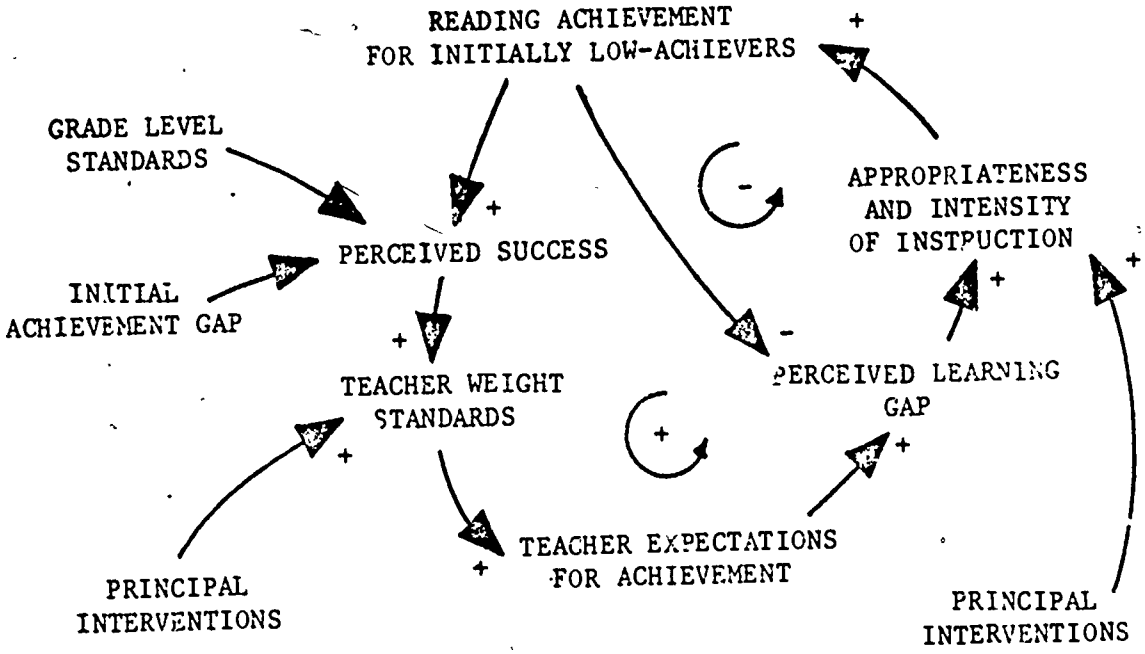

Figure 2. The Success Loop: Transition to Effectiveness.

The theory incorporates the idea that the transition to school effectiveness is a developmental process dominated by positive feedback. Success leads to more success.

What is success? Success means that student achievement, relative to standards, is better after a period of schooling than it was before. When teachers perceive success, teacher weight for standards begins to rise. A rising "weight for standards" means that teacher expectations are based more on grade level standards and less on current achievement patterns. This results in higher expectations for achievement for low achievers at all grade levels, a larger perceived learning gap and, consequently, more effort and concern on the part of teachers to provide more appropriate and more intense instruction. This leads to further gains in achievement, more success, higher weight for standards, and higher expectations. It is a positive feedback loop that can move a school toward effectiveness [8].

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[8] In the simulation model, success and its impact on teacher weight for standards is tied to initially low achievers and to reading achievement. This is consistent with the policy focus of this entire research endeavor. Our concern from the outset has been with the systematic bias against initially low achievers in urban elementary schools where often these initially low achievers are predominantly poor and/or minority children. Our focus is on reading achievement since we share the view with other educators (cf. Bloom, 1976, p. 50) that

One of the purposes of the model was to test two possible points of intervention to trigger the upwardly reinforcing effects of this loop. One is to attempt to raise teacher's weight for standards (and, thus, teacher expectations) through recruitment or staff development activities. This is in the tradition of "normative-reeducative" strategies of planned change (Chin & Benne, 1976, pp. 31-39). The effect of higher expectations is to increase the appropriateness and intensity of instruction for low-achieving cohorts. Presumably, with sufficient effort, this intervention can stimulate upward gain in the positive feedback loop and put the school in the position of taking off toward long-term effectiveness.

The second approach is to intervene directly to change the appropriateness and intensity of instruction through the implementation of what Chin & Benne (1976) call "empirical-rational" policies for change. One can attempt to change either the appropriateness of instruction through changing teacher emphasis (i.e., through strategies of behavior modification) and teacher effectiveness (i.e., by means of skill training) or the intensity of instruction through changing policies for allocating time and improving student behavior.

These interventions will be successful only if they are able to trigger the positive feedback loop described above. Until this occurs, there will be no lasting change in teacher expectations and no lasting improvement in achievement patterns for low achievers.

Assessing the Validity of the Theory

Policy analysis based on poor theory is useless and dangerous. Conclusions may be reached that appear plausible but are based on illogical or incomplete thinking. It is important, therefore, for the problem analyst to evaluate the validity of the theory before beginning policy analysis. In the current work, this evaluation took three forms.

The first level of evaluation focused on grounding the theory in the extant research and case study literature. There was an extensive review of primary and secondary sources on effective teaching and schooling to identify and justify important variables and relationships. These references are included in the preceding sections of this paper.

Extant literature is not the only source of data which can be used to formulate theory. In this endeavor, the unwritten wisdom and experience of school practitioners and researchers are also important. To tap this rich source of knowledge, we interviewed a selected group of people to receive feedback on important variables and relationships in the theory and to seek help in clarifying areas still under development. People were selected who represented a range of experiences and

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reading achievement is the key to success in schooling.

backgrounds. They included urban elementary school teachers, urban elementary and junior high school principals, a Title I reading coordinator, members of an urban school district's research and planning department, the director of a large urban school improvement project, several professors of educational administration, and an associate superintendent for instruction.

Each person was sent a brief overview of the project and a questionaire based on thirty-eight key assumptions and relationships in the theory. For each item, there was a Likert scale to rate the reasonableness of the item and space for comments. People were asked to complete the questionaire before the interviews. Interviews were in person or by telephone.

Feedback from the "panel" led to a major reformulation of the theory and to clarification of some of the assumptions and relationships. The reformulation centered on the factors influencing time available for instruction and the discretionary power of teachers. Initially, we had taken the position that teachers were able to expand the amount of time available for instruction beyond the normal limits if they wanted to. The panel consensus was otherwise. Respondents argued that, under most conditions, union contracts and administrative guidelines set an upper limit on total classroom time that is rarely broached. As a consequence of this feedback, our current theoretical position is that administrators set policy on out-of-classroom time and that a teacher has discretionary control only over the remaining time. We have called this remaining time <u>total classroom time</u>.

A second revision of the theory was also precipitated by panel feedback. In the early stages of theory building, we had begun to include the feedback effects on teacher and principal workload of efforts to implement school improvement policies. Panel responses helped us to realize that we were merging two issues: the relative merits of different policies for improving achievement and the organizational dynamics of policy implementation. The former focuses on the relative impact of different policies without considering whether or how one could actually implement them. The latter incorporates assumptions about the dynamics of organizational change. It combines a theory about the structural dynamics of school effectiveness with a theory about the structural dynamics of policy implementation. At this point, we made a conscious decision to restrict the theory, and the model, to the first issue and to leave the second to the next stage of research.

With the theory reformulated, we then moved to the third form of evaluation - the formulation of a computer simulation model. A simulation model allows one to determine whether a theory can <u>really</u> produce the problem behaviors. A theory with well-grounded variables is still flawed if it cannot generate the symptoms of the problem.

FROM THEORY TO SIMULATION MODEL

The fundamental purpose of system dynamics modeling is to represent a theory about the dynamics of a problem in the form of a computer simulation model. By representing a theory in this way, the analyst can examine it for internal consistency and assess systematically its implications for policy. The theory is represented in the form of a set of simultaneous equations which can generate the critical behaviors of the real problem system. The sections that follow outline the general structure of the simulation model developed to test the theory of schooling described above.

The School Effectiveness Model

The basic structural element of the School Effectiveness Model is the student cohort. The cohort is a group of similarly achieving students at a particular grade level at any particular point in time. Thus, in any given year, three cohort groups enter the first grade: a low-achieving cohort, an average-achieving cohort, and a high-achieving cohort. There are also three cohort groups at each of the other grade levels in the school.

We decided to restrict the model to these three cohorts for several reasons. First, most reading teachers group for instruction by achievement level. Second, even though teachers may have more than one group at a given level (average group size is four to eight students), they tend to treat groups at the same level in the same way. Therefore, modeling one group at each achievement level provides realistic diversity without undue complexity.

One could, in fact, reduce the cohort size to one and model seventy five cohorts at each grade level. There is nothing in the theory or the model structure which specifies the size of the group - the dynamics remain the same. For the problem at hand, the results would be marginal. Even in classrooms where individualized instruction is the norm, students are still grouped for instruction. Focusing on a "cohort of one" might be more appropriate if one were concerned with variations in individual learning over a shorter time frame.

The model contains a set of equations for each of the eighteen cohort groups. Each set of equations describes the physical flow of a cohort through the school and the changes that occur in the student attributes of achievement, motivation and behavior. Each set includes six main variables, or levels: Number of Students, Reading Achievement, Achievement in All Other Subjects, Reading Motivation, Motivation in All Other Subjects, and Behavior. In this model, as students flow through each grade, they learn, behave, and are motivated according to conditions affecting them during that time period.

Therefore, the logic of the flow is as follows: Students enter the grade at the beginning of the school year with the levels of

achievement, behavior and motivation with which they exited the prior grade level. These levels undergo certain changes during the current school year; then the students go on to the next grade taking their achievement, behavior and motivation with them. Following them in the next school year is another set of students with their own accumulated levels of achievement, behavior and motivation. Thus, the process continues from year to year.

The model also describes the teaching staff. The school has a teaching staff with an average level of skill and with an average weight for standards which determines their expectations for student achievement. Over time, teachers enter and leave the school and carry with them their attributes of skill and weight for standards. Weight for standards is a general teacher attribute rather than expectations because expectations vary from grade to grade and from month to month. The weight for standards is the same for all teachers across all grades. In addition to the normal turnover in staff, teachers can be recruited by the principal to raise staffing levels or fired if overstaffed. The average teacher skills and the average teacher weight for standards can be changed through recruitment and turnover and through specific staff development activities initiated by school administrators.

The third major component of the model characterizes the general behavioral climate associated with the school. This climate affects students and teachers over and above the effects of the behavior of a particular cohort group or grade level.

Simplifying Assumptions

The major simplifying assumptions in the model operate to reduce variability. The first of these is that students are of only three kinds: initially high, average, and low achievers. The only parameterized difference among students has to do with initial achievement. Bloom (1976) supports this assertion. He claims that the major input differences among students are in "cognitive entry characteristics" and that differences in "affective entry characteristics" (what the model characterizes as motivation and behavior) are developed after students enter school.

The model makes no other assumptions about input characteristics of students, but it does simplify the flow of students. In the model, there is no attrition, no gain and no turnover in students either during the school year or between school years. These are problems facing school administrators, but we believe they only exacerbate the otherwise essential dynamics or ineffective schools.

Another simplifying assumption in the model relates to teachers. The model characterizes the average teacher. It specifies no variation among teachers at any particular point in time. However, the model does account for changes in average teacher skills over time and it does incorporate the effects of changing skills on learning (including, for example, the interaction between teacher skills and class size in

determining learning rates).

The variables and relationships in the model are the same for high, average, and low achievers. It is the values of the variables which are different among the three groups, not the variables or the relationships among them. Only the values for initial reading achievement differ among the three groups when they enter school. Other values change responsively over time but the structure is the same for all three groups. It is the structure which generates the subsequent differences among the three groups in motivation, behavior, and learning rate, over and above the initial differences in achievement. This is the central assumption upon which the theory and the model are based.

Model Parameters

The grade 1 to grade 6 school is still the most prevalent type of elementary school in the U.S. (Dearman & Plisko, 1981, p. 68). Nationwide, the student-teacher ratio is 20:1 (Dearman & Plisko, 1981, p. 70), although evidence from class size research and from urban school districts suggests that urban elementary schools tend to have higher ratios for normal, self-contained classes (Katzman, 1971; NEA, 1977; Russell, 1977). In Philadelphia, for example, Summers and Wolfe (1975) report that the goal was to reduce elementary class sizes to thirty. In the model, the school is a grade 1-6 school with a uniform student-teacher ratio of 25:1.

The modal size of U.S. public elementary and secondary schools is 250-500 students (Dearman & Plisko, 1981). Statistics on urban schools suggests an average in the 400-600 range (c.f. Russell, 1977; Summers & Wolfe, 1975) and the base enrollment chosen for the model is 450. There are, then, three classes of twenty five at each of the six grade levels. In each class, for the base run, the ratio of cohort sizes is 4:5:1 (low : average : high). Studies such as Summers and Wolfe (1975) show a small fraction of high achievers in urban schools and a large fraction of low achievers. The impact of this imbalance is to magnify the effects of the low achievers and to diminish the effects of high achievers. The effects of variations in cohort size were tested and are reported later in the paper.

Teacher turnover is set at fifteen percent per year. This is consistent with data from the 1960's and 1970's (c.f. Katzman, 1971; NEA, 1980) but higher than the current nationwide figures. The reduced teacher turnover is probably not due to increased satisfaction with teaching, but rather with the security of tenure and the difficulty of finding jobs elsewhere. While a slower rate of turnover would theoretically enhance the effects of staff development activities, in reality there is probably little change if teachers are staying simply to hold onto their jobs. If anything, they might be less willing to change attitudes and skills.

The school day is 320 minutes long with 25 percent (or 80 minutes) spent in non-instructional activities. This is consistent with data

reported in Harnischfeger and Wiley (1980). The benchmark data on "normal" amounts of time allocated to instruction, non-instructional activities, and staff development are not good, but the values chosen for this model fall within the ranges cited in the literature. Ten percent of the school day is set aside for staff development activities. On a weekly basis, this is equivalent to one afternoon a week when students go home early and teachers remain for in-service. This is probably close to the upper limit. Of the time allocated for instruction, fifty percent is allocated to reading instruction and the balance to instruction in all other content areas. This value reflects the dominant importance of reading instruction in most elementary schools.

The teachers in the school represented in the School Effectiveness Model are assumed to be "average" teachers for an ineffective school. They have average skills (skills=1) and a weight for standards of zero. This means that their expectations for student achievement are based solely on present student achievement.

At the beginning of the simulation run, it is assumed that all students have normal motivation and behavior; that all initially high achievers, regardless of grade, are one grade level above average; that all initially average achievers are at grade level; and that all initially low achievers are one grade level below average. These initial conditions are not meant to represent reality in an ineffective school, but rather represent a convenient set of initial starting conditions. It takes a number of years into the run for the model to equilibrate at conditions corresponding to those of an ineffective school. This is an equilibrium in the sense that the patterns of instruction, achievement, motivation, and behavior are the same year after year at each grade level. All policy analyses on interventions attempting to improve an ineffective school occur after the model reaches the ineffective school equilibrium.

Testing for Model Validity

There are two broad categories of tests for model validity. First, as a set of mathematical equations, the model must be technically correct, internally consistent, and robust. Second, as a model of a real-world system, model structure and behavior should be congruent with what is known about the real system.

The DYNAMO compiler (Pugh, 1977) contains subroutines to check the technical correctness of model equations. Some of the errors found this way are simple typographical errors. Others are the result of logical errors that force one to reformulate equations or even to reconceptualize the theory behind the equations. All technical errors have been corrected in the School Effectiveness Model.

At the most fundamental level, internal consistency requires dimensional accuracy. As in equations in physics, variables in system dynamics models have dimensional units (e.g., minutes/day for engaged

time). Equations are correct only if the units on both sides of the equation agree. This agreement should be logical and not contrived through the use of gimmicky conversion constants. All conversion constants should make sense in the real system and be recognizable to practitioners.

In addition, equations must be carefully checked to ensure that they will not produce aberrant behavior if pushed to extremes. Absence of aberrant behavior testifies to the model's robustness. Of particular concern are situations where the denominator in a variable can fall to zero and cause division by zero. Often, problems with equations are not discovered until one begins testing model behavior. The School Effectiveness Model was carefully tested over several months to ensure internal consistency and robustness.

Forrester and Senge (1979) propose three congruency tests for model structure: the structure-verification test; the parameter-verification test; and the boundary-adequacy test. Model structure should be consistent with knowledge about the structure of the real system. The observable goals, constraints and cross-pressures on real decision makers should be reflected in the model. Model structure should withstand the scrutiny of people with direct experience in the real system. In the manner described earlier, the structure of the School Effectiveness Model was verified through panel feedback on the theory (Supra, pp. 21 ff.) and through ongoing dialogue with colleagues at the School of Education.

"It is easier to verify that a model structure is found in the real system than to establish that the most relevant structure for the purpose of the model has been chosen from the real system" (Forrester & Senge, 1979, p. 10). This raises the issue of boundary-adequacy. Is the model structure sufficient to generate the problem behaviors and to provide a platform for policy analysis? One's response depends on the purposes of the model.

For example, two criticisms of our model and theory were that they did not include variables relating to parents and did not consider personality variables and the day-to-day changes in student mood, attention and learning. We argued that the inclusion of a parent sector in the model was not necessary given the purposes of the model which were to demonstrate that schools are responsible for generating ineffective school behaviors and schools can correct the problem. Parents can enhance or inhibit the efforts of teachers and administrators, but the responsibility lies with the school. The second criticism also focuses on model purpose. Our interest is in the relative efficacy of school improvement policies initiated by administrators to "turn around" an ineffective school, not in the factors affecting student learning over a relatively short time frame. Were we researching the latter, our model would be radically different.

Finally, boundary-adequacy tests focus on the ability of the model structure to provide a platform for policy testing. We outlined the general nature of our policy tests before we completed the model

structure. This ensured that the necessary entry points for policy tests were embedded in the model. In addition, equations were initially written to allow whole sections of the model to be switched on or off for testing.

The last test of structure is parameter verification. Parameters (constants and the values in table functions) must be examined conceptually as well as numerically for their correspondence to elements in the real world. The section above on model parameters provides a rationale for the choice of many model parameters. More empirical research is needed to clarify the "normal" range of values for time allocations in schools.

The most difficult aspect of parameter selection involves constructing tables of values for table functions. Consider, for example, the effect of highly concentrated instruction on engaged time. In the equation for engaged time, a multiplier is needed to produce the saturation effect as the amount of instruction increases. The problem is that the multiplier is an artifact of the model necessary to generate realistic behavior and, as such, its precise values are not observable in the real world. The modeler has guidelines for constructing table functions (cf., Richardson & Pugh, 1981, pp. 173-174), but the final choice of values is often the result of a trial and error process of repeated simulations with changes in values until the model produces reasonable output behaviors. In essence, the model becomes the instructor. Several table functions in the model were adjusted this way when the general shape was known from the literature but the precise values were not.

Is the structure valid? We believe so. In the process of conducting the tests described above, we found problems. These problems were corrected and the model was retested. As the number of observed problems decreased, our confidence increased.

POLICY ANALYSIS

Overview

The goal of this research has been to try to understand the likely consequences and trade-offs associated with various efforts on the part of school administrators to change a school that is ineffective for initially low achievers into a school that is effective for these students. Consistent with what appears to be reality, at least at most times in most schools, there is nothing in the model which will allow the ineffective school to self-generate the conditions required for the transition to greater effectiveness. In the model, at least for any reasonable time frame, the ineffective school maintains a dynamic equilibrium which is characterized by a persistent gap in achievement between initially low achievers and other students in the school [9]. Thus the ineffective school will not by itself begin the transformation process unless there is a catalyst for change.

That catalyst may be a strong, dynamic principal, a cadre of highly motivated teachers, or strong parental or school district pressure. However, the literature on effective schooling is very clear in stating that the principal plays a central role in the transition process (Benjamin, 1980; Brookover, et al., 1979; Edmonds, 1979; Phi Delta Kappa, 1980; Salganik, 1980).

In the presentation that follows, interventions are described as if initiated by the principal. We assume that an ineffective school, in the absence of any active principal leadership, will remain ineffective. While individual teachers or parents may be concerned about achievement, without intervention by the principal there is typically no concerted effort to bring about change and no change occurs.

There are four classes of interventions that school administrators can make to try to improve reading achievement for initially low achievers. The first class has to do with changing the size or demographics of the student population. One tries to bring about an effective school through changing student inputs. The second class of interventions focuses on improving the intensity or quantity of instruction for the initially low achievers. This could be accomplished either by policies aimed specifically at increasing the intensity of reading instruction for low achievers or through grade level or school-wide policies aimed generally at improving the total time available for instruction. The third class of interventions aims to increase the appropriateness of the instruction for initially low achievers. One attempts to change the way teachers make decisions about instruction and to improve their general level of teaching skills. The fourth class of interventions focuses on the school climate and, in particular, on student behavior.

Some of these changes are focused specifically on the low achievers and have no direct impact on the other achievement groups. Other policies require diverting resources away from the average and high achieving groups to low achievers. Most of the policies, though, are ones which are school-wide or grade level policies affecting all three achievement groups. The policy interventions that were considered in this research project are summarized in Figure 3.

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[9] Recent experiments with non-linear feedback models suggest that, over extremely long time frames, seemingly well established equilibria may break down and mutate in ways that mirror patterns normally associated with stochastic interventions (Day, 1981).

CATEGORY AND POLICY	LOW ACHIEVER POLICY	RESOURCE DIVERSION POLICY	SCHOOL-WIDE POLICY
I. CHANGES IN SIZE OR STUDENT INPUTS			
- change school size			X
- change fraction of low achievers	X		
- change initial achievement of low achievers	X		
II. CHANGES IN INTENSITY OF INSTRUCTION			
- change fraction of time for reading for low achievers	X		
- change time on non-instructional activities			X
- increase staff			X
- vary class size among grades			X
III. CHANGES IN APPROPRIATENESS OF INSTRUCTION			
- change desired teacher emphasis		X	
- change teacher expectations			X
- improve teacher skills			X
IV. CHANGES IN STUDENT BEHAVIOR			
- change classroom behavior			X
- change school-wide behavior			X

Figure 3. Taxonomy of Policy Interventions.

With the exception of the first class of interventions (which were implemented as changes in initial conditions) all policies were begun in the 1981 school year after the model had reached the ineffective school equilibrium. Each policy was tried for a five-year period, a ten-year period and an indefinite period of time to assess its impact under various time constraints. Policies were also tested for different levels of intensity and for different target audiences (grades 1-6 vs. grades 1-3 vs. grades 4-6).

There has been no attempt to deal with the organizational responses to policy interventions. In this stage of analysis we have assumed that the principal has the necessary time, skill and rapport with the faculty to accomplish the intended interventions. In the next phase of policy analysis, structure will be incorporated which relates to principal time, principal skills, and staff resistance to change.

Summary of Findings [10]

Changes in the Student Body

The results of interventions tested which examined alterations in the student body suggest that there is no basic change in the patterns of appropriateness and intensity of instruction delivered to the different cohorts as changes are made in school size, percentage of low achievers, or entry level achievement of the low achievers. The school is still an ineffective school. The achievement scores may be slightly higher or slightly lower, but initially low achievers still leave the sixth grade with a larger achievement gap than when they entered school.

In fact, standard procedures for reporting average achievement scores may make a school that is structurally ineffective appear effective. Schools with a low fraction of low achievers appear to be effective when one examines average achievement scores. Such schools are no more or less effective structurally than schools with large proportions of initially low achievers. The latter schools simply appear less effective because (1) low motivation and low behavior have a negative impact on the entire school population and (2) the higher proportion of initially low achievers brings down the average score. The point is that structurally ineffective schools are bad for initially low achieving children even when there are too few of them to damage the the school's reputation.

One can conclude that interventions aimed at changing student inputs or changing the size of the school have no impact on the instructional process. The school continues to be ineffective for initially low achievers regardless of how many there are, or how low their initial achievement, or how big the school is.

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[10] Findings have been highly summarized. Because of space limitations, data tables have been omitted. Reference in the following sections is made to test interventions categorized in Figure 3.

Changes in the Intensity of Instruction

The class of interventions aimed at improving the intensity or quantity of instruction for initially low achievers produces mixed results. The only policy that results in clear and significant gains in achievement patterns is that aimed at reducing time spent on non-instructional activities. Policies aimed at varying class sizes among grade levels with a constant staff are not helpful. Policies aimed at increasing the staff and reducing class size have value only if one is able to reduce class sizes dramatically by bringing in a large number of highly skilled teachers for a period of years.

Changes focused on adjusting the amount of time devoted to reading instruction do enhance reading instruction but at the expense of instruction in other content areas. There seems to be a break-even point where slight increases in the fraction of time for reading both boost reading achievement and boost other achievement through the interaction effects of reading achievement on achievement in other subject areas. In summary, the two policies which seem to be the most effective are also those which are probably the least costly to implement: changing the fraction of time for non-instructional activities; and changing the fraction of time devoted to reading instruction.

Changes in the Appropriateness of Instruction

The interventions aimed at improving the appropriateness of instruction which have been tested focus either on general efforts to raise teacher expectations and skills or on more specific efforts directed at changing the emphasis on low achievers. Changing teacher expectations through staff development activities focused on the teacher's weight for standards and changing teacher's desired emphasis for low achievers both lead to significant gains for low achievers at the expense of other achievement groups. Increased teacher emphasis on low achievers leads to increased appropriateness and intensity of instruction for them, but decreased emphasis and instruction for the other groups. To what extent the other groups, and their parents, will allow this diversion of resources is problematic (cf., Weaver, 1982). These interventions are most successful when they are ongoing and affect all teachers.

Staff development activities aimed at improving teacher skills benefit all students. The initially low achievers make dramatic gains if teachers skills rise to a sufficiently high level. The improved instructional efficiency and reduced amount of time spent on behavior lead to gains in achievement which raise teacher expectations. There are two caveats, however, to the benefits from improved skills. Benefits will be dramatically lower if instructional time is reduced to provide more staff development time. Furthermore, unless school administrators establish ongoing procedures to ensure that the level of skills remains above average, the school will regress to the ineffective school condition as teacher turnover continues to dilute improved teaching skills.

Changes in School Climate

The results of the interventions to improve student behavior clearly show that these efforts should not be allowed to reduce time for instruction. Furthermore, efforts to improve school-wide behavior in the halls, lunchroom, playground and assemblies have only small effects on student achievement. Thus, we would argue that efforts to improve behavior directly should only be considered as a supplement to the main effort of improving instruction.

Evaluation of the Model as a Policy Tool

The effectiveness of a system dynamics model as a policy tool depends both on its appearance and on its performance. Appearances, as Mother Clauset always says, are important. Model structure, parameters, and policy tests must be recognizable and credible to one's audience. For this research, the audience is composed of scholars and practitioners interested in school effectiveness. Model variables were chosen and labelled based on current research and practice in education. Model structure was specifically designed to represent a typical urban elementary school. The model is designed to be a general model of an elementary school. Model parameters can be easily adjusted to have the model represent a school in Boston, Philadelphia, or any other city - a provision which would allow school administrators to use the model to think about their own school.

Performance is even more important. For a model to be a credible policy tool, it should generate realistic behaviors for policies that have already been implemented in real systems and it should generate new insights for understanding why different policies have the effects they have had or might have. As the preceding discussion on specific policy options shows, the policy results do correspond to the results of interventions already tried in elementary schools. The policy analysis does offer some new insights for school improvement. It clarifies the position of poor behavior as a symptom of ineffective schools rather than as a cause and demonstrates why some discipline policies can have very negative effects. It illuminates the importance of instructional decision making and the role of the teacher. It identifies important non-linearities in the effects of increasing the intensity of policy interventions and, most importantly, it allows school administrators to discriminate between more and less effective policies.

Another test of the model's policy performance is an assessment of the sensitivity of policy outcomes to parameter changes. Would the policy outcomes change dramatically if parameters were changed within reasonable bounds? This test was conducted during the model behavior testing phase. The only potential problem area is that of the effects of time fluctuations. The model is very sensitive to fluctuations in engaged time. Perhaps this is because there is no student absenteeism or turnover in the model. These components will be added in the next stage

of research.

Forrester and Senge (1979, p. 3i) argue that the ultimate test of a system dynamics model lies in applying policies that work in the model to real-life situations to assess their real impact. This is a test easier proposed than done. The primary focus of this phase of research has been on knowledge synthesis and the testing of the emerging theory. In future work, we would like to pursue this test by focusing on schools that are moving toward effectiveness to determine if the policies that work for them are the same as those indicated by the model.

GENERAL POLICY CONCLUSIONS

The model and the policy analyses based on the model have been described in considerable detail. Despite the risk of over-simplification, it seems important to state as directly as possible the essential understandings about school improvement that the analyses have produced.

The central conclusion is that it is possible to change an ineffective school into an effective one. There do exist policies which can either erase or greatly reduce the achievement gap for low achievers. The most effective school improvement strategies are those which better teacher skills, raise teacher expectations for low-achieving students, and maximize time available for instruction.

This implies that strategies of in-service training which are outside of regular class hours and do not take time away from instruction are essential. This training must focus on raising teacher expectations for low-achieving students and on directly improving skills of mastery learning (Bloom, 1976) and direct instruction (Fisher, et al., 1978; Rosenshine, 1979). Supervision must help teachers to integrate in their teaching the lessons of in-service training. Supervision and training must help teachers to intensify their instruction and to enhance their teaching skills, yet must not take teachers away from teaching children.

Maximizing the time available for instruction and increasing the efficient use of that time should be central concerns of school administrators. Time for non-instructional activities should be closely monitored and reduced wherever possible. Nothing should be allowed to interfere with instructional time. The allocation of instructional time among subjects is also important. Simulation runs suggest that a careful adjustment of time between reading instruction and instruction in other content areas can enhance achievement in reading as well as the other areas.

Teachers and principals trying to change an ineffective school often are very concerned about behavior and discipline (c.f. Phi Delta Kappa, 1980). A corollary to the central conclusion is that efforts to improve behavior should not diminish time for instruction. Efforts to improve

behavior take two forms: (1) improving behavior directly through behavior modification (Mable, 1978) and/or through altering the climate of expectations for behavior in the school; and (2) improving behavior indirectly by improving the appropriateness and intensity of instruction.

It follows from the policy analyses that efforts to improve behavior should emphasize interventions outside of the classroom and that efforts in the classroom should focus as much as possible on improving instruction. The role of the principal in developing structures to improve behavior seems critical. Such structures may include focusing administrative time on working with students outside of class and on organizing teachers and parents in setting expectations for student behavior.

Parents may also be involved systematically in improving instruction outside of regular classroom hours. Strategies may include: (1) working with parents to improve time on task at home (by enhancing the climate at home for doing homework and by setting expectations for their children for doing homework); and (2) training parents to teach their children at home when they need extra help in improving their academic skills.

Such strategies give meaning to "parent involvement" which is specifically related to improving the appropriateness and intensity of instruction for their children. Of course, the effectiveness of strategies for involving parents in improving instruction may also depend on the ownership parents have in the curriculum, on the extent of their trust in the teachers and the principal and, ultimately, in the extent to which they participate in a variety of decisions about their children in particular and about the school in general (Davies, 1980).

In a variety of cities, large and small, school districts are monitoring major school improvement efforts (cf. Larkin, 1980). Many of these efforts are based on what Edmonds (1979: p. 22) characterizes as the five essential elements of effective schools:

1. Strong administrative leadership;
2. Expectations for students where "no children are permitted to fall below minimum but efficacious levels of achievement;"
3. A school-wide atmosphere that "is orderly without being rigid, quiet without being oppressive, and generally conducive to the instructional business at hand;"
4. School-wide emphasis on basic skills instruction; and
5. Ongoing monitoring and assessment of pupil achievement.

What does our research have to say about these essential elements of effective schooling? First, no sustained improvement can occur unless there is longitudinal monitoring and assessment of pupil achievement. Feedback about achievement is essential to parents, teachers and principals in planning for improvement. However, data on achievement must be disaggregated to focus on the achievement patterns over time of different groups of students. When effectiveness is measured by indicators of average achievement, a school that is structurally ineffective can appear to be effective because of demographic characteristics (e.g., a low fraction of initially low achievers in the student body).

Second, feedback is only important if there are standards for assessment. No efforts will be made to close the achievement gap for initially low achievers if expectations are low and no learning gap is perceived.

Third, a school that maximizes time for instruction, commits resources to basic skills, and shapes a climate that underscores the importance of instruction can achieve significant gains - even without a cadre of "super" teachers.

Fourth, our research gives meaning to the plea for "strong administrative leadership." Our policy analyses show that a strong leader is one who sets policies that enhance time for instruction, one who maintains a supportive school climate, and, perhaps most importantly, one who is able to implement an effective in-service program that raises teacher skills and expectations in ways that are directly transferable to the classroom.

Finally, our research demonstrates the interactive nature of these variables and the importance of understanding the relationships among leadership, expectations, climate and instruction.

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