DOCUMENT RESUME

ED 174 390 SE 025 067

AUTHOR Churchman, David; Wingard, Joseph
TITLE Adapting Science Curricula to the Needs of Teachers and Students.
PUB DATE 78
NOTE 16p.; Paper presented at the Bat Sheva Seminar on Curriculum Implementation (Rehovot and Jerusalem, Israel, August 1978)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Academic Achievement; *Administrator Responsibility; Costs; *Curriculum Development; Curriculum Problems; *Decision Making; Knowledge Level; *Science Curriculum; Science Education; Secondary Education; Secondary School Science; Skills; Teacher Attitudes; Time Factors (Learning)

ABSTRACT

This paper focuses on the way that information from a field test of any new curriculum can be used by an administrator to implement it into a school or group of schools. Suggestions relate to estimating students' knowledge, skills, and attitudes, and to measuring the extent to which a curriculum is implemented. These factors are considered with regard to decision-making. Several models illustrate the relationships between teacher attitudes, elements of the curriculum and student outcomes. Program costs and time constraints are discussed. (Author/SA)

SE

ADAPTING SCIENCE CURRICULA TO THE NEEDS OF TEACHERS AND STUDENTS[1]

DAVID CHURCHMAN[2]

JOSEPH WINGARD[3]

[1]Presented at the Bat Sheva Seminar on Curriculum Implementation, Rehovot and Jerusalem, ISRAEL, August 1978.

[2]Science Education Directorate, National Science Foundation, Washington, D.C.

[3]Psychology Department, University of California, Los Angeles, CA.

ADAPTING SCIENCE CURRICULA TO THE NEEDS OF TEACHERS AND STUDENTS

Canute, the Danish conqueror of England, once ordered his throne set up on an Atlantic beach, assembled his nobles and had them watch while he commanded the tide to stop rolling toward ~~toward~~ them. Everyone got wet feet and Canute is remembered as a fool. In fact, he intended to demonstrate to men who regarded him as omnipotent that there was much he could not do. We who design and implement science curricula should recall King Canute's lesson, for we continue to fly in the face of powerful forces that we cannot control, instead of making them work for us.

In implementing a new curriculum, science teachers are analogous to the tides. When told to implement a new curriculum, a few teachers will throw everything into a cabinet and continue to do what they always have. A few, fresh out of school, full of ideas of their own but without tenure, will put some of the materials on their bulletin boards for administrators to see, then throw everything else in the cabinet and forget it. Most will use the books that come with the curriculum because there is no alternative, but they will skip some of the carefully ordered chapters, and rearrange the rest. They will have students do some of the exercises and some of the experiments and show some of the films without any respect for the way these parts were so carefully designed to fit together. A few teachers will follow the curriculum exactly as written regardless of what students seem to be learning, and blame any departure from the predicted results for the curriculum on students who are lazy or worse. One or two compulsives will get so wrapped up in the new curriculum that they will forget all else, and their students' work in other subject areas will suffer.

Curriculum designers and administrators have reacted to this situation by looking for ways to convince or to force teachers to implement the new curriculum more nearly as planned. They have tried to involve teachers in selecting the curriculum and in planning the implementation. They have provided inservice training. They ' 'd faculty meetings and give talks on the importance of adhering to the curriculum plan. They prowl about on inspection tours of classrooms.

They get nowhere.

The main reason is that a curriculum is designed for a generalized student, and the teacher faces 25 or 30 very specific ones. Each teacher, varying from others in philosophy and experience and ability, adapts any set of materials to what he perceives to be the needs and abilities of those specific students. Instead of trying to stamp out this kind of adaptation, we think that curriculum designers and administrators should be searching for a better way to use it to advantage.

Instead of comparing two dissimilar curricula in an approximation of a control group experiment, the variation in the way teachers adapt curricula can be measured and related to student achievement. The mathematical model on which this approach is based is described in a separate paper;[4] another paper provides a step-by-step outline for carrying out the approach.[5]

This paper will concentrate on the way the information resulting from the field test can be used by an administrator wishing to implement a new curriculum in a school or a group of schools.

The first type of information resulting from almost any field test is some estimate of what students learned. This might be measured by a paper-and-pencil test, a performance test or any other type that is appropriate. There might be a single score, or several subscores. For example, the geology curriculum that will be used as an example throughout this paper uses measures of student knowledge, laboratory skills and attitude toward further study of the subject. A less frequent

---

[4] Structural Models of Teacher Preference as a Method for Estimating the Effectiveness of Educational Innovations, presented at the annual meeting of the International Sociological Association, Uppsala, SWEDEN, August 1978.

[5] Maximizing Information from Implementation of Innovative Courses, presented at the meeting of the International Council of Associations for Science Education, Nijmegen, the NETHERLANDS, April 1978.

but equally important type of information is a measure of the extent to which the curriculum actually was implemented. These two types of information can be related to one another as in Figure 1.

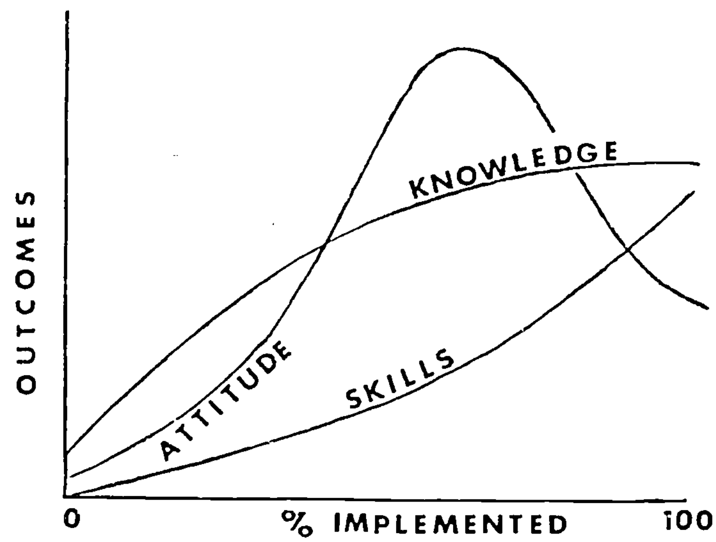

Figure 1.

Notice that separate curves are shown for each of the outcome measures. We do not attach any importance to the particular pattern of curves here. Rather, the important point is that student outcomes might vary from one another with different degrees of implementation. In such a circumstance, it is easy to imagine different classes requiring different versions of the curriculum. If my goal were to train lab technicians, I would opt for full implementation, at some cost to student attitudes toward further study. But if my goal were to long-term study of geology, I would be willing to make sacrifices in skills and knowledge to maximize results on the attitude measure.

An administrator will of course consider more than just student needs in making such a decision. Improved implementation also presumably means increased costs as shown in Figure 2, raising questions of just how much improved knowledge is worth in terms of money that is available and alternative uses to which it can be put.

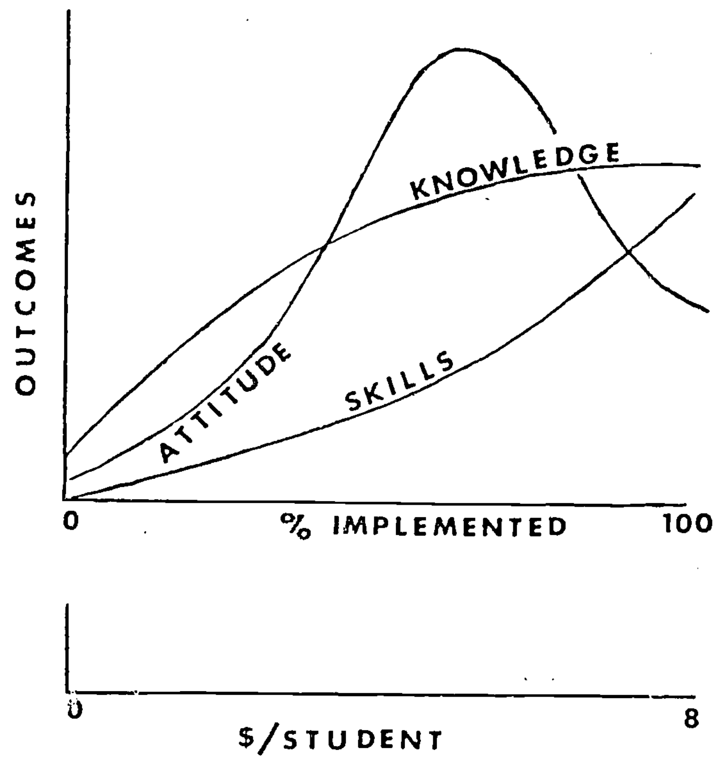

Figure 2.

The figure is an oversimplification in other ways as well. An important one is that the degree of implementation is taken as a uni-dimensional variable. In fact, our model assumes that any curriculum has several different elements and that the degree of implementation of each must be measured separately. Thus, instead of a single figure, you might imagine several of them, one for each element of the curriculum, each showing the contribution to knowledge, skill and attitude that that particular element makes at various levels of implementation.

Any number of factors may determine the degree of implementation of a specific element of the curriculum by a particular teacher, but at this point we think that they might be summarized as teacher attitude. We think of this analogously to a construct in factor analysis, made up of such factors as satisfaction with current curriculum, perception of student needs and abilities and willingness to try new ideas.

The relationship between teacher attitude, curriculum elements and student outcomes provides the model on which we base our analysis and interpretation of field test data. At its simplest, with a curriculum that includes only two elements, it could be shown as in Figure 3.

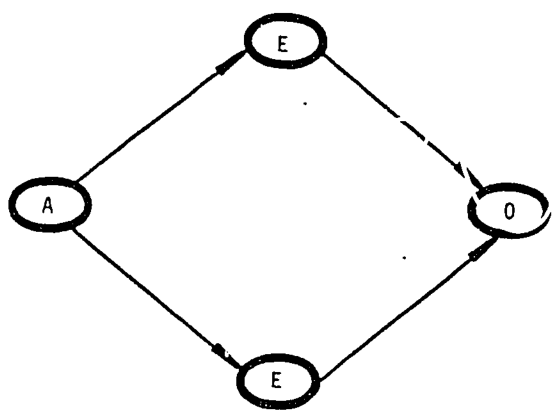

Figure 3.

Student outcomes are represented on the right as the consequence of the degree to which the two elements of the curriculum, represented vertically in the center, are implemented by the teacher. The degree to which this happens is dependent on the teacher's attitude toward the innovation, represented on the extreme left. The pattern of causal effects is represented by arrows joining the components of the model.

Each of the four components of the model must be measured in some way. This may be portrayed as in Figure 4. In this example, student outcomes are measured by three instruments (to continue the example of the geology curriculum, one each for skills, attitude and knowledge) and teacher attitude is measured by two instruments (say, one for satisfaction with current practices and one for willingness to try new methods). Similarly, the degree of implementation of the two elements of the curriculum must be measured. In this case a total of three instruments was used to measure the two elements.

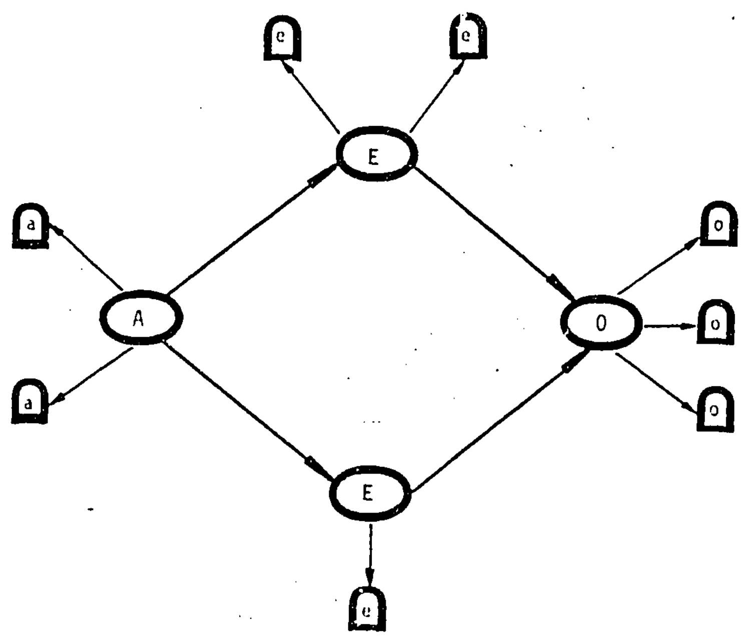

Figure 4.

That is, each component of the model must be measured, but different numbers of instruments can be used to measure each. The advantage of multiple measures lies in the potential for reducing measurement error. The disadvantage lies in increased cost. Thus, guesses must be made as to how much effort should be placed on measuring each component of the model.

During analysis of the data, it is possible to determine if the model is the best explanation of how the curriculum is working. The greater the number of components to the model, the more complex this becomes. But even in this simple model, there are many possibilities. For example, one could test for a direct link between teacher attitudes and student outcomes, or that there is a correlation between the degree of implementation of the two elements of the curriculum. Considering all the one-way and two-way arrows that can be drawn on the diagram, there are about twenty-five possible variations. Some don't make much sense, but others are worth testing. This model opens fairly complex possibilities in spite of its apparent simplicity.

The administrator wishing to implement a new curriculum has one of two problems. He must get the greatest amount of student achievement from a specified amount of money, or he must bring students to a predetermined level of achievement as cheaply as possible. In either case, the money can be spent in only two general ways: first, in training aimed at improving teacher attitudes toward the new curriculum; second, in providing the teacher with materials needed for each of the curriculum elements. The problem is to divide the resources between the two in the most advantageous way possible.

To illustrate this, let us continue with the two element geology course. Assume that it is to be implemented in a school system in which each teacher has five classes averaging thirty students each. One of the key elements of the course is a set of ten experiments. These cost an average of $6.00 per class or $30.00 per teacher. The second element consists of twenty instructional guides for classroom demonstrations and discussions that require an average expenditure of $15.00 per teacher for audiovisual and other classroom aids. The results from the field test of the curriculum suggest that each experiment contributes an average of three points to the total on the final criterion test, while each classroom demonstration contributes an average of two points to the total. Full implementation of the curriculum would result in a class mean of 85 points, 70 of which can be accounted for by the model. The remaining 15 may be attributed to unmeasured elements of the curriculum and to error. The results of the field test also suggest that if teachers simply are given all the classroom supplies and materials needed and are required to implement the curriculum, that on average four of the experiments and five of the classroom demonstration guides will be used. Finally, the results of the field test suggest that each day of inservice training would result in the typical teacher using two more of the classroom demonstration guides and one more of the experiments. A single day of inservice training costs $60 per teacher and would increase the demand for supplies by an additional $30 for experimental supplies and an additional $30 for classroom aids.

Each day of inservice training would thus raise program costs by $120 per teacher and would raise the class mean by 7 points (3 for the experiment and 2 for each of the classroom demonstrations).

This information would have been obtained through structural equations analysis of field test data using the methods described in the two papers alluded to above. It can be summarized conveniently in tabular form as in Figure 5. (See page 9.)

It then becomes a relatively simple matter for an administrator to determine from field test results the total amount of money that should be budgeted, and the way it should be divided between inservice training, experimental supplies and classroom materials, to achieve any desired level of student performance. It would be equally easy to determine what achievement will result from any specified budget for implementing the curriculum and, equally important, to determine how to allocate that money to inservice training and to classroom needs to maximize student outcomes.

Of course, this still is an oversimplification.

SIMULATED PREDICTIONS FROM ANALYSIS OF FIELD TEST DATA

TOTAL DAYS OF INSERVICE	EXPECTED NUMBER OF EXPERIMENTS IMPLEMENTED	EXPECTED NUMBER OF INSTRUCTIONAL GUIDES USED	PREDICTED CLASS MEANS FROM EXPERIMENTS	FROM GUIDES	EXPECTED ERROR	TOTAL MEAN SCORE	COST	COST PER PUPIL
0	4	5	12	10	+ 7	29	$220	1.46
1	5	7	15	14	8	37	340	2.27
2	6	9	18	18	9	45	460	3.07
3	7	11	21	22	10	53	580	3.87
4	8	13	24	26	11	61	700	4.67
5	9	15	27	30	12	69	820	5.47
6	10	17	30	34	13	77	940	6.27
7	10	19	30	38	14	82	1060	7.07
8	10	20	30	40	15	85	1180	7.87

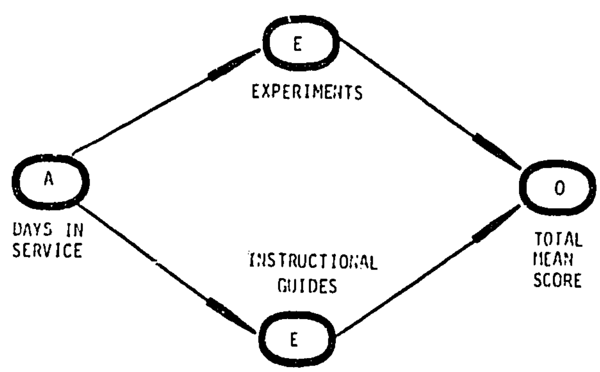

Figure 5.

First, in figuring costs we have not separated recurring from nonrecurring costs. This may seem trivial, but it can become an important factor in any curriculum used over several years.

Second, knowing that teachers will require supplies for a certain number of experiments and classroom demonstrations on average does not tell which of the experiments and demonstrations will be used, or how many teachers will use fewer and how many will use more of either. The best solution we have to this problem at the moment is to let each teacher do his own buying.

Third, we have treated a day of inservice training as a fixed item. In practice, the field test could be designed to gather more precise information, so that the administrator could vary the inservice training to achieve more precise objectives, or more importantly to have more patterns of implementation from which to choose.

Fourth, a real curriculum would involve not two but many elements, so that even more patterns of implementation would exist.

Fifth, it is possible to improve the predicted outcomes for a particular class by taking into account characteristics of students that are known to affect learning outcomes.

Thus, in any real situation, there would be several different ways of implementing a particular curriculum to obtain a desired score, and there would be several different ways of implementing it for a given amount of money, and there would be variations for different types of students. The results of an actual field test of a real curriculum would hardly result in the simple decision making situation portrayed in the two element example. The more complex example of Figure 6 will demonstrate the full potential as well as the complexities and problems of this approach to curriculum implementation. (See pages 11 and 12.)

The geology course now has two additional elements, and provision has been made as well for considering the effect of socioeconomic status on student outcomes. The number of separate measures required has grown to fourteen. The arrows connecting the components of the model form a more complex pattern of hypotheses. In addition to those following the direct path from teacher attitude to curriculum elements to student outcomes, some of the elements themselves are portrayed as affecting others: the impact of socioeconomic status on discussion for example.

In one case--that between discussions and experiments--doubled arrows describe interrelated components.

Further, inservice training covering twenty-six topics under seven major categories, each with two levels of training possible, and each having its own differential effect on the degree of implementation of each

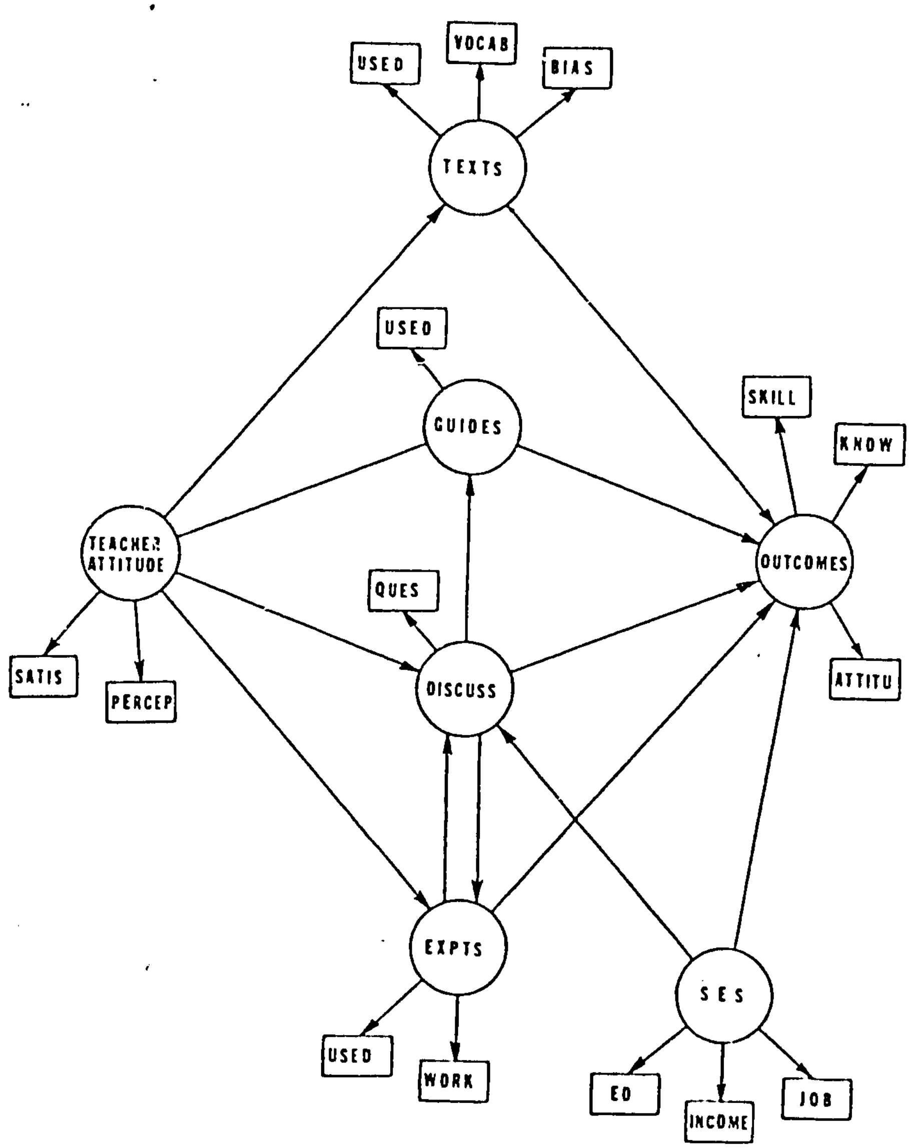
USED
VOCAB
BIAS
TEXTS
USED
GUIDES
SKILL
KNOW
TEACHER
ATTITUDE
OUTCOMES
QUES
SATIS
PERCEP
DISCUSS
ATTITU
EXPTS
SES
USED
WORK
ED
INCOME
JOB

Figure 6.

Latent Variables and Their Overt Indicators

Exogenous Variables

1. Teacher Attitude: The general attitude of teachers toward the current educational practices and their effectiveness in meeting student needs.

   Overt Indicators:

   1. SATIS - Satisfaction with current educational practices.
   2. PERCEP - Perception of student needs and abilities.

2. Student Socioeconomic Status (SES): General socioeconomic status of the student as measured by parent indicators.

   Overt Indicators:

   1. ED - Educational level of parents.
   2. INCOME - Average parent income.
   3. JOB - Status of parent occupation.

Endogenous Variables

1. Textbooks (TEXTS): Perceived adequacy of the text materials.

   Overt Indicators:

   1. USED - Number of chapters used.
   2. VOCAB - Perceived appropriateness of vocabulary level.
   3. BIAS - Perceived cultural bias of textbook.

2. Guides (GUIDES): Perceived adequacy or degree of implementation of guides.

   Overt Indicators:

   1. Number of pages and/or chapters used.

3. Discussion Sections (DISCUSS): Perceived adequacy or implementation of the discussion sections.

   Overt Indicators:

   1. QUES - Ratio of questions asked to instructor talking.

4. Experiments (EXPTS): Perceived adequacy or implementation of the laboratory experiments.

   Overt Indicators:

   1. USED - Number of experiments used by instructor.
   2. WORK - Degree of individualized student work occurring in the experimental sessions.

5. Student Outcomes (OUTCOMES): Outcomes of the innovative program.

   Overt Indicators:

   1. SKILL - Laboratory skill of students acquired.
   2. KNOW - Student knowledge of the subject matter.
   3. ATTITU - Student attitudes toward the subjects.

Key to Figure 6.

of the curriculum elements, can be manipulated within time and cost constraints.

INSERVICE TRAINING PROGRAM
FOR GEOLOGY CURRICULUM

	Hours of Instruction for: Orientation:	Expertise:
1. Identification of Student Needs		
Stufflebeam's model	2	4
Alkin's model	2	8
Stake's model	2	8
2. General Course Introduction		
Purpose of the course	1	-
Elements of the course	1	-
Development of the course	1	3
3. Use of Experiments in the Course		
Relationship of experiments to course goals	1	10
Individualization of instruction	2	5
4. Discussion Techniques for the Course		
Socratic techniques	3	10
Insult techniques	1	-
Small-group techniques	2	5
Large-group techniques	2	5
Delphi techniques	2	8
5. Use of Classroom Guides		
Relationship of the guides to course goals	3	-
Comprehension through coherent presentation	1	5
Behavior modification	2	15
Types and uses of humor	2	10
Audio-visual and other classroom aids	1	15
6. Use of the Textbook		
Individualization of assignments	2	10
Linking textbook concepts to classroom activities	2	5
Vocabulary building	1	-
7. Socioeconomic Status and Student Achievement		
Affect of SES characteristics on learning	2	5
Cultural bias in testing	2	4
Discipline	2	-
Parent cooperation	1	3
Advantages and disadvantages of heterogeneity and homogeneity in the classroom	2	10
TOTAL	45	148

Figure 7.

The data required to describe the options open to the administrator can no longer be summarized in a simple table, but will require a full report on the many combinations and permutations possible. Even at this level of complexity it already is likely that the administrator may have to request additional predictions for specific patterns of implementation that interest him, rather than expecting to find all possibilities discussed in the report.

This approach to curriculum implementation provides an administrator with a much better method of predicting effects of his decisions, and, equally important, of explaining his decisions to others or working with staff to reach mutually acceptable decisions. The essence of the approach we are suggesting is to:

1. Conduct a field test using student outcomes as dependent and teacher attitudes and adaptations of a curriculum independent variables;
2. Construct a model of the way teachers, curriculum and students interact through structural equations; and
3. Use the model to <u>adapt</u> the curriculum to any situation in which factors of cost, teacher preferences or student outcomes must be taken into account.