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ABSTRACT

This paper describes a model of classroom processes that can be used in research on the nature of the relationship between school practices and student achievement. It is stated that the model specifies that criterion performance is a function of initial abilities and of the following four constructs: (1) opportunity, (2) motivators, (3) structure, and (4) instructional events. The paper describes each construct as it pertains to the classroom and deals with evaluating the model and testing the assumptions. The model is applied to the Ashton-Warner approach, the Montessori system, and the individualized programs developed by the Learning Research and Development Center. The paper then describes the variables that make up each of the four constructs and two additional constructs (initial performance, and outcomes). Lastly, the paper deals with the construction of measures of the previously identified variables. The problems involved in moving from variables to measures are discussed, methods that have been found to be useful in describing classroom processes are summarized, and an example of a classroom data-collection instrument is described. (RC)

THE APPLICATION OF A MODEL FOR INVESTIGATING CLASSROOM PROCESSES

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Over the past decade, numerous evaluation studies[1] have presented a dismal picture of the effects of education. All of these studies concluded that school practices do not affect children's learning. As a result, many educational policy makers are asking why more effort and funds should be directed toward the implementation of innovative educational programs or even the improvement of existing ones. More recent research focusing on classroom rather than school variables (e.g., Leinhardt, 1974; Stallings, 1973; Cooley & Emrick, Note 1; Leinhardt, Note 2) suggests that educational programs implemented in classrooms do affect student learning. Additional work at the classroom level is needed to offset the detrimental effect that the larger-scale studies, which centered on the school, are having on attempts to improve education.

The nature of the relationships between classroom processes and student performance has been an intriguing problem for educational researchers for several decades (e.g., Barr, 1929). Although it seems logical to

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[1] See, for example, Averch, Carroll, Donaldson, Kiesling, and Pincus (1972); Coleman, Campbell, Hobson, McPartland, Mood, Weinfeld, and York (1966); Jencks, Smith, Acland, Bane, Cohen, Gintis, Heyns, and Michelson (1972); and Wargo, Campeau, and Tallmadge (1971).

suggest that what happens in a classroom is directly related to what a student learns in that classroom, far too little is known about the specific ways in which classrooms differ and the effects of those differences on student learning. Summaries of research in this area (e.g., Rosenshine, 1971; Travers, 1973) illustrate the lack of consistent results.

In conducting research on classrooms, one problem that must be dealt with is the vast array of possible influencing variables. It is probable that no single, observable classroom variable will have a consistent, significant effect on student learning. Instead, there will be a cumulative effect for sets of variables. In many classroom research studies, the approach has been to collect as much data as possible in the hope that meaningful findings will emerge. These studies have resulted in an unmanageable quantity of data that has produced no clear insight as to what practices make a difference in student learning (e.g., Stallings, 1973). This suggests the need for a systematic program of research on classroom processes that is guided by a finite set of classroom variables and a technique for combining these variables into major dimensions of classroom differences that are likely to affect learning.

A program of research on classroom processes is also needed to provide a basis for improved procedures for educational evaluation. Cooley and Lohnes (in press), for example, have developed an approach to evaluative inquiry that requires the direct measurement of the major ways in which classrooms vary. Their model is a means both of assessing the effects of instructional programs and of deriving general principles of effective classroom processes. They see the direct measure of classroom processes as the only way to provide the necessary controls in evaluation studies, since the main tool of control in experimental design (i.e., random assignment to treatment differences) is not available in classroom research. Even if randomization were possible, it is very doubtful that the desired treatment could be uniformly applied within treatment levels without imposing conditions that would make it impossible to generalize the results to field conditions.

A model of classroom processes that is designed to help in interpreting the relationship between classroom practices and student achievement can serve as a useful heuristic for the design of data collection and analysis. Clearly, a model is most functional when it serves this purpose. A model of classroom processes can guide researchers not only in what to look for, but also in how to organize the information into specific domains. Rather than being left with a nearly infinite series of hypotheses that need to be tested, the researcher is provided with basic constructs. If data collection is designed in accordance with some model, the constructs of the model can be validated, challenged, or re-interpreted. The revised model can serve to guide research in a precise way, the results of which can help further refine the model.

To use a model in a dynamic way as a means for guiding classroom research rather than as the final goal of research, certain conditions must be met. First, the model must be clearly stated. There can be little ambiguity with regard to each of the terms in the model. Second, as measures are developed for testing the model, there must be evidence for the face validity of the measures for tapping the constructs of the model. Finally, there must be a consistent attempt to use these measures and relate the results back to the model. This paper addresses itself to these tasks.

A Model of Classroom Processes

Currently, one of the more popular models of classroom processes is the one suggested by Carroll (1963). Several researchers have described their results in terms of this model (e.g., Bloom, 1974; Wang & Lindvall, 1970; Wiley, 1973). The popularity of the model may be the result of its small number of components and the flexibility with which one can treat each of those components. Cooley and Lohnes (in press) have proposed a revision of the Carroll model that consists of six constructs (two student ability constructs--initial performance and criterion performance--and

four classroom process constructs--opportunity, motivators, structure, and instructional events). It is this model that we will use to provide a framework for the investigation of classroom processes.

Before examining the specific constructs and how they might be measured, some general features of the Cooley-Lohnes model should be considered. The purpose of the model is to explain the variation in student performance that occurs among classrooms following an extended period of instruction in those classrooms. Figure 1 illustrates the six constructs that the model incorporates. As the figure indicates, the model specifies that criterion performance is a function of initial student performance and of certain classroom processes that occur in the interval between the assessment of initial student performance and the assessment of criterion performance. Classroom processes are represented by four constructs that are assumed to affect the criterion performance.

In using the model to guide data collection, one begins by specifying the criterion performance that is of interest. The criterion performance can be any measurable educational outcome.[2] For example, it can be as specific as a subset of arithmetic skills or as general as general academic achievement or social development. Variables are then selected in the other five constructs that are assumed to influence the criterion performance. The process by which one chooses specific measures of the five constructs, given the criterion performance, will be described in a later section of this paper. The main point here is that different measures will represent these constructs depending upon the criterion performance that the model is intended to explain.

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[2]We do not mean to imply that the justification of educational outcomes is a trivial matter. Establishing the value of the criterion behavior is critically important, but doing so is not the purpose of the model.

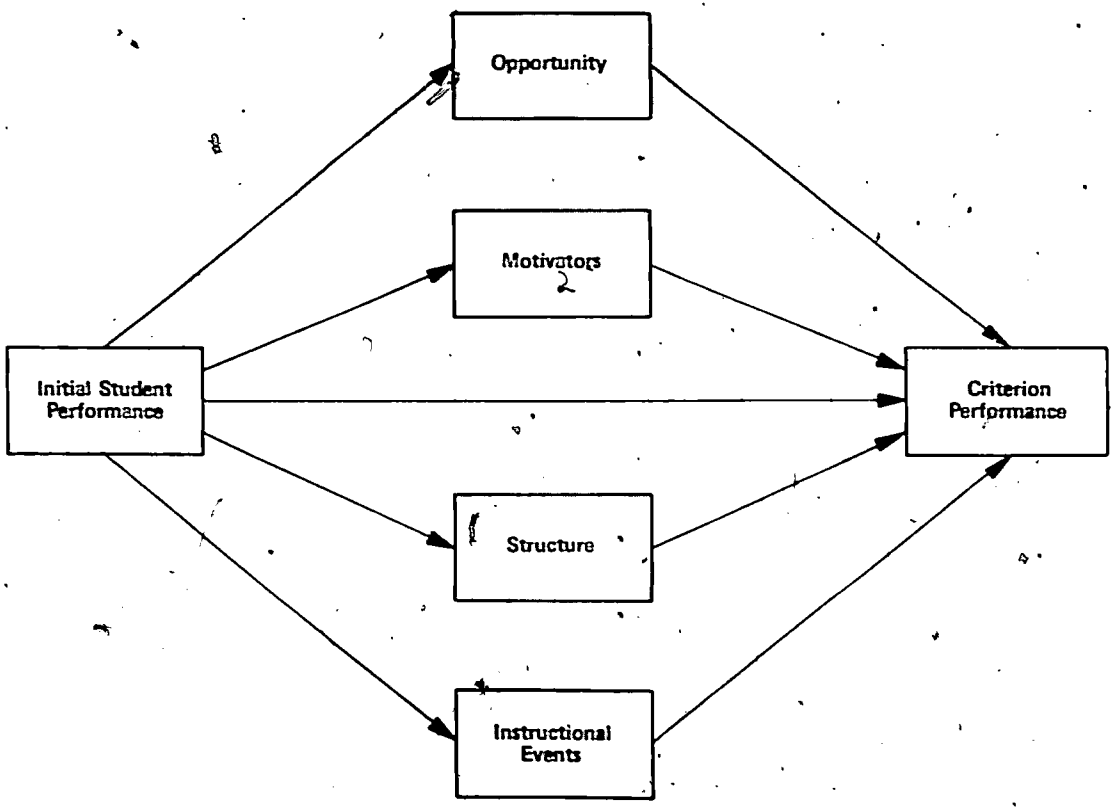

Figure 1. Cooley–Lohnes model of classroom processes.

The four classroom process constructs in the Cooley-Lohnes model are briefly described as follows:

Opportunity. Opportunity represents the possibility for learning what is sampled in the criterion performance measures. If, for example, the criterion performance is a measure of arithmetic skills, then the amount of time that the student could work on those arithmetic skills in the classroom would be an appropriate opportunity measure.

Motivators. Motivation can be viewed as being internal or external. By internal motivation, we mean those sets of student behaviors and attitudes that tend to support high rates of learning activity. By external motivation, we mean those elements that can be built into an educational environment to increase the likelihood of an individual engaging in and sustaining learning activities. In the Carroll model, motivation refers to the students' tendency to engage in learning activities when the opportunity exists. In the Cooley-Lohnes model, the construct is represented by observable elements in the environment that are designed to encourage the student to undertake learning activities (e.g., teacher reinforcement for on-task behavior, instructional materials that appear to interest the students). We refer to these elements as motivators.

Structure. The structure construct deals with the degree to which a curriculum is organized and sequenced, the specificity of the objectives, and the manner in which a student and a curriculum are matched. The construct does not specify the particular way in which the curriculum should be structured (e.g., linearly or not), nor the way in which matching should be done (e.g., choice or assignment).

Instructional Events. This construct concerns the content, frequency, quality, and duration of instructional interactions. It is different from structure in that it refers primarily to an interpersonal contact, either between a student and a teacher or among students. Clearly, one could treat every interaction between a student and any learning resource (human or nonhuman)

in the same construct, whether that interaction was between a student and an audiotape or between a student and a teacher. However, given the tremendous flexibility in the interactions between a student and other human beings, these interpersonal interactions are given special emphasis.

All four of these process constructs are viewed as necessary for describing classroom differences that can explain variation in criterion performance not explained by initial student performance. For instance, no matter how much opportunity and motivation are provided in a classroom, learning will also be a function of how well the curriculum is structured and whether or not students are working on tasks that they have the prerequisites to learn. Similarly, even though opportunity may be ample, motivation high, and the curriculum well structured, learning will also depend upon the quality and quantity of the instructional contacts with the teacher. We recognize that the constructs will be difficult to measure, but until progress is made toward the measurement of classroom processes, there will be no significant improvements in the ability of educational researchers to explain classroom differences that affect what students learn.

Commenting recently on the current model-building fad in psychology, Underwood (1975) pointed out the importance of having model evaluation accompany model building:

> The fact remains that we have models running out of our ears, and there seems to be no surcease. This may be quite healthy: at least lots of people are getting skilled in drawing boxes, arrows, and circular nodes. But all of these models cannot be right, or even useful or believable, and evaluation seems to be rather low on the priority list. It seems to be easier to formulate a new model than to test an old one, and one never gets pinned down that way. (p. 128)

In the spirit of this rather valid criticism of model building, let us turn to how we plan to evaluate the model.

Evaluating the Model

At this stage of the model's development, the major empirical activity must be to define adequate measures of the constructs. As discussed later in more detail, a large number of variables is suggested by each construct, and each variable can be measured in a variety of ways. A construct can be considered to be adequately measured when the addition of new measures does not add new information to the measurement of the construct, where new information is defined as an increase in construct variance that improves prediction of criterion performance.

After measures of each construct are developed, one type of empirical activity that can be carried out is to test the null hypothesis suggested by each construct. Such tests involve determining the significance of the relationship between each of the five predictor constructs and the criterion performance, in the presence of the other four predictors. The question being asked in this approach is whether each construct is necessary, that is, does it add significantly to the prediction of criterion performance. Although this test of the model is a very minimal one, it is a reasonable first step. If a construct cannot "pass" this test, either it needs to be more adequately measured or the model needs to be redefined.

Another hypothesis testing approach is to test the sufficiency of the constructs by searching for process variables that are not relevant to the four process constructs, yet add to the prediction of criterion performance in the presence of adequate measures of those constructs. For example, the variable "years of teacher experience" can be shown to be related to criterion performance, but it is not likely to add new information to adequate measures of the process constructs, at least not according to the model. If teacher experience is relevant, it is because of something the teacher does as a result of that experience. Knowing the effect of experience in terms of classroom process is both more useful (training can affect process, but one has to await experience) and more likely to be related to

the criterion (not all teachers improve with age). If, however, teacher experience does provide information relevant to criterion performance that is not present in the process constructs, then the model or the measurement of its constructs is somehow inadequate.

Eventually, it will be desirable to explore a research alternative to hypothesis testing, which is to estimate the shape and parameters of a function that relates the independent variables to the dependent variables (Simon, 1974). This approach can reveal the relative influence of the five predictor constructs upon criterion performance. It does not require experiments in which one kind of teaching is contrasted with some other kind, in search of a significant difference. Rather, the approach recognizes that teacher and classroom differences can be described in terms of a finite set of dimensions, and that the form of the relationship between these dimensions and criterion performance is of prime concern. Specific statistical procedures for considering this relationship are described in the last section of this paper.

Testing the Assumptions

The Cooley-Lohnes model assumes that classrooms that "look alike" in terms of the process constructs will produce similar criterion performances given similar initial student performances. One way of investigating the validity of this assumption is to examine the consistency of the criterion gains produced by the same teacher using the same curricula in the same way with similar children from year to year.

Correlational analyses between residuals of criterion performances not explained by initial performance for the same teacher from year to year have produced a wide range of results, indicating limited stability (Rosenshine & Furst, 1970). However, later work by Brophy (1972) is more encouraging. He suggests that "teacher consistency may be higher than previously suspected, at least among experienced teachers working in their

usual fashion" (p. 1). In our own studies of this phenomenon, we obtained correlations of residuals in the range of .50 to .80. Considering the amount of uncontrolled variation in initial student performance and its possible interaction with classroom process, this degree of consistency supports the validity of the assumption, but further clarifying research is obviously needed.

Recognizing that environments other than the classroom can also affect criterion performance, another necessary assumption is that nonclassroom influences are stable between initial and criterion performances, normally a time span of one school year. For example, differences among home environments clearly exist and clearly are relevant to intellectual development, but these differences are accounted for in the initial performance measures, unless, of course, home environments change differentially following initial performance and preceding criterion performance. Research such as Keeves' (1972), where dimensions of home environment were introduced in the presence of classroom and initial status measures, has found no home environment differences that explain variation in criterion performance not explained by the initial status and process constructs of the model. That kind of evidence supports the validity of the assumption regarding the stability of nonclassroom influences.

Using the Constructs Descriptively

Before detailing the kinds of variables that are suggested by the four process constructs and possible measures of those variables, it seems useful to further develop the constructs as concepts by describing a few different educational approaches in terms of the constructs. Also of interest here is how the model, as illustrated in Figure 1, is helpful in describing the ways in which different educational approaches emphasize different educational processes. For purposes of this discussion, consider the performance criterion to be general academic achievement. The three approaches

to be considered in this section are the Ashton-Warner approach, the Montessori system, and the individualized programs developed by the Learning Research and Development Center (LRDC).

Since the mid-1950s, several approaches to elementary education have arisen that share the features of being developed by a teacher and of having a single, rather "dramatic" teacher as their most observable characteristic. John Holt (1964), Herbert Kohl (1967, 1969), and Jonathan Kozol (1967) are just a few of the more well-known educational reformers in the United States who have proposed approaches of this type. Although she did her work in New Zealand, Sylvia Ashton-Warner (1963) is also quite well known in the United States. What is interesting about all of these educators is that their contributions have come through popular literary works that criticize the existing status quo in education; their dissemination system is the novel; their funding has been their respective teaching salaries; and, relatively speaking, their impact on education has been substantial.

The Ashton-Warner educational approach will be described here primarily because it is the most clearly stated of the teacher-developed approaches. Sylvia Ashton-Warner taught elementary school with a traditional state-authorized curriculum that she gradually modified. The specific part of her program that has attracted the most attention is "organic reading." In this system, the teacher organizes the instructional situation so that the children dictate their own "readers" and learn to read words whose meaning is especially important to them. Therefore, the substance, or content, of the readers varies from group to group; the specific way in which the "books" are written varies from teacher to teacher, but the relative significance of reading for each child is somewhat constant.

In the Ashton-Warner approach, opportunity is limited by the desire to keep the students highly motivated. Therefore, only brief periods of time are spent in specific subject-matter areas such as reading. The approach emphasizes the child's interest in certain words or concepts,

which act as motivators. To a great extent, both the instructional events and structure are developed by the children themselves and, as a result, are variable.

A second approach to elementary education is reflected in the Montessori (1965) system. The main features of this complex and innovative educational approach are cross-age groupings, systematically arranged materials, specific series of lessons for each set of materials, and child independence with regard to what work will be done and when it will be done. There are three components to the Montessori curriculum: practical life activities, concrete sensory motor training, and didactic materials. One of the most often noted features of the Montessori program is the practical life activities. Examples of these activities include: washing tables, washing dishes, shining shoes, polishing silver, and taking care of plants or other elements in the environment. The main purpose of these activities is to provide children with the responsibility and pleasure of caring for their own environment while involving them in useful and productive activities. The sensory motor training generally involves the use of very finely constructed painted wooden objects or insets that foster the development of specific sensory skills. This training introduces fundamentals that are more fully taught with didactic materials. Didactic materials consist of concrete objects that can teach abstract concepts concerning, for example, number and relative size. Most didactic materials can be used to teach more than one educational objective; thus, the materials and the curriculum are not identical sets.

In a Montessori classroom, the exercise of opportunity to work in specific subject-matter areas varies from child to child and from classroom to classroom because it is the child who determines how much time, if any, is spent in a given area. The motivators built into the Montessori system consist of the materials that were designed specifically to appeal to children. Further,

the materials are displayed in an extremely effective manner so that the child is "invited" to work with them. Although there is an attempt to organize the total environment, the structure of a particular child's activities is dependent on the child's selection. There is no guarantee that the child will select at the level at which the most learning will occur. The structure of the curriculum has not been empirically validated; however, the sequence of the materials was developed by continuous observation of children's development over time. Instructional events are emphasized in the Montessori system. There is a sequence of presentations for each lesson, and a precise set of wordings for each lesson so that the teaching element in this system is consistent and of a high quality. There are built-in checks in the sequence of presentations to make certain that the child has grasped what has been presented. This is markedly different from the Ashton-Warner, Holt, Kohl, or Kozol approaches, in which the quality of the instructional events is dependent on the individual who gives the instruction. A weakness of the Montessori system, in terms of the process constructs, is that a student may never engage in a particular activity. Also, in some situations, the teacher may not act as a motivator. It is possible, too, that students may not respond to the internal sequencing of the materials and, therefore, not benefit from them to the extent possible.

A third innovative approach to elementary education is reflected by the individualized programs of the Learning Research and Development Center. The LRDC curricula were designed primarily to reflect known behavioral learning principles. They consist of carefully sequenced instructional materials. Students move through the sequence at different rates and, to some extent, at their own volition. However, where the student enters a curriculum and how much time a student spends on each program per day is generally determined by the teacher and the curriculum design. The curricula have specific built-in monitoring points, which help the teacher decide whether or not the child should proceed with new materials or recycle through previously presented material that has not yet been mastered.

In terms of the four process constructs of the model, opportunity tends to be fixed either at the LRDC developers' recommended level for subject matter or by school system requirements. However, in some cases, there is student-controlled scheduling, and opportunity may change from student to student and classroom to classroom. The motivators are primarily built into the close fit between the learning situation and the child's needs and into the teacher as an interpersonal motivator. If the teacher fails to act as a motivator, the resulting loss in motivation would be particularly detrimental to student performance. The curricula are highly structured and have been empirically validated as to the accuracy of their structure. The instructional events vary from classroom to classroom. Some teachers are very supportive and precise in their instruction, while others exhibit a more punishing and less appropriate instructional approach. Instructional events do not have the consistency that is found in the Montessori system, for example.

The preceding discussion has attempted to illustrate the four process constructs by describing several educational approaches with differing emphases. The illustrations help to show how different approaches can emphasize different constructs in ways that balance off so that the various approaches yield similar outcomes. Although all four constructs are viewed as necessary for describing differences among a reasonably heterogeneous set of classrooms, the constructs are expected to behave in a compensating fashion, where more of one can make up for less of another within a particular approach. A linear model of the constructs will provide for that possibility. Such a model is outlined in the final section of this paper.

From Constructs to Variables

In order to use the model to develop a specific set of measures, each construct must first be analyzed and a set of variables must be derived that describes that construct. Table 1 illustrates a set of variables that could possibly tap each construct. Each variable, in turn, can be assessed by a

Table 1

Suggested Variables and Measures for Each of the Six Constructs

Constructs	Variables	Measures
Initial performance	Academic performance	General ability tests Standardized subject-matter tests Curriculum-based tests Teacher-developed tests Parent or teacher reports
	Attitude toward school, peers, teachers	Attitude inventories Semantic differential Observations
Opportunity	Time spent in subject	Time scheduled in subject by teacher Time spent by class in subject Time spent by individuals in subject averaged over individuals Time on task within subject
	Criterion-relevant instruction	Percentage overlap between instructional items (or materials) and criterion tests by subject
Motivators	Curricular attractiveness	Ratings (student, teacher) Observed frequency of usage Observed time discussed
	Curricular diversity (modality and content)	Catalogued diversity Observed diversity Diversity of usage
	Interpersonal contacts (peers, teachers)	Percentage of observed support behavior Frequency of observed support behavior

(Continued)

Table 1

Constructs	Variables	Measures
Structure	Clearly stated objectives	Ratings of curriculum
	Sequencing and branching	Ratings Observation Hierarchy analysis (Guttman scaling)
	Materials	Ratings Observation
	Matching: rate, unit, accuracy, mechanism (e.g., free choice, test results)	Teacher self-reports Review of test and assignment records Retesting, reassignment intervention
Instructional events	Didactic techniques	Observations or ratings of teachers and/or materials
	Explanations	Ratings Frequency
	Feedback	Ratings Frequency
	Diagnosis	Ratings Student performance
	Reinforcement	Ratings Frequency
	Pacing	Ratings Frequency
	Basic abilities	Test of teacher abilities (Coleman)
Outcomes	Academic performance	Standardized subject-matter tests Curriculum-based tests Teacher-developed tests Parent or teacher reports
	Attitude toward school, peers, teachers	Attitude inventories Semantic differential Observations

number of measures. As an example, for the initial performance construct, general academic performance is one of the variables that can be considered. It can be measured in different ways (e.g., by a variety of standardized tests or by teacher-assigned grades).

Generally, in measuring a construct, the domain of possible variables must be identified first. The selection of variables will be based primarily on the criterion performance to be explained. Specific measures must then be selected. In some cases, the measurement procedures are relatively straightforward, while in others, the procedures are somewhat ambiguous. In addition, more than one system of measuring a variable may be used in order to tap a construct. What follows is a description of the most probable variables for each process construct.

Opportunity. There are two main aspects to the opportunity construct. One has to do with how time is allocated, and the other with how good the fit is between the curriculum and the performance criterion. In some situations, the time aspect of opportunity will simply be the average daily time allocated by the teacher for the subject matter sampled in the criterion performance. If, for example, the children in a classroom work on mathematics for a 45-minute period per day, then that period defines the opportunity to learn what may be relevant to a mathematics performance criterion. If another teacher assigns 90 minutes of mathematics per day, and if other aspects of classroom process are identical for the two classrooms, then one would expect students in the 90-minute classroom to learn more mathematics than students in the 45-minute classroom. How much more learning would occur depends upon the relationship between opportunity and criterion performance.

This aspect of opportunity can be difficult to measure in some settings, such as classrooms that are "open" with respect to allocation of time. In an individualized setting with student self-selection, there is, for example, no easily measured reading period. The amount of time allocated to reading

varies from student to student and from day to day. In such settings, it is necessary to develop estimates from classroom observations, where the estimates are based upon time samples across students and days, yielding classroom averages.

Another possible opportunity variable is the overlap between objectives sampled in the performance criterion and objectives included in the curriculum. As an example, opportunity could be measured as the percentage of material included in a mathematics achievement test that was previously "covered" by the math curriculum in use. All other conditions being equal, students who had the opportunity to learn 90% of the test material should perform better than students who followed a curriculum that aimed to teach only 60% of the material sampled by the criterion measure.

A complication of classroom research that must be recognized in designing appropriate models for guiding that research is the possible relationships among classroom process variables. For instance, in the above example, the amount of time that a teacher assigns to mathematics in the daily schedule may be a function of that teacher's attitude toward or competence in mathematics, which may, in turn, affect the quality of the motivators and/or the instructional events. This possible interdependency among the process variables must be recognized and dealt with in the tools selected for determining the relative influence of the process constructs. It is important that the process dimensions be considered in combination, in some multivariate model, as shown in the final section of this paper.

Motivators. As mentioned previously, the concept of motivation can reflect both external and internal influences. The Cooley-Lohnes model, however, includes only external motivators (i.e., curricular and interpersonal). Curricular motivators refer to teaching materials that are interesting or "catchy" (e.g., games that encourage interpersonal interaction). What is required is a measure of the degree to which materials that attract students

are able to keep them interested long enough to learn from them versus the degree to which the materials are only superficially attractive and produce no learning. A balance should be struck between the desire to engage in new and exciting materials and the desire to stay on task over some time with one set of materials, and this balance should be measured.

As far as interpersonal motivators are concerned, the teacher is the primary, though not the only, interpersonal motivator. The teacher can reinforce work, inquiry, and investigation behaviors by attending to students who exhibit those behaviors. Undoubtedly, certain types of peer tutoring are also highly motivating, both to the student receiving the tutoring and to the one giving it. In contrast, negative verbal and physical behavior work against motivation; that is, if the environment is punishing, then the student's motivation will be directed toward escaping from that environment.

Structure. The structure construct addresses several basic concerns. First of all, is the curriculum structured and, if so, how? This aspect of the construct will be a function of the clarity and specificity with which objectives are defined, as well as the manner in which they are sequenced. This aspect could include the process whereby the sequencing was validated, if indeed it was, as well as descriptive features of the resulting structure, such as whether or not branching is involved.

A second concern is whether or not a mechanism for matching students to the curriculum is provided and, if so, who does the matching. The mechanism can vary. For example, matching can be based on student interest, self-assessment, and so on, or on teacher assignments based on where the student is assumed to be in the curriculum. The curriculum designer is generally responsible for the matches made in individualized curricula. Testing is built into these curricula in such a way that test results specify how the student and the curriculum should be matched. A slight variation on

this is matching based on the designer's opinions and some empirical data on student performance. Of course, any combination of student, teacher, or designer matching can be used in the classroom.

Another relevant concern is how frequently one needs to match the student and the curriculum. Frequency is important; matching is time consuming for both students and teachers. The accuracy of the match must also be taken into account. In traditional testing situations, the question is merely how reliable or how valid the test is. But if students or teachers are the matching mechanism, it is difficult to determine how accurate the match has been in any given situation.

A related question, one that bears very strongly on individualized curricula, involves the unit of match. Is it the class as a whole, a subunit of the class, or one child? When it is the entire class, it is easy to have either the designer or the teacher decide where the children should be in the curriculum. When there are small groups, it is probably even easier for the designer or the teacher to do the matching. But when the child is the unit of match, it becomes much more difficult for the teacher to make all the matching decisions. In some individualized programs, the students learn how to match themselves by diagnosing their own needs and prescribing educational experiences to meet these needs, not to the exclusion of the teacher or the curriculum designer, but as a more effective and flexible mechanism for benefiting from the curriculum.

Instructional Events. As stated earlier, instructional events are primarily based upon the interpersonal aspect of the instructional process, although the quality of the instructional materials themselves can have considerable impact on the quality of the instructional event. There are several facets to this area: content, presentation, questioning, feedback, and frequency. For example, the content of the teacher's interactions with a student can be specific subject matter, the relationship among subjects, or

managerial behavior. When a new procedure is presented, it can be modeled by the teacher or the model may be embedded directly in the curriculum. New skills can be introduced by presenting information in a series of small steps that the student can learn easily or by covering large general chunks of material. The teacher can question students in a focused, closed way or in a way that anticipates broad open-ended answers. The teacher can wait for a student to work out answers or s/he can supply the answer when the student hesitates. And, finally, teachers can vary in the frequency with which they interact with students.

From Variables to Measures

This section deals with the construction of measures of the previously identified variables. The problems involved in moving from variables to measures are discussed, methods that have been found to be useful in describing classroom processes are summarized, and an example of a classroom data-collection instrument is described.

Problems

There are several problems involved in constructing measuring instruments. Classroom practices, for instance, are interpreted differently by different individuals. Classroom practices vary from hour to hour, let alone from year to year. Further, once instruments are constructed, there needs to be a mechanism for adding to existing information. For example, if one is concerned with opportunities for reading and collects data on number of library periods, reading lessons, and reading groups, and then discovers that the science program includes a large reading component, there must be some mechanism in the data-collection procedure that permits the addition of this information.

Measurement of each of the four classroom process constructs is a challenging task. Measuring opportunity can be reasonably straightforward only in classrooms where there are consistent daily schedules. In open-scheduling environments, or in environments that have flexible daily schedules, the opportunity construct becomes more difficult to measure. If one or two curricula are installed for a given subject-matter area and those curricula are rather faithfully followed by the teacher, it is reasonably easy to analyze structure. However, if the structure is modified by the teacher, as it often is, its measurement becomes more complex. The various motivators available to students in a given classroom and the quality of the instructional events are always extremely difficult to measure and require some form of classroom observation.

Methods

The methods used to obtain accurate descriptions of classroom processes must, in some way, include monitoring the working classroom. One must be in the classroom taking notes or an instrument must be used to gather information. The specific methods that have proven most useful for our research are a combination of questionnaires/interviews with the students, teachers, and supervisors, inventories of what materials are available and are used in the classroom, and videotapes of the classroom.

Questionnaires and interviews are useful in determining the general practices that the teacher employs. There is a myth that teachers will provide only that information that they think the researcher wants to hear. However, if an observer collects information and confirms relevant portions of that information with the teacher or with the teacher and supervisor, a high degree of reliability and validity results (Leinhardt, 1972). In general, teachers will attempt to provide accurate information, particularly if the questionnaire is the basis for a structured interview and is followed up by another mechanism for checking the validity of the results.

In addition to the combination of questionnaires and interviews, videotapes can be used to collect information about classroom processes. There are at least two advantages of videotaping over classroom observation alone. First, it is considerably cheaper to tape because teams of highly trained analyzers do not have to visit each site. Second, videotapes provide a permanent record that can be analyzed as often as necessary in order to confirm interrater reliability and to conduct analyses with different types of instruments.

An Example

The Appendix consists of a questionnaire/interview designed to gather information on classroom processes for the Cooley-Lohnes model. This prototype instrument, which includes 58 questions, was constructed to provide information on three of the four process constructs: opportunity, motivators, and structure. Some background information is also collected. Questions 2-15 and 55-56 deal with the opportunity for students to engage in academic activities. These questions ask primarily for information about the amount of time available for various subject-matter areas.

Questions 16 and 19-38 concern the motivators that are available to students. A single rating of an environment's ability to motivate students would be desirable but, unfortunately, what will motivate a particular individual is not always obvious. Therefore, in designing the questions, an attempt was made to list as many conceivable motivators as possible in the hope that the responses to the questions would provide adequate evidence on the degree to which the environment can be considered motivating or not. It appears, for example, that the availability of various modes of instructional material is more motivating to the student than a single mode (Questions 19-20). The teacher's assessment of how motivating the material is (Questions 21-22) also seems useful in this context. Other questions relate to the

use of feedback, student independence, and peer interactions as motivators.

Twenty of the questionnaire items are designed to assess structure. The first two of these questions (Questions 17-18) ask for the basic reading and mathematics texts in use in the classroom. This information, however, is not sufficient for rating structure. Information about actual classroom practice must also be taken into account. As an example, some of the LRDC curricula include pretests, lesson-embedded tests, and posttests. If a rating were based only on the information that a classroom was using these curricula, then structure in that classroom would be rated as high. It may be the case, though, that the teacher uses only one of those testing systems. More extensive information about classroom practice is collected in Questions 39-46, 48-49, and 52, which ask the teacher to rate the degree to which the curriculum is organized and sequenced, and the degree to which the student and the curriculum can be easily matched. In most cases, the teacher will perceive the curriculum as being more structured than will the researchers.

There is also a series of questions that tap whether or not the teacher is adding monitoring devices to a curriculum that may not include such devices (Questions 43, 47, 50, and 51). In addition, two very open-ended questions ask about teaching practices in general (Questions 53-54). Two other questions ask for a listing of student assignments--activities that a child engages in during the day relatively independently (Questions 57-58). These questions provide information that will be useful in estimating the degree of individualization in assignments and the degree of monitoring or tracking capabilities of tests.

The quality of the instructional events cannot be easily measured, since interpersonal contacts are dynamic events. Thus, for the purposes of our investigation, information on instructional events is gathered by the use of videotapes that focus on the teacher's (whether that teacher is an adult

or another student) interactions with students. These interactions are coded with regard to the following considerations:

1. The frequency of teacher-student contact.

2. The substance of the contact (that is, what the teacher talks about with the student).

3. The affect of the contact (that is, whether it is positive or negative).

4. The degree to which the teacher provides the opportunity for the student to indicate knowledge or response (that is, the degree to which the interaction is, in fact, interactive).

5. The nature of the interaction (that is, whether it is a yes-no response or a response that includes additional information).

Information about the classroom must be combined with input about the students and analyzed with respect to its effects on criterion performance. Considerations regarding data analysis are dealt with in the next section of this paper.

Data Analysis

The task of showing the extent to which different classroom practices can affect student learning presents many challenges. Three key aspects of this task are considered here: (a) choice of the unit of analysis; (b) reduction of classroom observations to primary construct dimensions; and (c) analytic techniques appropriate for estimating the relative importance of those dimensions in producing the observed outcome effects, given the field conditions that prevail in classroom research.

One of the first considerations in defining an appropriate strategy for the analysis of classroom data is the unit of analysis. The model presented here suggests observations of the individual student in terms of initial abilities

and criterion performance, as well as observations of the classroom environment. In such cases, it is possible to aggregate the student data within the classroom and use the classroom as the unit of analysis. An alternative is to use the student as the unit of analysis by assigning process values to each student based on the measures collected for his or her classroom.

From a statistical inference point of view, the sampling unit determines the appropriate unit of analysis. If, for example, classrooms were randomly selected from some well-defined population of classrooms, and then randomly assigned to one of two possible classroom treatments, the classroom would be the appropriate unit of analysis. Analyzing data at the student level would result in a very inflated number of degrees of freedom. Thus, even if the unit of observation were the individual student, data should be aggregated into classroom descriptors, such as class means prior to the analysis of treatment differences. Unfortunately, however, classroom research does not lend itself to such neat sampling designs. Therefore, the sampling unit does not necessarily prescribe the appropriate unit of analysis. But since the class and not the student is generally the unit of assignment for a particular educational approach, the classroom is a more justifiable unit of analysis, at least from an inferential point of view.

The unit of observation is very relevant to the unit of analysis question. If it were feasible to observe the environmental influences for each student, as well as that student's initial and criterion performances, then one could at least consider the possibility of using the individual student as the unit of analysis. Although each child receives a different treatment, it is not feasible to collect data at that level of detail for many classrooms. The objective is to define a model that describes the main ways in which classrooms vary and the effect of that variation upon student learning.

Many studies have attempted to explain achievement variation using the school or even the school system as the unit of analysis (e.g., Averch et al., 1972; Coleman et al., 1966; Flanagan, Dailey, Shaycoft, Orr, & Goldberg,

1962). However, general school practices, as measured in these studies, do not seem to have much effect upon student achievement. School variables, such as cost per pupil or percentage of teachers with advanced degrees, are too removed from the educational process to be useful. Differences at the classroom level must be analyzed if the research is going to identify educational practices that make a difference in what students learn.

A second data-analysis task is to define the minimum number of dimensions needed for representing each construct in the analysis. Since the classroom is to be the unit of analysis, it is important to keep the dimensionality small or an inordinate number of classrooms will be required. For example, at least 60 classrooms would be needed to avoid overfitting the data if six dimensions were defined--one dimension for each of the four process constructs and the two performance constructs.

One possible approach to defining a reduced set of dimensions representative of a particular construct is principal components analysis, in which the patterns of correlations among the measures for each construct are the basis for reducing dimensionality. The problem here is that variables that do not happen to be correlated with other measures in the construct are not preserved in the principal factor and thus are not part of the variance representing that construct. An alternative to factor analysis might be multiple scalogram analysis, in which a Guttman-type hierarchy of items is sought. Although this approach might eventually be possible, our experience with the measures representing the process constructs suggests that they do not scale in this fashion.

It is clear that the number of dimensions within constructs must be reduced prior to combining information from the several constructs. Also, it seems necessary to consider the process variables as compensating. That is, more of one variable can make up for less of another, such as the presence or absence of particular motivators or instructional events. Linear functions

of these measures would make it possible to adjust for these compensations.

Given one or two dimensions of each construct and a single dimension of criterion performance, determination of the relative influence of the process constructs calls for some form of multiple regression analysis. The exact method used must deal with the possibility that some of the constructs will have nonlinear effects and with the possibility of correlations among the constructs. This latter possibility implies a regression model that allows one to sort out the unique effects of the constructs from the effects that are confounded with other constructs. Commonality analysis is such an approach. This analytic technique has been proposed by Mood (1971) and others in situations where the objective is to understand the relative influence of predictors, but where it is not possible to experimentally control the degree of their relationship. This method makes it possible to describe the relative effects of the process constructs, both in terms of their unique contribution to explaining achievement variation and in terms of contributions that are common to two or more of the constructs. A complete description of commonality analysis and its applicability to this type of problem can be found elsewhere (Cooley & Lohnes, in press; Kerlinger & Pedhazur, 1973).

In making inferences about the relative importance of the process constructs, it will be very important to specify the overall nature of the population of classrooms with respect to each construct. Obviously, if all of the classrooms in a sample are using the same approach with respect to a particular construct (e.g., providing the same amount of opportunity for children to learn in each subject-matter area), then it will not be possible to determine the importance of that particular construct to the outcome variables. If there is no variance in the construct being measured, it cannot be used to explain variance in anything else. This illustrates how important sampling considerations will be in this work.

Next Steps

In order to conduct classroom research that is guided by the model, work must proceed along two fronts. First, research to collect information on all aspects of the model over a broad sample of classrooms should be conducted. This work has already begun and is continuously being refined with respect to the problems of measurement, sampling, and analysis. Second, research that is aimed at investigating each construct separately must be initiated. While this work must also be conducted in classrooms, these classrooms need not be as "natural" nor as numerous as those required in the first line of research.

The total program of research implied by the application of this classroom process model is indeed ambitious. Good measures of the constructs are not suddenly going to come into existence. The work is complicated by its complete dependence upon the cooperation of a large number of school administrators and teachers. It is prolonged by the fact that each successive approximation requires one school year to achieve, and refinement of the model will surely require a long series of successive approximations.

Fortunately, the work of others can be made relevant to the task, whether or not they are guided by this particular model. For example, current work on time by Wiley and Harnischfeger (1974, Note 3) is relevant to clarification of the opportunity construct. Gagné (Note 4) is developing a model for assessing instructional events. Bissell (1970) has constructed measures of structure similar to those suggested here.

Although the research of others can be useful in further refinement of the model and in designing the required measurement techniques, model builders have an obligation to demonstrate the value of their model through their own research. It is our intent to do just that. The emphasis for the immediate future must be on demonstrating the usefulness of the model rather than its "truthfulness." We intend to explore how the area of classroom

research can be improved through the employment of such a model. In this way, a more realistic view of the importance of educational differences can eventually be realized.

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Appendix

Classroom Processes Questionnaire (Form 7)

Name of person filling out questionnaire _____

Date _____

School District _____

School _____

Teacher's Name _____

1. How many years of teaching experience (prior to this school year) does the teacher have? _____

2. How many students are enrolled in this classroom? _____

3. How many students are present today in this classroom? _____

4. How many adults are normally in the room? _____

5. At what time do the students arrive for school? _____

6. At what time do classes begin? _____

7. Does the teacher tell the students when to begin work each day? _____

8. At what time are students dismissed for lunch? _____

9. At what time are students scheduled to return from lunch? _____

10. At what time are students dismissed for the day? _____

11. How many minutes are scheduled (available) for reading in an average day? _____

12. How many minutes are scheduled (available) for math in an average day? _____

13. In your judgment, for what percentage of the scheduled reading time are the students actively engaged in reading? _____

Appendix continued

14. In your judgment, for what percentage of the scheduled math time are students actively engaged in mathematics? _____

15. How many days are there in the school year? _____

16. Does the classroom have a systematic drill of number facts three or more times a week for ten minutes or more for all students? _____

17. What is the basic text (series) used to teach reading (e.g., Houghton-Mifflin, IPI)? _____

18. What is the basic text (series) used to teach mathematics? _____

19. Check the various mode(s) of instruction used in reading in your classroom. _____

    Audio tapes _____
    Worksheets _____
    Text _____
    Additional books _____
    Other, please specify _____

20. Check the various mode(s) of instruction used in mathematics in your classroom.

    Text _____
    Worksheets _____
    Flashcards _____
    Games _____
    Other, please specify _____

21. Rate the math materials available in the classroom in general as to their interest level for the students (i.e., do the materials hold the child's attention?).

Not Interesting				Very Interesting
1	2	3	4	5

22. Rate the reading materials available in the classroom in general as to their interest level for the students.

Not Interesting				Very Interesting
1	2	3	4	5

Appendix continued

23. When does a student's classwork or homework get corrected and by whom (e.g., after school, by teacher)? _____

24. When is homework and classwork returned to students? _____

25. May a student decide what material(s) to use in order to learn a new skill? _____

26. May a student decide what subject to study at a given time? _____

27. May a student decide what skill or concept to study within a subject area? _____

28. May a student decide when to take a test in an area to assess his/her learning of the materials covered? _____

29. Do students ever score their own tests?

Never				Frequently
1	2	3	4	5

30. May a student decide when to stop working on a task on a given day? _____

31. May a student decide to work alone or in a small group? _____

32. Do students ever work in teams? _____

33. Is there peer tutoring in the class? _____

34. Are there any forms of group contests (e.g., spelling bee)? _____

35. If so, please specify. _____

36. May a student decide whom to sit next to during class? _____

37. Do you have any time during the day in which the child engages in free exploration of cognitively oriented materials? _____

38. If so, please specify:
How much time in general is used for this purpose? _____

Appendix continued

When does it occur (e.g., set periods of time during the day, contingent on completion of work throughout the day, at the end of the day)? _____

39. Rate the reading curriculum as to the degree of structure (i.e., the degree to which it is organized and sequenced and the degree to which the student and the curriculum can be easily matched).

Not Structured				Very Structured
1	2	3	4	5

40. Rate the mathematics curriculum as to the degree of structure.

Not Structured				Very Structured
1	2	3	4	5

For the following set of questions please respond to each question for reading and mathematics.

	Reading	Mathematics
41. Is there a systematic way of assessing student initial abilities built into the curriculum?	_____	_____
42. Does the teacher use it?	_____	_____
43. Is there an informal way which the teacher uses to assess student initial abilities?	_____	_____
44. If so, please specify.	_____	_____
45. Is there a systematic way of assessing student mastery of specific skills built into the curriculum (e.g., are tests provided)?	_____	_____
46. Does the teacher use it?	_____	_____
47. Who constructs the tests which are used to assess student learning (e.g., teacher, curriculum)?	_____	_____
48. At the completion of one unit of material, is it clear what the next unit should be?	_____	_____
49. Does the teacher have to skip around in the sequence or text?	_____	_____

Appendix continued

	Reading	Mathematics
50. Does the teacher use his/her own sequencing of material which is different from that of the curriculum?	_____	_____
51. Who decides on what skill or concept the student will work (e.g., teacher, curriculum child)?	_____	_____

52. If a student does not pass a test, what does the teacher usually do?

a. Tutor
b. Give special work
c. Continue on
d. Give extra homework
e. Other, please specify _____

53. If a student has been working for several days on a difficult concept or skill and seems to be making no progress toward mastery, what does the teacher do? _____

54. Please describe very briefly the way in which you teach children to decode words in early reading. For example, you may use sight words, phonetic sounding-out, blending, rhyming, and so on. _____

55. Since the beginning of this school year, how many students have transferred into your room? _____

56. Since the beginning of this school year, how many students have transferred out of your room? _____

Appendix continued

57. List the assignments in reading for today.

Level	Unit	Skill	Date of Last Test Given	Did the Student Pass This Test?	Assignment Pages

58. List the assignments in mathematics for today.

Level	Unit	Skill	Date of Last Test Given	Did the Student Pass This Test?	Assignment Pages