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STUDENTS' POTENTIAL FOR LEARNING CONTRASTED UNDER TUTORIAL AND GROUP APPROACHES TO INSTRUCTION

A DISSERTATION SUBMITTED TO
THE FACULTY OF THE DIVISION OF THE SOCIAL SCIENCES
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BY
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Larry Hedges and Betsy Becker guided me in the meta-analytic techniques employed throughout this work.

John Bormuth reminded me that evaluation is more than testing and that a formal investigation of the achievement profiles would elucidate the effects of the treatments over time.

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CHAPTER I

INTRODUCTION

Of all the problems facing education today, the most lamentable is that many students do not achieve to their full potential. One reason for low achievement is rooted in the traditional practice of teaching learners in large groups. Under conventional instruction, the teacher's time and attention are so divided among a group of students that the specific needs of most students are not met. On every learning task, some students in the group need more time and extra attention, time and attention which the teacher simply can not provide. On every learning task, students who do not get sufficient help are likely to develop errors. And by the end of a series of tasks, the learning of most students is so full of errors that their achievement is far below their potential.

Several approaches attempt to minimize students' errors in learning by supporting particular learning needs. For example, Computer-Assisted Instruction provides unending drill; Mastery Learning provides systematic feedback and correction (Bloom, 1976); Advance Organizers provide introductory cues to the main points of each lesson (Ausubel, 1963); and Keller's Personalized System of Instruction provides the reinforcement of allowing students to proceed at their own pace (Keller, 1968).

Using methods for research synthesis, we can compare students' potential for learning under these different approaches. Under the most effective of them, Mastery Learning, the average student typically achieves at a level above approximately 80 percent of the students who learned under conventional instruction. Clearly, this is the development of students' potential to quite a high level.

The thesis of this work is that students' potential for learning can be developed to even higher levels, provided that the quality of the instruction becomes optimal -- not as the instruction becomes optimal for the learners as a group, but as the instruction becomes optimal for individual learners. The distinction is basic for this research. The reason for this distinction becomes clear when we contrast tutoring and conventional instruction in the light of notions of instructional quality drawn from two major theorists of school learning.

For John Carroll, the essence of instruction is the communication of the learning to the learner (Carroll, 1963). For Benjamin Bloom, the essence of instruction includes not only the communication, but also the management of the learning: Learning should be managed so that everyone participates, everyone is praised and encouraged, and everyone's errors are corrected (Bloom, 1976).

The notions of Bloom and Carroll about instructional quality help explain the disadvantages for individuals when learners are taught in groups. In Carroll's terms, under group instruction the learning could hardly be communicated adequately to everyone. In Bloom's terms, under group instruction the learning could neither be communicated adequately nor managed adequately, since not everyone could understand the main points, not everyone could participate actively, not everyone could be rewarded, and especially, not everyone's errors could be corrected. In contrast, tutoring could be optimal instruction, since the tutor's time and attention flow uninterruptedly to individual learners. In Carroll's terms, under tutoring the learning could be communicated adequately to everyone. In Bloom's terms, under tutoring everyone could understand the main points, be rewarded, participate actively, and especially, everyone's learning could become error-free.

The focus of this research is on the quality of the instruction. We define the instructional quality as the degree to which the instruction is adapted to the specific needs of each student. We conceptualize instructional quality as a continuum, with conventional group instruction at the "low" end and tutoring at the "high" end. This research examines students' cognitive development, affective development, and processes of learning under three qualities of instruction: tutoring, Mastery Learning, and conventional instruction.

As we operationalize conventional instruction, it represents the most common classroom environment -- teachers lecture and lead discussions, and students participate in learning tasks as members of a group. We examined conventional instruction to estimate a "baseline" for instruction which does not meet the needs of individual learners. We examined tutoring to examine the theoretically "optimal" quality of instruction. We examined Mastery Learning to compare the effects of "optimal" instruction against enhanced, yet group-based instruction.

This research addresses five major questions. The first is whether students' achievement is determined by the quality of the instruction: Does tutoring produce the greatest achievement, followed by Mastery Learning and then conventional instruction? The second question is about the affect of students who experience different qualities of instruction: Do students who receive superior instruction and subsequently achieve at a high level feel more positive about themselves and their learning than students who receive less efficacious instruction and subsequently achieve at a lower level?

Bloom (1976) has advanced the interesting hypothesis that achievement need not be determined by ability or intelligence: "What any person in the world can learn, almost all persons can learn if provided with appropriate prior and current conditions of learning." The third research question examines that proposition: Do students of similar aptitude learn to a similar level no matter what the quality of the instruction they receive? Or do students who receive superior instruction outperform students of equal aptitude who receive less effective instruction? And when the instruction meets the needs of individual learners, do learners of low aptitude achieve as much as learners of high aptitude? Evidence which answers these questions positively supports the notion that school achievement is not predetermined by aptitude or intelligence, but is alterable when instruction is adapted to the needs of individual learners.

The fourth question is whether differences between the treatments in achievement are related to differences in students' learning processes. Are students receiving superior instruction more actively involved in learning, do they process instruction more effectively, and do they learn faster than students receiving conventional instruction?

In comparing rates of learning under the different qualities of instruction, we will also compare their efficiency. Until this research, there was little evidence to demonstrate that superior instruction is efficient -- efficient in that the return in achievement is satisfactory for the additional investment in time which may be required.

The fifth question compares retention of achievement under different qualities of instruction: Do students who experience instruction which is adapted to their needs retain more of their achievement than students who experience less favorable instruction?

These guiding questions were addressed in three experimental replications, divided between two sites. At the first site, the study involved approximately 170 fourth and fifth graders. At the second site, the study involved approximately 108 fifth graders.

The subject taught in this research was probability. Probability was chosen because it was a new topic for the students in our sample, because attractive commercial materials were available, and because a technical, sequential subject was appropriate for studying lower and higher mental processes.

This research is important on both theoretical and practical levels. Because it included the range of the instructional "continuum" from conventional to optimal, this research provides a statistical "ruler" to evaluate the effectiveness of any instruction. Because students' use of time was carefully monitored, this research determined not only the effectiveness, but also the efficiency of enhanced instruction. Because it examined the relationship between students' antecedent characteristics and their performance, this research determined whether performance in school is alterable by improved instruction or fixed by static traits such as aptitude.

On a practical level, this research was important because it addressed possible remedies for the lackluster achievement which for many students is so common today. We did this by examining instructional quality, which is controllable by societies willing to invest the necessary resources. We must emphasize that it was not our purpose to suggest that all instruction should be tutorial. Despite its great potential, tutoring has been used more for remedial than for primary instruction. This has happened because large-scale tutoring by professionals or para-professionals would demand huge investments in financial, logistic, and management resources. Rather, the purpose of this research was to point a new direction for education, to demonstrate that, when instruction is adapted to each student's specific needs, students' potential for learning reaches very high levels.

CHAPTER II

LITERATURE REVIEW

The conceptual framework of this research was derived, with some modification, from Bloom's (1976) theory of school learning. Bloom attributes individual differences in school learning to three main variables: cognitive entry behaviors, affective entry characteristics, and the quality of the instruction.

Cognitive Entry Behaviors

To each school task students bring certain abilities, skills, and knowledge. These traits comprise the students' cognitive entry behaviors for a new learning task. There are two levels of cognitive entry behaviors: generalized and specific. General mental ability is a global trait which relates to many kinds of thinking and relates especially well to the kinds of thinking demanded in school learning -- using concepts, and understanding and manipulating both verbal and quantitative symbols. Thus general mental ability predicts school achievement quite well. For example, over many studies intelligence has been found to correlate about .50 with achievement (Lavin, 1965).

Students bring, to every new learning task, behaviors which are appropriate specifically to that task. These specific cognitive behaviors include the knowledge and the skills developed in previous study of a particular subject or related subjects. Since much of school learning is sequential -- skills from previous tasks are needed to learn subsequent tasks efficiently -- specific cognitive entry behaviors predict achievement quite well. Over many studies, achievement on one task has been found to correlate about .70 with achievement on the next task (Bloom, 1976; Froemel & Leyton, 1980).

Specific cognitive entry skills are alterable by instruction. Perhaps the most successful example of this is Mastery Learning, where periodic feedback and correction make students well-prepared for each new task (Block, 1970; Arlin, 1973; Anderson, 1973; Ozcelik, 1974; Levin, 1975; Lee, 1979).

Recent work suggests that, when students are appropriately prepared for each new task, their achievement depends less on their general mental ability. Froemel (1980) contrasted 8 Mastery against 8 conventional classes over six months. In the conventional classes, over the semester the correlation between ability and achievement remained almost constant. In contrast, under the Mastery classes, the correlation between ability and achievement steadily decreased. The difference between the Mastery and the conventional instruction was that periodic feedback and correction prepared the Mastery students well for each new task, while the conventional instruction did not prepare most students well for each new task. Froemel's results demonstrate that, even though general mental ability is itself relatively stable after age 10 (Bloom, 1964), it does not determine the achievement of students who receive superior instruction.

This research adds another dimension to knowledge of how superior instruction reduces the influence of stable traits like intelligence on achievement. Previous research contrasted Mastery and conventional instruction. This research included tutoring, which should prepare most students very well for each new task. If under superior instruction achievement becomes less determined by general mental ability, then the goal of schooling should be to bring all learners -- no matter what their aptitude or intelligence -- to satisfactory levels of achievement.

Affective Entry Characteristics

In addition to their cognitive skills, to every learning task students bring a constellation of attitudes, interests, and self-concepts. These traits comprise the students' affective entry characteristics for a given task. Like cognitive entry behaviors, affective entry characteristics may be generalized or specific. Generalized affective characteristics include students' interests, attitudes, and self-concepts regarding learning in general. Specific affective characteristics include students' interests, attitudes, and self-concepts with regard to specific subjects and learning tasks.

Just as students' cognitive skills determine how well prepared they are for a given task, their affective characteristics determine how strongly motivated they are for a given task. Students are strongly motivated when they are confident that their learning will be successful and rewarding, and when they are interested in their learning and want to learn more.

Students' Affect And The Quality Of The Instruction

It is likely that students' motivation for new learning is largely determined by their learning history. Kifer (1973) explored the relationship over grades 1 through 8 between academic performance (measured by teacher's grades) and academic self-concept (measured by the Brookover Self-Concept of Ability Scale). Kifer compared the academic self-concept of students in the top fifth of their class with the academic self-concept of students in the bottom fifth of their class. The difference in academic self-concept between the more successful and the less successful students was very small in the early grades. However, by the later grades the difference had become dramatically more pronounced. Kifer's results imply that students who are frustrated by unsuccessful learning over a long time develop negative concepts of themselves as learners. In contrast, students who are rewarded for successful learning over a long time develop positive concepts of themselves as learners.

Although Kifer's samples were cross-sectional, his results are consistent with comparisons of Mastery and conventional instruction within-grades. This research has shown that, over a series of learning tasks, students' interest, attitudes, and confidence improve as their achievement improves (Block, 1970; Arlin, 1973; Anderson, 1973; Ozcelik, 1974; Levin, 1975).

In addition to this experimental evidence, there is abundant correlational evidence about the strength (if not the direction) of the relationship between motivation and achievement. From his review of 122 correlations from 22 studies published between 1953 and 1974, Bloom (1976) estimated that affect correlates up to .50 with achievement, depending on the measures of affect and the age of the sample. Uguroglu and Walberg (1979) reviewed Bloom's evidence plus 110 correlations from 18 more recent studies. They report that the mean correlation between motivation and achievement is about .34 and is stronger in the later grades than in the earlier grades. This is consistent both with Bloom's evidence and with Kifer's finding that repeated experience of success or failure determines motivation.

The research reviewed above demonstrates that the quality of the instruction affects students' achievement, that students' achievement affects their motivation, that students' motivation affects their achievement, and that under superior instruction students' aptitude and intelligence no longer determine their achievement. It is clear that there are complex and reciprocal causal interactions between cognitive abilities, cognitive achievement, affective characteristics, and instructional quality. It was not our purpose to tease out these interdependencies. This research treated students' cognitive and affective development as a function of the quality of the instruction. Even though we did not test the more complex relatonships, we refer to them throughout this work in order to more fully describe the course of learning under the different instructional conditions.

This research tested the degree to which superior instruction produces superior achievement. We also tested whether students under superior instruction develop significantly more positive afffect towards their learning than students under conventional instruction.

Quality Of Instruction

The thesis of this research is that students' achievement is determined by the quality of the instruction. But by what criteria should we evaluate the quality of the instruction? For instance, are elaborate, expensive facilities and highly paid, experienced teachers necessary for high-quality instruction? Bloom (1976) reviewed studies of the relationship between students' achievement and the characteristics of teachers, classrooms, and schools -- characteristics such as the age, experience, and salary of teachers; and the size, facilities, and expenditures of schools. Bloom found that the professional qualifications of teachers and the financial and physical characteristics of schools contribute relatively little to students' achievement. This suggests that the quality of the instruction lies in the interaction between the teacher and the student.

Focussing on the interaction of the teacher and the student, Carroll (1963) theorized that the quality of the instruction depends on how well the learning is communicated to the learner. Bloom (1976) theorized that instructional quality includes both the communication and the management of the learning. For Bloom, the model for the most effective "management of learning" is an excellent tutor interacting with a single student. From his observations of tutoring, combined with the learning theory of Dollard and Miller (1950), Bloom formulated instructional quality in terms of four components: cues, participation, reinforcement, and feedback and correction.

This research adopted Bloom's (1976) definition of instructional quality as the degree to which these four components are adapted to the specific needs of each learner.

In what follows, we demonstrate the educational importance of these components by contrasting, in general terms, the teacher's management of each component for a group of learners with the tutor's management of the same component for an individual learner. Especially for the first three components, the following discussion draws heavily on the work of Sophie Bloom (1976).

Cues

Instructional cues indicate what are the main points of each lesson and what the students must do in learning them. Cues may be presented in many forms: verbal instructions from the teacher, printed information from learning materials, or words and pictures from audio/visual displays. But no matter how cues are presented, if the instructional message is to be communicated adequately, the cues must be intelligible to the learners. There are a number of reasons why instructional cues may be unintelligible -- they may not be seen or heard clearly, or they may not fit a particular student's learning style. In any case, providing intelligible cues to each learner poses a severe challenge for the teacher's management of group instruction.

Cues In Group Instruction

Both when they plan and when they manage instruction most teachers are quite aware of the needs of their students. Teachers try to select instructional material which is informative and appropriately difficult for their students; they also present lessons at a pace and level appropriate for those students. Furthermore, most teachers take care to communicate the learning task effectively -- they repeat when students misunderstand the instructional cues and they try to find alternate cues when the original cues are not helpful.

Despite the teacher's best efforts, the fact that instruction takes place in a group inevitably means that the learning is not communicated ideally for each student. Because of individual differences in learning styles, cues which work well for one learner may not work well for others (Cronbach and Snow, 1976). And faced with a group of learners, the teacher does not have time to tailor cues for individual learners. As a result, under group instruction some learners are bound to misunderstand the main points of each lesson.

Cues In Individualized Instruction

From repeated interaction with an individual student, the tutor comes to know what sort of cues are most appropriate for that student's learning style. The tutor can then lead the student through a task step-by-step. If the student hesitates, the tutor can repeat the lesson, or furnish additional materials or exercises chosen specifically for the student. As a result, it is likely that each tutored student will understand the main points of each lesson.

Participation

In order to fix the main points of each lesson firmly in their minds, students must participate actively during instruction. This participation may be overt or covert. Active overt participation includes behaviors such as reading aloud or solving problems at the board; active covert participation includes behaviors such as reading silently or attending to anothers' recitation. In all these cases the student is actively engaged in learning the task.

Participation In Group Instruction

Teachers manage the participation of groups of learners in a number of well-tried ways. For example, the teacher may lead a discussion or set the class to written work. But housekeeping and organizing the group rob a considerable amount of time from instruction. Kemmerer (1980) described several studies indicating that 12 to 15 percent of class time is spent on non-instructional matters (Gump, 1967; Grannis, 1978; Garner, 1978). Goodlad (1983) reports that non-instructional matters occupy 25 to 30 percent of class time. However, even when instructional activities are under way, they are frequently dominated by teachers who do not allow sufficient opportunity for most students to participate actively. This typical situation is succinctly described by "Flanders' Rule of Two-Thirds": Two-thirds of the time in classrooms in spent in talking, and two-thirds of that talking is done by the teacher (Flanders, 1965).

<u>Participation In Individualized Instruction</u>

The tutored student is not competing against a number of other students for the teacher's time and attention. As a result, tutoring offers a double benefit for the student. Each student can participate as much as necessary to learn the task. And more importantly, this participation, which is specifically chosen for an individual's learning style, is at all times under the close supervision of the tutor.

Reinforcement

It is well known that events subsequent to a response determine in some degree whether or not that response is learned. In the terminology of learning theory, this phenomenon is known as the "Law of Effect". The driving force behind this law is the principle of reinforcement. In order to be a reinforcement, an event must occur subsequent to a response and increase the probability that the response will occur again.

Whether or not they recognize a formal statement of the principle of reinforcement, teachers have several different ways of reinforcing their students. Teachers provide posiive reinforcement by rewarding students' successful efforts, with the expectation that the reward will spur further successful efforts. Or teachers provide negative reinforcement by calling the students to task for not participating or for misusing the instructional cues, with the expectation that the admonishment will spur further successful efforts.

Reinforcement In Group Instruction

In the world according to Skinner (1954): "Perhaps the most serious criticism of the current classroom is the relative infrequency of reinforcement." While many might agree, few would take the next step with Skinner, who argued that the teacher is "out of date" as an instrument of reinforcement -- and therefore, reinforcement has to come from "teaching machines". Skinner's remedy aside, for several reasons reinforcing each student is a difficult problem in classrooms. In the first place, the teacher must be sensitive to differences between students: What is rewarding for some students may be neutral or unpleasant for others (White, 1959; Rosenhan, 1966; Havighurst, 1970). In the second place, even if the teacher knew what was reinforcing for each student, when there are many students it is impossible to reinforce each one.

Many children do not interact favorably with the teacher for reasons that have little to do with the number of the children in the class or the teacher's uncertainty about how to reinforce each one. Research has shown that high-achieving students receive more praise and support than low-achieving students (Brophy and Good, 1970; Good, 1970; Good, Sikes, and Brophy, 1973). This is doubly unfortunate because abundant evidence indicates that students achieve more when teachers praise and encourage them (Page, 1958; Cantrell, Stenner, Jackson, and Katzenmeyer, 1977; Frederick, Walberg, and Rasher, 1979).

Reinforcement In Individualized Instruction

A tutor readily assesses what is rewarding for each learner. Since the tutor's attention is not divided among a group of learners, the tutor can immediately reinforce each correct response. Most importantly, the tutor rewards not just correct responses, but also active participation. As a result, under tutoring learning can become both effective and enjoyable.

Feedback And Correction

Cues, participation, and reinforcement: these are the elements which, when managed appropriately for individual learners, breathe the life of learning into the instruction. But even when instruction -- whether group instruction or individualized instruction -- manages "CPR" effectively, some students will still develop errors in their learning. Unless these errors are corrected they will carry-over to the next learning task. When this happens, the "CPR" which should be devoted entirely to helping the students master the new learning task must instead be modified to overcome their errors from previous learning. To prevent errors from accumulating, a system of feedback and correction must be available for each learning task.

Feedback and Correction In Group Instruction

In group instruction, only the students who communicate to the teacher that they need help are likely to get correction. Probably, most students are unaware that they do not completely understand the task; for this reason many do not ask for help. But even if every learner who did not understand the task sought help, the teacher would not have time to help them all.

Of several attempts to improve feedback and correction in the group environment, the most successful has been Mastery Learning (Bloom, 1976; Block and Burns, 1977). In Mastery Learning, students receive feedback and correction at the end of each instructional unit. Largely as a result of this feedback and correction, Mastery students tend to achieve at higher levels than students who do not receive periodic feedback and correction.

Feedback and Correction In Individualized Instruction

Individualized instruction has an advantage over Mastery Learning: Where Mastery students receive feedback and correction at the end of each instructional unit, students in individualized instruction receive continual feedback and correction. The tutor corrects errors as soon as they occur during learning. Together with the more systematic feedback and correction based on the formative tests, this continual correction helps the learning of tutored students to be nearly error-free.

Research On The Quality Of Instruction And Students' Cognitive Achievement

The Meta-analysis Of Research On Instruction

In recent years, techniques have been developed for the quantitative synthesis of research. Here we discuss certain empirical techniques for combining the results from multitudinous studies of some treatment into a single, quantitative estimate of the "Effect-Size" for that treatment. These techniques, called "meta-analysis", generally follow the direction pointed by Glass (1976) and used by him to review the effects of psychotherapy (Smith and Glass, 1979) and class-size (Glass and Smith, 1979; Smith and Glass, 1980).

Since the notion of "Effect-Size" is used extensively throughout this work, we will briefly describe the derivation and interpretation of the "Effect-Size" estimator.

We are interested in a single estimator of the "Effect-Size" of a treatment, a treatment which has been the subject of a series of independent experiments. For a given experiment, let $\bar{Y}_E$ and $\bar{Y}_C$ be the outcome means for the experimental and the control groups, and let S_C be the sample standard deviation of the control group. Then the estimate of the "effect-size" for that experiment is given by:

$$E.S. = \frac{\overline{Y}_E - \overline{Y}_C}{S_C} \quad .$$

And the "Effect-Size" for the treatment is simply the average of the "effect-sizes" for each of the experiments in the series.

The "Effect-Size" is a standardized mean difference. As a result, its interpretaion is straightforward. Suppose we have averaged the effect-sizes of each of a series of experiments and have obtained an Effect-Size of 1.13 for that treatment. For an Effect-Size of 1.13 we read the corresponding percentile rank of 87 from a table of the unit normal distribution. This implies that the average individual who received the treatment is at the 87th percentile of the control group.

Cohen (1977) has suggested that there is an arbitrary, yet enlightening classification of Effect-Sizes into "small", "medium", or "large". "Small" Effect-Sizes (.2) are the magnitude of the difference between the IQ's of twins and nontwins, or between the heights of 15 and 16 year old girls. "Medium" Effect-Sizes (.5) are the magnitude of the difference between the IQ's of clerical and professional workers, or between the heights of 14 and 18 year old girls. "Large" Effect-Sizes (.8) are the magnitude of the difference between the IQ's of PH.D. graduates and typical college freshmen, or between the heights of 13 and 18 year old girls.

Other researchers have trained meta-analytic guns on various efforts to improve achievement: Block and Burns (1977) meta-analyzed Mastery Learning; Luiten, Ames, and Ackerson (1980) meta-analyzed Advance Organizers; and Kulik, Kulik, and Cohen (1978) meta-analyzed Keller's Personalized System of Instruction. In addition, Cohen, Kulik, and Kulik (1982) meta-analyzed studies of tutoring, and Lysakowski (1981) and Lysakowski and Walberg (1980) meta-analyzed studies of the relationship between achievement and the components of instructional quality.

These meta-analytic reviews have two important applications to this research. In the next section, we will use them to evaluate the evidence, over hundreds of studies, for the notion of instructional quality which we have developed in this research. And secondly, we will use meta-analytic results to compare tutoring aainst various approaches.

Meta-analytic Evidence For The Notion Of Instructional Quality Used In This Research

To evaluate our notion of instructional quality, we compare the meta-analyses of the two instructional conditions examined experimentally in this research (Mastery Learning and tutoring) and two other approaches to improving instruction which are not examined experimentally in this research (Advance Organizers and Keller's Personalized System of Instruction).

Following Bloom (1976), this research emphasizes four components of instruction: cues, participation, reinforcement, and correction. We define instructional quality as the degree to which these four components are adapted to the speciifc needs of individual learners. Quality of instruction may be conceptualized as a continuum, with instruction in which the needs of individuals are not met at the "low" end and instruction which better meets the needs of individuals at the "high" end.

Under <u>conventional</u> group instruction, the students' needs for instructional cues, active participation, praise and encouragement, and feedback and correction can hardly be met by a harried teacher who must manage instruction for a large group of learners. Consequently, conventional instruction represents the "low" end of the quality of instruction continuum.

Under <u>Mastery Learning</u>, instruction is similar to conventional instruction, with the exception that Mastery Learning provides periodic feedback and correction. On the strength of this enhancement, achievement under Mastery Learning has usually proven superior to achievement under conditions where there is only haphazard feedback and correction.

<u>Tutoring</u> is not an instructional program, in the sense that Advance Organizers, Keller's PSI, and Mastery Learning are instructional programs. These are programs because they prescribe how the teacher should behave. Rarely is a system of instructional behaviors prescribed in tutoring: Tutoring is simply an arrangement for the instruction of one or a very few learners. So while tutoring offers a unique opportunity for instruction -- cues, participation, reinforcement, and correction may be enhanced for individual learners -- at the same time it poses a conceptual problem for meta-analysis. Tutoring situations probably differ more than say, Mastery Learning situations. Tutors may be trained or untrained; tutors may be peers, cross-age, professionals, or para-professionals; tutoring may be brief or long; tutoring may be a substitute for, or a supplement to, classroom instruction.

In this discussion, we can not account for all the different guises tutoring may assume. Here, tutoring is represented by a sample of 12 studies which reported results on locally-constructed instruments. We will assume, for the discussion, that these studies represent reasonable implementations of tutoring.

<u>Advance Organizers</u>, as proposed by David Ausubel (1963), are written or spoken introductions which highlight the main points of the lesson to be learned. In the framework of this research, Advance Organizers correspond to

instruction enhancing only cues. We predict that instruction using Advance Organizers should be more effective than conventional instruction. But Advance Organizers do not correct errors that arise during learning. Thus we predict that Advance Organizers should be less effective than Mastery Learning and tutoring.

In the Personalized System of Instruction (PSI), developed by Keller (1968), students work at their own pace through "programmed" learning materials (this is one sense in which PSI is truly "personalized"). In PSI, students take a diagnostic test at the end of each instructional unit. PSI students are not permitted to begin the next instructional unit until they master the previous unit at the assigned level.

The PSI system of correction is, however, in no way "personalized". In PSI, students are directed to restudy the same material which they missed on the diagnostic test. And despite the availability of "proctors", their formal role is not to tutor, but to supervise testing. This is a weaker system of correction than is typically found in Mastery Learning, where correction deals systematically with the errors revealed by the diagnostic test. All in all, we predict that PSI should be less effective than tutoring and Mastery Learning. But because PSI does provide feedback, it should be more effective than Advance Organizers and conventional instruction.

Our definition of instructional quality suggests a specific order of effectiveness (from low to high) for these programs: conventional, Advance Organizers, PSI, Mastery Learning, and tutoring. The comparison of the meta-analyses of these programs is shown in Table 1.

TABLE 1

META-ANALYTIC COMPARISONS OF SEVERAL INSTRUCTIONAL PROGRAMS WITH CONVENTIONAL GROUP INSTRUCTION

	ADVANCE ORGANIZERS	KELLER'S PSI	MASTERY LEARNING	TUTORING
MEAN EFFECT SIZE	.21	.49	.83	.84
NUMBER OF COMPARISONS	110	61	73	12
PERCENTILE RANK	58	69	80	80
TREATMENT EFFECT	SMALL	MEDIUM	LARGE	LARGE

The effect size of .49 for PSI estimates that, under PSI, the average student achieves at a level .49 of a standard deviation above the average student who receives conventional instruction. The corresponding percentile rank of 69 indicates that the average PSI student outperforms 69 percent of students who receive conventional instruction.

Table 1 suggests that the programs are effective to the degree that they fit the definition of instructional quality developed in this work. It is particularly interesting that the "Personalized" system is less effective than Mastery Learning, a group-based approach. Furthermore, the increase is strikingly linear from conventional through AO through PSI through ML. This regularity is consistent with the "quality" of the first three programs -- they enhance unique components of instruction.

The result for tutoring is a surprise. We might have expected that the effect of tutoring would be a very large "step" above the group-based programs. But according to these results, tutoring has not been more effective than Mastery Learning. Upon reflection, we can see that this is consistent with our notion of instructional quality. We insist that the quality of the instruction depends not on the size of the group, but on how well the instruction meets each learner's specific needs for cues, reinforcement, participation, and feedback and correction. There is an indication in the meta-analysis of tutoring that some of the tutors were trained, but it is not clear that they were trained to enhance the dimensions of instruction which we consider most crucial.

This analysis ignored questions of affect, efficiency, and expense. As a result, the rankings of these programs by effect-size are in no sense absolute. The purpose of this analysis was to indicate that the notion of instructional quality developed in this work is empirically supported in several hundred studies.

Meta-analytic Evidence Concerning The Components Of Instrutcional Quality

The preceeding analysis provided strong, but indirect, evidence that our notion of instructional quality is valid. Direct evidence comes from meta-analyses by Lysakowski (1981) and Lysakowski and Walberg (1980). These authors reviewed studies contrasting conventional group instruction with instruction enhanced by one of the components -- cues, participation, reinforcement, or correction. Their results are displayed in Table 2.

TABLE 2

META-ANALYTIC COMPARISON OF CONVENTIONAL GROUP INSTRUCTION WITH INSTRUCTION ENHANCED IN SINGLE COMPONENTS

	PARTICI-PATION	CORRECTIVE HELP	REINFOR-CEMENT	CUES
MEAN EFFECT SIZE	.88	.94	1.17	1.28
NUMBER OF STUDIES	22	20	39	17
PERCENTILE RANK	81	85	88	90
TREATMENT EFFECT	LARGE	LARGE	LARGE	LARGE

Table 2 suggests that achievement can be substantially improved by enhancing any one of the components of instruction. However, this analysis gives no indication of the benefits of enhancing several of the components simultaneously.

Nordin (1979) tested the effects of enhancing the components of instruction singly and in combination. Nordin assigned 328 sixth-grade Malaysian students to study math under four conditions: control, enhanced cues, enhanced participation, enhanced cues and participation, or feedback and correction. The control group was surpassed by all the groups in which the instruction was enhanced. To be consistent with the previous analyses, we present the effect-size for each enhancement examined in Nordin's experiment. These are given in Table 3.

TABLE 3

EFFECT-SIZES FOR ENHANCED INSTRUCTION FROM NORDIN'S STUDY

	CUES	PARTICIPATION	CUES + PARTIC	CORRECTIVE HELP
EFFECT SIZE	1.41	1.32	1.54	2.18
PERCENTILE RANK	92	91	94	99
TREATMENT EFFECT	LARGE	LARGE	LARGE	LARGE

Tables 2 and 3 demonstrate that achievement can be improved by training teachers to enhance even one component of instruction. In training tutors, this research adapted many of the techniques used by Nordin.

All the evidence in this section demonstrates that enhancing the quality of group instruction improves achievement. This research went further: By training tutors to adapt cues to each learner's needs, to praise and encourage each learner, to keep each learner participating actively, and to correct each learner's errors, this research estimated the effect of truly "individualizing" instruction.

Instructional Quality And Students' Retention Of Cognitive Achievement

Educational research has looked closely at final achievement under different instructional conditions and less closely at retention of achievement under different instructional conditions. Block and Burns (1977) reviewed 7 studies which examined retention of cognitive achievement under Mastery and non-Mastery conditions. These 7 studies contained 20 comparisons of Mastery vs. non-Mastery instruction. In 11 comparisons, the Mastery students retained significantly more than the non-Mastery students. In the other 9 comparisons, the Mastery students retained somewhat more than the non-Mastery students, but these differences did not reach statistical significance. In any event, these results suggest that when students are brought to high levels of final achievement that achievement is retained at high levels.

Few studies have examined the levels of the cognitive skills retained under different instructional conditions. Poggio (1976) retested over 250 college students every 3 months for a year and a half; some of these students had learned under a mastery approach and others under a lecture-oriented non-mastery approach. Poggio found that the mastery students retained significantly more knowledge skills than the non-mastery students, but not more higher order skills than the non-mastery students.

In their review of the effects of tutoring, Cohen, Kulik, and Kulik (1982) do not include retention among the outcomes examined.

It is unfortunate that the effects of instructional conditions on retention have been ignored to this degree, for it is often not difficult to incorporate a test of retention into research on instructional effects. But more importantly, the increased expense of enhanced instruction must be justified by demonstrating continuing benefit.

This research examined retention of lower and higher mental processes under different instructional conditions. The unique contribution of this research is that it examined the development of lower and higher mental processes under instruction which was adapted to the specific needs of each student.

Instructional Quality And Students' Learning Processes

Over the past twenty years, the paradigm which explains school learning has come to be dominated less by models which focus on the characteristics of students, teachers, and schools and more by models which focus on the processes by which students learn. If we examine the characteristics of these models, we can understand why the paradigm changed.

The Production-Function Model

Following the publication of the Coleman Report (1966), many educational researchers became enamored with the "production-function" model of school achievement. In the production-function model, "inputs" (characteristics of students, families, peers, teachers, and schools) are transformed, through a process which is never specified, into "outputs" (affect, achievement). The goal of a production-function analysis is to identify "inputs" which account for significantly large amounts of "output" variance.

This goal has not often been realized. For example, characteristics of teachers rarely account for even as much as 5 percent of achievement variance (Bloom, 1976). This low explanatory power is partly a mathematical artifact of analyzing correlated independent variables. But even if production-function analyses consistently identified "inputs" which account for large proportions of achievement variance, a satisfactory explanation of school learning could never rest on this approach. In ignoring the mechanisms which transform "inputs" to "outputs", the production-function approach treats the student as a "black-box".

Participation Models

Even though the production-function approach ignored students' learning processes, these processes have been investigated since the early part of this century. In his review of research on students' learning processes, Hecht (1977) reports that, beginning in the 1920's and for two decades after, there were numerous studies of students "attention" (Morrison, 1927; Bjarnason, 1925; Symonds, 1926; Blume, 1929; Gray, 1929; Long, 1927; Knudson, 1930,; Brueckner and Ladenberg, 1933; Edminston and Braddock, 1941; Shannon, 1942). This early research assumed that students' total "attention" was desirable and related students' "attention" to characteristics of teachers and classrooms. However, in many cases this research did not relate students' "attention" to their achievement (Jackson, 1968).

Bloom (1954) examined the relationship between students' achievement and specific kinds of students' "attention". He examined how 45 college students participated -- both "overtly" and "covertly" -- in classroom activities. "Stimulated-recall" procedures were used to estimate what proportion of the students' thoughts during class were relevant to the topic being discussed. This measure of "covert" participation correlated .61 with achievement. "Overt" participation was estimated from the instructor's rating of the extent and quality of the students' participation in the activities of the class. These correlated .57 and .67 with achievement. Bloom's study demonstrated that mental and physical participation are both important during instruction.

Models For Use Of Learning Time

Bloom's study and the earlier studies of "attention" examined students' participation. A new direction for examining the relationships between students' achievement and their use of instructional time was pointed by the John Carroll's (1963) theoretical model of school learning.

Carroll proposed that school achievement is best understood as a function of two parameters: the time a student needs to learn some task and the time the student actually spends in learning it. Subsequently, research began to examine students' use of time under different instructional conditions and to relate differences in achievement to differences in how time was used. This research investigated two aspects of the relationship between instructional conditions and use of time. The first was whether students are more actively involved under some instructional conditions than others, and whether students who are more actively involved achieve at higher levels than students who are less actively involved. The second was whether a given task is learned faster under some instructional conditions than others. The first issue is about "time on-task" under different instructional conditions. The second is about rates of learning under different instructional conditions.

In the early 1970's, these issues were investigated in a series of studies (Block, 1970; Arlin, 1973; Anderson, 1973). These studies monitored achievement and use of instructional time under "mastery" and "non-mastery" conditions. In the "mastery" conditions, students were not allowed to begin a new task until they learned the current task to a criterion. In the "non-mastery" conditions, students could proceed to the next task as soon as they had completed a prior task, no matter what their level of accomplishment for that prior task.

These studies are interesting, but also frustrating. The authors conclude that time is used more efficiently under mastery conditions -- mastery students are on-task more (Anderson), and mastery students learn faster (Arlin and Block). Furthermore, the authors relate differences in achievement under mastery and non-mastery conditions to these differences in use of time. But in these studies neither the experimental nor the control conditions were typical of most school environments. For example, all these studies were extremely brief (1-5 hours); Arlin taught "imaginary science"; Block's experimental samples were very small (11-14); and in Block's, Anderson's, and part of Arlin's studies instruction consisted of students working, at their own pace, through "programmed" instructional materials. In this research, we examined time on-task and rate of learning under realistic school conditions.

A different approach to studying students' use of instructional time was taken by researchers who adapted procedures from psychological "lab" studies of learning. In laboratory studies, achievement is measured frequently, and the rate of learning is estimated from curves fit to the (achievement, time) data points. Using these procedures, Kim (1968) fit a hyperbola and Pearson (1973) fit a parabola to describe rate of learning. However, school learning is a series of tasks of changing complexity and difficulty. As a result, these procedures are not appropriate for estimating learning rates in school. In this research, we develop appropriate procedures for expressing the relationship between students' achievement and the amounts of time they spend learning.

Instructional Processing Models

Hecht's (1977) study corrected some of the weaknesses in the earlier studies. Hecht conducted his study in a realistic school environment. His subject matter was the regular tenth-grade geometry curriculum and his experiment lasted about a month. Hecht assigned about 160 students to either a Mastery group, a "modified" Mastery group, or one of three control groups. The Mastery students were required to reach a criterion of 85 percent correct for each instructional unit. The "modified" Mastery students were not held to any criterion, and correction was optional. The control students were held to no criterion and received no systematic correction. They did, however, have review sessions.

Hecht examined students' achievement and their "instructional processing", by which he meant overt and covert time on-task, and use of cues, reinforcement, correction, and participation.

Hecht found that the quality of the students' "instructional processing" was strongly related to their final achievement. The correlation between final achievement and time-on-task was .69, and the correlation between final achievement and the behavioral measure of processing was .73. However, the time on-task and processing behaviors of the Mastery and the "modified-Mastery" groups were significantly superior to the controls only on the third unit. Furthermore, there were no significant differences in final achievement between the Mastery and the control conditions.

Nordin (1979) examined students' use of time, their learning processes, and their achievement in a study which examined the quality of the instruction in finer detail. Previous studies contrasted mastery vs. non-mastery conditions. Nordin contrasted conventional group instruction with four treatments: enhanced cues, enhanced participation, enahnced cues plus enhanced participation, and feedback and correction. These "enhanced" instructional conditions more or less correspond to the four elements which, according to Bloom (1976), determine the quality of the instruction.

Nordin found that students were on-task considerably more under enhanced instruction than under conventional instruction. It is interesting that the rank order of the groups for time on-task was identical to the rank order of the achievement of the groups. Nordin also found that students under enhanced instruction developed more effective processing behaviors than the students under conventional instruction. Students under enhanced instruction understood instructional cues better, participated more actively in the learning activities, and were far more active in correction than students under conventional instruction.

This research investigated whether tutored and Mastery students are on-task more and learn faster than students under conventional instruction. This research also investigated whether, right from the start, cues, participation, reinforcement, and feedback and correction would be significantly better under tutoring than under conventional instruction. Lastly, we investigated whether Mastery students use cues, participation, reinforcement, and feedback and correction better under group conditions.

A Conceptual Framework For Analyzing Students' Achievement In Relation To Their Use Of Instructional Time

This research analyzed the relationship between students' achievement and their use of time in a framework developed from John Carroll's (1963) theoretical model of school learning. This framework was much more comprehensive than those guiding previous research.

Following Carroll (1963), we express final achievement as the ratio of two time parameters:

degree of achievement = TIME SPENT/TIME NEEDED.

TIME SPENT is time spent actively learning. It can be calculated either as "clock-time" or as "time on-task". We will see the difference shortly.

TIME NEEDED estimates the rate of learning. It is expressed as:

TIME NEEDED = TIME SPENT/TEST SCORE.

When TIME SPENT is calculated as "clock-time", TIME NEEDED estimates the amount of clock-time needed to learn a task to a level of 100 percent, given the actual level of time on-task. This we call the CLOCK-TIME LEARNING RATE.

When TIME SPENT is calculated as amount of "time on-task", TIME NEEDED estimates the amount of time on-task needed to learn a task to a level of 100 percent. This we call the TIME ON-TASK LEARNING RATE. The difference between the two rates is that the former includes all instructional time while the latter includes only time spent actively learning. If different instructional conditions cause students to learn at different rates, there will be differences between the conditions in the average CLOCK-TIME LEARNING RATE and TIME ON-TASK LEARNING RATE.

This formulation of learning rate has conceptual as well as practical advantages. The practical advantage is that TIME NEEDED is computed from quantities which are both relatively easy to obtain and interesting in other contexts: test scores, records of elapsed time, and observations of time-on-task. The conceptual advantage is that TIME NEEDED estimates exactly what we want to know (or should want to know) to compare rates of learning under different instructional conditions. For a given instructional condition, TIME NEEDED estimates how long it would take students to learn a task completely.

We illustrate these ideas using Block's (1970) data. Block's best performing Mastery group averaged 64.9 percent correct on the posttest, and averaged 51.4 minutes in initial learning and 31.5 minutes in correction. The controls averaged 50.5 percent correct and 49.1 minutes in initial learning (by design the controls got no correction). We see at once that the Mastery group had about 70 percent more opportunity-to-learn (82.9 vs 49.1 minutes), but achieved only 30 percent more. We compute the CLOCK-TIME LEARNING RATE for the Mastery group: (82.9/.649 = 127.73), and for the control group: (49.1/.505 = 97.22). Taking the ratio, we see that the Mastery group was learning only .76 as much per unit of time as the control group.

It is clear that in Block's study the advantage of the Mastery group was due not to more efficient learning, but to the large additional investment in time spent on correction. Anderson's (1973), Wentling's (1973) and Levin's (1975) data show a similar pattern: Under Mastery Learning, the time spent for correction was greater than the gain in achievement.

This research sought to demonstrate that enhanced instruction (whether Mastery Learning or tutoring) can be efficient as well as effective. This can happen if initial instruction is extremely effective (as it can be under tutoring), and if feedback and correction can be managed quickly (as they can be under both tutoring and Mastery Learning). For example, Block's Mastery students spent about 60 percent more time in correction -- if correction had been completed in 20 percent rather than 60 percent more time, the Mastery students would have had the superior learning rate.

In some previous studies, students worked individually to correct their errors -- the inefficiency in this is obvious. In other studies, students worked cooperatively to correct their errors -- an admirable arrangement, but this too guarantees that correction will be inefficient. In this research, correction was paced and supervised by the instructors.

Higher And Lower Mental Processes

The *Taxonomy of Educational Objectives* classified the cognitive outcomes of instruction into six hierarchically ordered categories, categories chosen to reflect distinctions teachers made among students' behaviors (Bloom, Englehard, Furst, Hill and Krathwohl, 1956). The Knowledge level of the *Taxonomy* involves the identification of terms, facts, rules, or principles, or the use of these elements in solving familiar problems. Comprehension involves understanding the communication of an idea by, for example, being able to express the communication in another form. Knowledge and Comprehension are "lower" mental processes.

Application, Analysis, Synthesis, and Evaluation involve processes such as solving unfamiliar problems, developing proofs, or discovering patterns or structures. These are considered "higher" mental processes.

The construct validity of the *Taxonomy* has been investigated in many studies. These studies sought to demonstrate that comprehension depends on prior knowledge, application depends on prior comprehension as well as prior knowledge, and so on up the taxonomic hierarchy. We will treat these studies only briefly here. Kropp and Stoker (1966) presented data which largely supported the taxonomic structure. Madaus, Woods, and Nuttall (1973) reanalyzed the Kropp and Stoker data, and also reported results that supported the hypothesized hierarchy. But Seddon (1978) has raised methodological objections to the validity of these claims.

Recently, Miller, Snowman and O'Hara (1979) reanalyzed a subsample of Kropp and Stoker's data and rejected the simple hierarchical model in favor of a two-factor model. And most recently, Hill and McGaw (1981) applied Joreskog's method of analyzing linear structural relations to Kropp and Stoker's data, in an attempt to resolve the different interpretations of the structural properties of the data. Their analysis upheld the hierarchy, but suggested that knowledge is separate from the other categories. Their best-fitting model, a five-factor simplex, did not include Knowledge: Comprehension > Application > Analysis > Synthesis > Evaluation.

Despite the ingenuity of educational researchers in analyzing Kropp and Stoker's correlations, the hierarchical structure of the Taxonomy has not yet been confirmed statistically. However, the great value of the Taxonomy is not that it captures the absolute structure of knowledge, but rather that it shows clearly and compellingly the distinctions between students' cognitive behaviors. That much of the taxonomic structure has been confirmed: A good deal of research shows that the six taxonomic categories are distinct. Thus this research dichotomized cognitive achievement into lower (Knowledge and Comprehension), and higher (Application, Analysis, Synthesis, and Evaluation) mental processes.

Developing Higher Mental Processes Through Instruction

Several studies investigated the levels of the mental processes developed under mastery approaches. Morris and Kimbrell (1972) assigned 37 students in introductory psychology to a traditional lecture/discussion class, and 39 students to an experimental group. The experimental group was required to restudy material until a mastery criterion was reached. On the final exam, the experimental group scored slightly better in recalling and identifying concepts and principles, but significantly better in applying concepts and principles.

Levin (1975) assigned 100 9th graders to study probability under control or one of three mastery conditions. All three mastery groups were held to an 85 percent criterion of "rules knowledge" on the formative tests. Furthermore, two of the three mastery groups practiced solving problems which were selected to give more opportunity to learn higher mental processes. The Mastery group outperformed the control group on the application posttest. The Mastery groups which were given practice considerably outperformed the control group, and outperformed the Mastery groups which were not given practice. Interestingly, the correlation between math achievement and math ability, as measured by the National Educational Development Test Mathematics Usage subtest, decreased in the Mastery groups. Furthermore, the variance of application achievement was less in the Mastery groups than in the control group.

Using the instructional materials developed by Levin, Weber (1976) taught probability to 114 9th graders. In two Mastery classes, the teachers graded and returned formative tests; in one of those Mastery classes, the teacher led a discussion of items the students had missed. In two other classes, the students did not receive correction based on formative tests. On the application posttest, both Mastery classes were superior to the non-Mastery classes. In addition, the Mastery class where the teacher discussed missed items outperformed the other Mastery class. This suggests that there may be an advantage in having the teacher manage correction.

Block and Tierney (1974) divided 44 students of European historiography into three groups. The controls received traditional lecture/discussion instruction. The "redirected study" group received the traditional presentation, plus formative tests. These formative tests included both lower and higher cognitive items. For missed items, the students were given the correct answer along with directions to review the appropriate original material. The "small-group study" treatment received the traditional presentation and the same formative tests as the "redirected study" group. But here the formative tests were returned for scrutiny and discussion in small, cooperative study groups. On the final achievement test, only the "small-group study" section answered significantly more application items correctly than the controls.

Morris and Kimbrell's (1972) results indicate that a thorough mastery of lower mental processes may facilitate the development of higher mental processes. Similarly, the formative tests developed by Levin were intended to bring the Mastery groups to an 85 percent criterion for "rules knowledge". But these formative tests include items whose solutions require higher mental processes. Thus it is not clear in Levin's and Weber's studies whether the Mastery groups learned higher mental processes as a result of mastering lower mental processes, or directly from the formative tests. But either way, the evidence shows that Mastery approaches are successful in developing higher mental processes.

Where the previous studies examined lower and higher mental processes under Mastery and conventional instruction, this research examined lower and higher mental processes under tutoring.

CHAPTER III

METHODOLOGY

This chapter describes the methodological background of this research. We begin by introducing the conceptual framework from which the model for this research is derived. Next, we introduce the model and describe how its component variables are measured and operationalized. Following that, we describe what the model predicts. Finally, we describe the research hypotheses and the research design.

Conceptual Framework

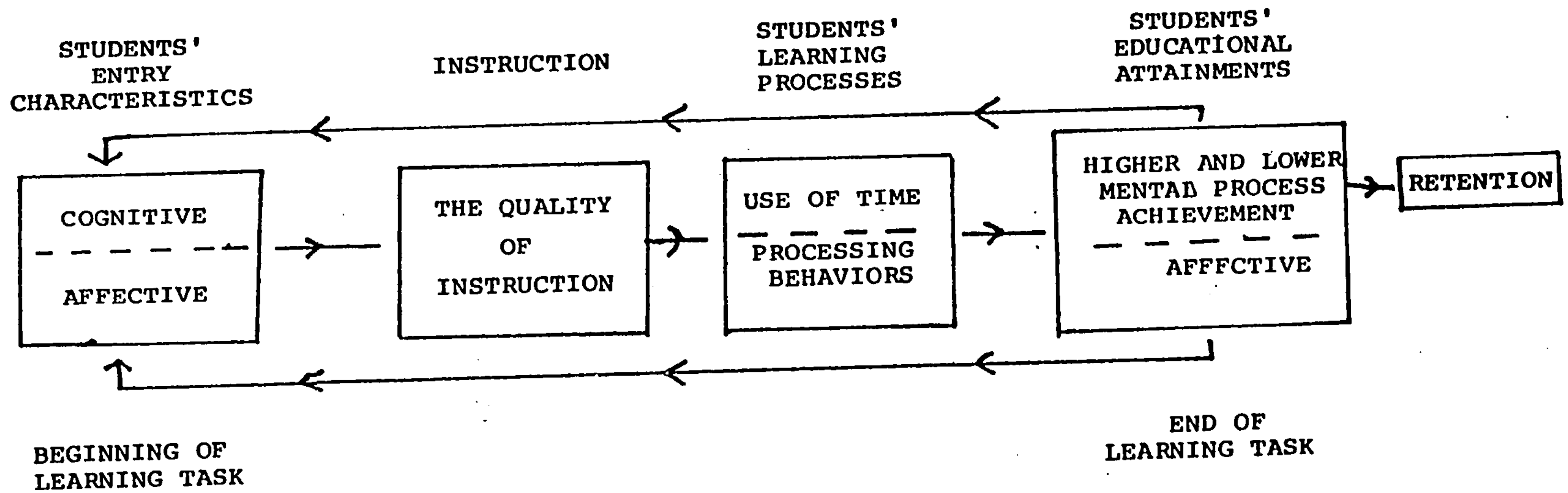
The conceptual framework for this research was largely derived from Bloom's (1976) theory of school learning. In Bloom's theory, students' cognitive and affective development is determined by the interactions of certain of the students' characteristics with the quality of the instruction. Bloom's model considers both the affective and the cognitive characteristics which students bring to a new course of learning. Instructional quality is the degree to which cues, participation, reinforcement, and feedback and correction are appropriate to the specific needs of each learner.

In the previous chapter we reviewed a great deal of evidence relating the quality of the instruction to students' achievement. We saw that, of many attempts to improve achievement, one of the most successful has been Mastery Learning. Mastery Learning is effective because it prepares most students well for each new learning task. Further research indicated that when students' achievement improves, as it does under Mastery Learning, their interest in learning, attitudes toward learning, and concepts of themselves as learners all show similar improvement.

This research departed slightly from Bloom's formulation of the process of school learning. We share with Bloom the specification that students' learning processes are functions of the instructional conditions. However, in our formulation students' learning processes are the sole proximal cause of their achievement.

In brief, this research was guided by a framework in which students' educational attainments are directly determined by their learning processes, which, in turn, are determned by the quality of the instruction. This framework is represented by the model in Figure 1. Before we discuss the relationships predicted by the model in Figure 1, we will discuss how the variables were operationalized.

Fig. 1. -- The model for this research.


STUDENTS' ENTRY CHARACTERISTICS
INSTRUCTION
STUDENTS' LEARNING PROCESSES
STUDENTS' EDUCATIONAL ATTAINMENTS
COGNITIVE
AFFECTIVE
THE QUALITY OF INSTRUCTION
USE OF TIME
PROCESSING BEHAVIORS
HIGHER AND LOWER MENTAL PROCESS ACHIEVEMENT
AFFECTIVE
RETENTION
BEGINNING OF LEARNING TASK
END OF LEARNING TASK

Variables

In this section we formally define the variables in the model. The model predicts that students' educational attainments are a function of their learning processes, and that these learning processes are determined by certain characteristics of the students in conjunction with certain characteristics of the instruction.

The model includes both the cognitive and affective entry characteristics of students. We distinguish these entry characteristics at two levels: generalized and specific.

The model includes one important instructional characteristic: the instructional quality.

The model also includes students' learning processes, that is, their use of time and certain of their mental and physical behaviors during instruction.

The model includes both students' cognitive and affective attainments. Students' cognitive attainments are their lower and higher mental processes. Students' affective attainments are their interests, attitudes, and self-concepts regarding their learning. Furthermore, the model is concerned with the retention of both the cognitive and the affective attainments.

Cognitive And Affective Entry Characteristics

Generalized Cognitive Entry Characteristics

In the context of this research, generalized cognitive entry characteristics reflect an individual's capacity to use mathematical concepts and to understand and manipulate quantitative symbols. These skills are called "generalized" because they are useful in many different kinds of mathematical studies and because they are not altered, from task to task, by instruction. They are called "entry" because they are brought by the students to the beginning of each learning task.

Generalized cognitive entry characteristics were measured by the Cognitive Abilities Test, Multilevel, Form 3 (Thorndike and Hagen, 1978), and the Science Research Associates Achievement Tests, Level E, Form 1 (Science Research Associates, 1978). The quantitative subtests of these instruments estimate not only computational skills, but also knowledge and facility with mathematical symbols, concepts, and relations. Scores from these instruments were available from school files.

Specific Cognitive Entry Characteristics

Behaviors specifically relevant to the current learning task are called the specific cognitive entry behaviors for that task. These behaviors are developed through prior study of the same subject or a related subject. In this research, specific cognitive entry behaviors were monitored on the formative tests which concluded each instructional unit. Under tutoring and Mastery Learning, cognitive entry behaviors for a new task were estimated by the students' score from the formative test following all feedback and correction from the previous learning task. Students in the conventional conditions received no correction after the formative test; as a result, their cognitive entry score for a new unit was their score on the formative test from the previous unit. The construction and validation of the formative tests is discussed in more detail in the section "Instruments for Assessing Students' Cognitive Achievement" (pp. 64-65).

Specific Affective Entry Characteristics

Students' specific affective entry characteristics are their interests, attitudes, and self-concepts in regard to a particular subject, in this case probability. These specific affective characteristics were measured, at the beginning of each instructional task, on the Affective Survey Instrument.

To assess students' interests, attitudes, and self-concepts in regard to probability, the experimenter prepared a number of items. These items were rated by two judges. If both judges agreed that an item fairly assessed affect toward probability, the item was included on the affective instruments. We estimated students' interest in probablity from their desire to learn more about it. We estimated students' attitude toward probability from the value they placed on it in comparison to other subjects. Lastly, we estimated students' self-concept in relation to probability from the way they saw themselves as competent or incompetent learners of this subject.

The Quality Of The Instruction

For our purposes, the quality of the instruction is the degree to which four components -- cues, participation, reinforcement, and feedback and correction -- are appropriate to the needs of individual learners. It is likely that, in any instructional environment, different learners experience different qualities of instruction. This happens when, for example, teachers devote different amounts of time and attention to different students. Thus we speak of the quality of a given instructional environment in terms of what we reasonably estimate to be the typical experience of an individual in that environment.

Instructional quality may be conceptualized as a continuum. This research operationalized instructional quality in three experimental treatments: conventional group instruction, Mastery Learning, and tutoring.

Conventional Group Instruction

To create the "conventional" conditions, the teachers managed instruction according to their usual teaching practices -- so long as these practices did not include formative testing or tutoring outside class. The teachers lectured and led class discussions. They made no attempt to improve the instructional cues for individual learners, to increase the participation of individual learners, or to provide additional reinforcement to individual learners beyond what is normally possible when instruction is conducted with a group of learners. They used tests only to record the students' performance; students received no feedback from the tests, nor any feedback or correction beyond that which flowed naturally out of the classroom activities.

Conventional group instruction may be understood as instruction in which errors occur because the needs of individual learners are unmet, and in which the learners, because they do not receive adequate feedback and correction, become increasingly ill-prepared for subsequent learning tasks.

Mastery Learning

Like the teachers in conventional group instruction, the teachers in the Mastery conditions managed instruction according to their ususal style. In particular, they provided instructional cues, assigned practice, praised and encouraged, and provided feedbak and correction to the learners as a group. However, there was one important difference between the Mastery and the conventional instruction.

At the end of each instructional unit, the Mastery students completed a formative test. This test indicated to the teacher and to the students what the students still had to learn in order to master the unit at a level of 80 percent correct. Students who did not attain the mastery criterion on the first formative test were assigned to correct their errors. This was done with the help of instructional materials, constructed by the experimenter, which explained the solution to each item and provided additional explanation and examples of the idea tested by each item.

The formative tests were corrected by aides assigned to the Mastery classrooms; these aides recorded the students' scores and the items missed by each student. Items missed by more than half the class were explained by the teacher to the group. After that, individual students used the corrective materials to help understand the items they got wrong.

Following this first round of testing and correction, students who had not initially reached mastery were retested on the items they needed to reach mastery. Students who still had not reached mastery on this second test repeated the corrective activities as time allowed. One instructional period was alloted to all testing and correction.

Under the teacher's supervision, students who reached mastery on the first formative test assisted students who had not reached mastery on the first or the second formative tests.

Mastery Learning may be understood as an attempt to remedy, in a single period of correction, errors which have developed and remained unremedied over many periods of instruction, so that students become well-prepared for subsequent learning tasks.

Tutoring

Tutoring was managed in a manner fundamentally different from instruction under the conventional and the Mastery conditions. Each tutor was responsible for only three learners. The tutor provided cues appropriate to each student's learning style. The tutor made sure that each student participated actively in the learning activities. The tutor was, when appropriate, generous with praise and encouragement. And most importantly, the tutor managed feedback and correction far more effectively than the teachers in conventional instruction, more effectively even than the Mastery teachers. As the instruction proceeded, the tutor provided on-going feedback and correction. This constant correction, together with the formative tests and the corrective materials, made the learning of each tutored student nearly free from errors. Tutored students were held to a mastery criterion of 90 percent for each instructional unit.

Tutoring may be understood as an attempt to bring each student to a high level of mastery for each learning task by making instruction appropriate to each student's specific needs.

Students' Learning Processes

For this research, students' learning processes included their use of instructional time and certain of their mental and physical behaviors during instruction. How students use time during instruction is best indicated by their time on-task and their rate of learning. Of the many mental and physical behaviors which students display during instruction, our model involves those behaviors which we believe are most sensitive to the quality of the instruction -- how students use instructional cues, how students participate in the learning tasks, how students are reinforced during learning, and especially, how students receive and use feedback and correction.

Rate of Learning

The formulation of rate of learning for this model has been discussed in the section "A Conceptual Framework for Analyzing Students' Achievement and Their Use of Time" (pp. 40-43). Here, we need only remind ourselves that our learning rates estimate the time students would need to learn a task to a level of 100 percent correct.

Time On-Task

Time on-task is the amount of instructional time students are actively engaged in learning. Time on-task was estimated from observations of the students' behaviors during instruction. Observers scanned the classroom at the beginning, middle, and towards the end of an instructional period, focussing on each child for about 5 seconds and then rating whether that child was on-task or off-task. After completing one scan, the observer paused and began another. Using this process, during a single instructional period a number of observations were made of each learner. Details of the training of the observers will be given in the Design section (pp. 86-88). .

Instructional Processing
Behaviors

During the learning activities, students' behaviors were monitored both by self-report and by observation. On the Components Checklist, adapted from Hecht's (1977) "Activities Checklist", students reported the following: (1) whether they understood the instructional cues; (2) whether they participated frequently in the learning activities; (3) whether they were rewarded during their learning; (4) whether they received adequate feedback and correction.

On the Components Observation Instrument, constructed for this research, observers rated the following: (1) how the teacher or tutor managed instructional cues for individual learners; (2) how the teacher or tutor managed the participation of individual learners; (3) how the teacher or tutor reinforced individual learners; (4) how the teacher or tutor provided feedback and correction for individual learners.

The content validity of these instruments was assessed by having two judges (familiar with our definition of instructional quality) rate whether the items or observation categories were consistent with tour definition. Only those items and observation categories which, according to both judges, fit the definition of instructional quaility were included on these instruments.

Students' Educational Attainments

This research examined how the quality of the instruction affected students' cognitive and affective learning. Students' cognitive and affective development was monitored for three different purposes. First, assessments were made during the experiment to reveal the different courses of learning under the different instructional conditions. Second, assessment was made at the end of the instruction to reveal the overall effects of the different instructional conditions. And finally, assessment was made a short time after the posttest to reveal the degree of retention under the different instructional conditions.

Lower Mental Processes

The model predicts that the quality of the instruction detrmines students' lower and higher mental processes. Lower mental processes were estimated from the students' performance on test items at the Knowledge or Comprehension levels of the Taxonomy. A Knowledge item required the student to identify a term, fact, rule, or principle, or to use these elements to solve problems similar to ones encountered during the instruction. A Comprehension item required the student to translate information from verbal to quantitative form.

Higher Mental Processes

Higher mental processes were estimated from the students' performance on items at the Application or Analysis levels of the Taxonomy. An Application item required the student to use the relevant terms, facts, rules, or principles to solve a problem which was different from the ones encountered during instructon. An Analysis item required the student to determine what additional information beyond what was given was necessary to develop a solution to a problem.

Lower and higher mental processes were estimated from formative, summative, and retention tests. We next describe the construction and validation of these tests.

Instruments for Assessing Students' Cognitive Achievement

Formative tests were constructed according to procedures recommended in the _Handbook for Formative and Summative Evaluation of Student Learning_ (Bloom, Hastings, and Madaus, 1971). The content of each instructional unit was classified, in a table of specifications, according to what mental processes were expected of the students. Items for the formative tests were chosen from the most important elements in the table of specification.

The validity of the items was established in two steps. First, two judges rated whether each item appropriately represented the content of the instructional unit. Next, the judges rated, on the basis of the content and objectives of the instructional unit, whether the item was a lower or higher mental process item. An item was included on a formative test for a given unit only if both judges agreed on the cognitive level of the item, and that the item appropriately represented the content of the instructional unit.

A second pool of items was developed on the most important content and objectives of the course. An item was included in this pool only if two judges agreed first on the cognitive level of the item, and second that the item represented the content of the course. For each item selected for the summative test, a similar item was selected for the retention test. For all students, the final lower and higher mental process score was estimated from the summative test. The score for lower and higher mental process retention was estimated from the retention test.

Affective Outcomes

This research monitored three dimensions of students' affect regarding probability: interests, attitudes, and self-concepts. We estimated students' interests in probability from their desire to learn more about it. We estimated students' attitudes toward probability by how highly it was valued in comparison with other subjects. We estimated students' self-concepts as learners of probability by how highly they rated their performance in probability. The affective instruments were described in detail in the section "Generalized and Specific Affective Entry Characteristics" (pp. 55-56). Affect was measured before instruction began, at the beginning of each instructional task, and after the students were informed of their final achievement.

The Course Of Learning Predicted By The Model

We have reviewed the conceptual framework from which the model is derived, and we have formally defined the variables in the model. Later we formulate a number of hypotheses and research problems to explore the relationships predicted by the model. But first we will describe the course of learning predicted by the model. For several reasons this description will be rather detailed. First, we wish to explain the formal characteistics of the model itself. Second, we wish to provide an overview of the process represented in the model, instead of a piecemeal picture when we discuss each hypothesis and problem.

The model represents school learning as a dynamic process, a process which "cycles" continuously throughout learning. It is most convenient to describe this process as if school learning were a series of instructional tasks, each bounded by a formal beginning and a test at the end. It is also convenient to describe the process as if it occurred in three distinct stages.

In the first stage, the student's entry characteristics interact with the quality of the instruction to determine the student's learning processes. In the second stage, the student's learning processes determine the student's educational attainments. And in the third stage, attainments from one instructional task become the student's entry characteristics for the next instructional task. This last stage, indicated by the "feedback-loops" in Figure 1, establishes the cyclic character of the model.

This model represents the learning of an individual student from the start to the finish of a single instructional task, and generalizes immediately to groups of learners, series of instructional tasks, and series of courses -- that is, to school learning. We now describe the relationships predicted by the model. First we will describe what the model predicts for a single student over a single instructional task. We will then generalize that description to series of instructional tasks.

The Model For A Single Learning Task

Students' Entry Characteristics

The student enters a new learning task with both generalized and specific cognitive characteristics. In this research, the students' generalized cognitive entry characteristics include knowledge and facility with mathematical symbols, concepts, and relations. Specific cognitive entry characteristics are computational and reasoning skills, developed from previous instruction in probability, which are relevant to the new task. Naturally, since probability was a new topic for most students in this research, these specific skills were negligible for the first task.

A student also enters a new learning task with both generalized and specific affective characteristics. We are concerned with specific affective charcteristics. school, along with the student's general academic-self concept. The specific affective entry characteristics are the student's interest, attitudes, and self-concepts in regard to specific topics in probability; these characteristics were developed from previous experience with the study of probability. Here too, for the first instructional task, most students have the same specific affective characteristics.

The model predicts that, over a series of instructional tasks, students' specific cognitive and affective characteristics alter in a direction which depends critically on the quality of the instruction.

Instructional Characteristics: Instructional Quality

The quality of the instruction is the degree to which the instruction meets the needs of each learner for four elements: cues, participation, reinforcement, and feedback and correction. Our model applies to all the possible qualities of instruction. We have, however, operationalized instructional quality in three treatments. We will examine how each treatment determines the student's processing behaviors and use of time.

Under conventional instruction, the teacher's time and attention are divided among many learners. The individual student may not receive appropriate instructional cues; as a result, the student will not always comprehend the main points of the lesson. The student may not get a chance to participate actively in the learning activities; as a result, the main points may not be fixed firmly in the student's mind. The student may not get praise and encouragement from the teacher; as a result, the student will not find satisfaction in learning. And most importantly, the student may not get the feedback and correction needed to correct particular errors in learning; as a result, the student will be inadequately prepared for subsequent learning tasks. Under these conditions, the student's time on-task and rate of learning are likely to be poor. Finally, since the instruction does not bring the student to mastery, achievement is highly predicted by prior characteristic such as aptitude or intelligence.

Under Mastery Learning, as under conventional instruction, there are disadvantages during initial instruction for individual learners. However, Mastery Learning provides feedback and correction to help most students learn each unit at a high level. As a result, Mastery students are adequately prepared for subsequent learning tasks. Under these conditions, the student's time on-task and rate of learning are likely to be quite high. Finally, since the instruction brings the student to mastery, achievement becomes less predicted by prior cognitive characteristics such as aptitude or intelligence.

Tutoring presents many advantages for the individual learner. The student continually receives appropriate instructional cues; as a result, the student nearly always comprehends the main points of each lesson. The student is in constant participation with learning exercises; as a result, the main points become fixed in the student's mind. The student receives continual praise and encouragement; as a result, the student's learning becomes very satisfying. Most importantly, the student's errors are corrected immediately, as they occur during instruction, and if not immediately, then at the end of the instructional unit through the formative tests. Under these conditions, the student's time on-task and rate of learning are likely to be very high. Finally, since the instruction brings the tutored student to a very high level of mastery, the student's achievement will depend very little on prior characteristics such as aptitude or intelligence.

The Model For A Series Of Instructional Tasks

The model predicts that, over a single learning task, students' use of time and their processing behaviors become very different under different qualities of instruction. These differences in use of time and processing behaviors explain the differences in achievement between the instrucional conditions. In this section we examine the model for a series of instructional tasks. We remember from Figure 1 that students' educational attainments from one learning task become their entry characteristics for the next learning task.

Students' Educational Attainments Over A Series of Tasks

Under conventional instruction, the student's processing behaviors and use of time are relatively inefficient. Without efficient processing behaviors and without feedback and correction, the student does not master the first task at a high level. Over time, the student becomes increasingly ill-prepared for new learning. As a result, the student's time on-task, rate of learning, and processing behaviors will continue to be relatively poor. Since the student's achievement is likely to be far below mastery, it will be increasingly better predicted by the student's aptitude or intelligence. Finally, the student's interest, attitude, and self-concept in regard to learning will become less and less positive.

Under Mastery Learning, the student receives feedback and correction to learn the first task at a high level. As a result, the Mastery student learns new tasks better under group instruction. That is, under Mastery Learning time on-task and rates of learning are at high levels, and processing behaviors are very effective. As the student's achievement reaches higher levels, it depends less on the student's aptitude or intelligence. Finally, the Mastery student's interests, attitudes, and self-concepts in regard to learning become more and more positive.

Under tutoring, the specific learning needs of each student are constantly met. As a result, time-on task, rate of learning, and processing behaviors become quite efficient. Since learning is efficient, and feedback and correction are available from formative tests, the tutored student masters the first learning task at a high level. Tutored students continue to receive appropriate attention, as well as periodic feedback and correction from formative tests. As a result, the tutored student's time on-task, rate of learning, and instructional processing behaviors continue to improve. Because achievement under tutoring is at very high levels, it depends hardly at all on the student's aptitude. Finally, the tutored student's interests, attitudes, and self-concepts in regard to learning become highly positive.

This model has several conceptual advantages. By specifying that the outcomes from one instructional task become the entry characteristics for the next, this model represents the sequential nature of school learning. By specifying all the variables at the level of the student, and especially by positing students' learning processes as the major proximal cause of the students' educational attainments, this model forges tight conceptual links between students' entry characteristics, instructional characteristics, students' learning processes, and students' educational attainments.

Hypotheses And Research Problems

We did not formulate hypotheses for all the relationships implied by the model. Partly, this was because we did not collect the necessary data at both sites. But the more important reason was that we wished to focus attention on the critical role played by the quality of the instructon in determining students' educational attainments. The effects of the quality of the instruction were examined in three hypotheses. The first hypothesis examined the effects of the instructional quality on the students' lower and higher mental processes. The second hypothesis examined the effects of the instructional quality on the students' learning processes. The third hypothesis examined the effects of the instructional quality on the students' retention of lower and higher mental processes.

Two other issues were investigated as research questions: students' affect under the different qualities of instruction, and the relationship between aptitude and achievement under the different qualities of instruction.

Instructional Quality And Students' Cognitive Achievement

Of all the problems facing education today, the most lamentable is that many students do not achieve to their full potential. One reason for low achievement is rooted in the traditional practice of teaching learners in large groups. Under conventional instruction, the teacher's time and attention are so divided among a group of students that the specific needs of most students are not met. As a result, some students develop errors on each learning task. And by the end of a series of tasks, the learning of most students is so full of errors that their achievement is far below their potential.

Students' potential for learning has been improved by several instructional approaches. For example, under

Advance Organizers the average student achieves at the 58th percentile of students who learn under conventional instruction (Luiten, Ames, and Ackerson, 1980); under Keller's Personalized System of Instruction the average student achieves at the 69th percentile of students who learn under conventional instruction (Kulik, Kulik, and Cohen, 1978; and under Mastery Learning the average student achieves at the 80th percentile of students who learn under conventional instruction (Block and Burns, 1977).

Students' potential for learning has improved significantly under these innovations. But none of them develop students' full potential for learning, because each enhances a single dimension of instruction -- and ignores others. The thesis of this research is that students' potential for learning will be developed to very high degrees when, as in tutoring, the instruction is fully adapted to the specific needs of each student. The first hypothesis explores students' potential for learning lower and higher mental processes under instruction adapted in different degrees to the specific needs of each student: tutoring, Mastery Learning, and conventional group instruction.

HYPOTHESIS 1: STUDENTS' LOWER AND HIGHER MENTAL PROCESS ACHIEVEMENT IS DETERMINED BY THE QUALITY OF THE INSTRUCTION.

Students' lower and higher mental processes were estimated from their responses to items on formative and summative tests. To answer a lower mental process item, the student had to solve a familiar problem, to identify a fact, rule, term, or principle, or to translate an expression from verbal to symbolic form. These behaviors correspond to the Knowledge and Comprehension levels of the Taxonomy. To answer a higher mental process item, the student had to either solve a non-routine problem or distinguish relevant from irrelevant information in developing a solution to a problem. These behaviors correspond to the Application and Analysis levels of the Taxonomy.

The quality of the instruction is the degree to which the instruction meets the needs of individual learners for cues, participation, reinforcement, and feedback and correction. We operationalized the quality of the instruction in three treatments: conventional group instruction, Mastery Learning, and tutoring. The instructional treatments and their implications for students' lower and higher mental processes have been described in detail on pages 57-60, 68-70, 70-72. We will summarize those discussions here.

In conventional instruction, the teacher lectured and led class discussions, without enhancing the instruction for individuals.

In Mastery Learning, initial instruction was identical to conventional instruction. However, in Mastery Learning the teachers assigned and supervised corrective activities until as many students as possible reached the mastery criterion for each instructional unit.

The tutors adapted instruction to the specific learning needs of each student. Tutors paid special attention to cues, participation, reinforcement, and feedback and correction.

The first hypothesis predicts this order of effectiveness, from low to high, for both lower and higher mental processes: conventional instruction, Mastery Learning, and tutoring. We expected that final achievement under tutoring would be very homogeneous and at the highest levels. We further expected that final achievement under Mastery Learning would not be as high and as homogeneous as under tutoring, but that it would be higher and more homogeneous than final achievement under conventional instruction.

The first hypothesis also predicts a different course of learning over time for the three instructional treatments. We expected that the tutored students would initially achieve at a higher level, with less variable achievement, than the other students.

We expected that the achievement of the tutored students would continue to improve and become less variable over the series of instructional tasks. We expected that the Mastery and the control students would initially achieve at a level lower than the tutored students, and similar to each other. However, we expected the Mastery students to develop successively higher levels of achievement, with less variability, while the control students achieved at approximately the same levels with increasing variability.

Instructional Quality, Students' Achievement, And Students' Learning Processes

More and more, researchers have begun investigate not only students' achievement, but also students' learning processes under different qualities of instruction. Some of this research suggests that when the quality of the instruction is improved, students begin to use instructional time more efficiently, and thus achieve more. For example, Mastery students have been on-task more than non-Mastery students, and thus have achieved at higher levels (Anderson, 1973).

In the same vein, research has begun to investigate more closely the mental and physical behaviors which cause some students to learn better than others. Hecht (1977) showed that Mastery students begin to use instructional cues, participation, reinforcement, and feedback and correction more effectively than non-Mastery students. Nordin (1979) showed that instructional conditions which enhance cues, participation, both cues and participation, or feedback and correction have positive effects on students' behaviors and subsequently on students' achievement.

The model for this research predicts that the quality of the instruction determines students' learning processes, and that these learning processes then determine the students' achievement. The first hypothesis examined the direct effects of the quality of the instruction on the students' achievement. The second hypothesis examines how students' achievement depends on their learning processes, and how these learning processes depend on the quality of the instruction.

HYPOTHESIS 2: ACHIEVEMENT IS DETERMINED BY STUDENTS' LEARNING PROCESSES, WHICH, IN TURN, ARE DETERMINED BY THE QUALITY OF THE INSTRUCTION.

The quality of the instruction has been described in the discussion of the previous hypothesis.

Students' learning processes include their use of instructional time (time on-task and rate of learning) and their processing behaviors (cues, participation, reinforcement, and feedback and correction).

Time on-task was determined for each student from observations of the students' behaviors during instruction. Rate of learning was calculated from the measures of the students' time on-task in relation to their test scores.

Students' behaviors with cues, participation, reinforcement, and feedback and correction were estimated from observations and from students' self-reports of their behaviors during instruction.

The second hypothesis predicts that students under conventional instruction should demonstrate the least effective use of time and the least effective processing behaviors. These students should have the poorest rate of learning and the lowest time on-task, as well as the least effective use of cues, participation, reinforcement, and feedback and correction. These relatively ineffective processing behaviors explain why achievement under conventional instruction is so low.

Time on-task, rate of learning, and processing behaviors should be significantly better under Mastery Learning than under conventional instruction. These more efficient learning processes explain why achievement is higher under Mastery Learning than under conventional instruction.

Students who receive "optimal" instruction, tutoring, should be on-task the most and learn the fastest. Furthermore, tutored students should use instructional cues most effectively, should participate most actively in the learning tasks, should find their learning most rewarding, and should make the best use of feedback and correction. These very efficient learning processes should explain why achievement under tutoring is very high.

Over a series of tasks, students' use of instructional time and their processing behaviors improve, or fail to improve, depending on the quality of the instruction.

Tutored students will initially use their instructional time well and have effective processing behaviors. Over time, tutored students should begin to use instructional time with increasing effectiveness, and their processing behaviors should become even more efficient.

Since they learn under group conditions, Mastery students may not initially use instructional time well, nor have effective processing behaviors. However, over time Mastery students should learn better under group instruction; that is, their time on-task, processing behaviors, and rate of learning should improve.

On the other hand, we expected that students under conventional instruction would initially use instructional time poorly and have ineffective processing behaviors. Over a series of tasks, these students should not improve in their use of instructional time and in their processing behaviors.

Instructional Quality And Students' Retention Of Cognitive Achievement

Research on instruction has for the most part ignored the continuing effects of differential instructional conditions. There is evidence, from a handful of studies, that in Mastery conditions students retain cognitive achievement better than students in non-Mastery conditions (Block and Burns, 1977). There is even less evidence about the cognitive level of the achievement retained under different instructional conditions. One study, by Poggio (1976), suggests that Mastery students retain significantly more lower order behaviors, but not significantly more higher order behaviors, than students in non-Mastery conditions. The experimenter has been unable to locate a single study of the lower and higher behaviors retained under tutoring.

This research recognizes that in order to understand fully the effects of different instructional conditions, it is necessary to examine students' retention of lower and higher cognitive achievement under those instructional conditions. The third hypothesis is formulated to examine the effects of the instructional quality on the students' retention of lower and higher mental process achievement.

HYPOTHESIS 3: STUDENTS' RETENTION OF LOWER AND HIGHER MENTAL PROCESSES IS DETERMINED BY THE QUALITY OF THE INSTRUCTION.

We described the instructional treatments earlier.

Students' retention of lower and higher mental processes was measured by an instrument which was a parallel form of the achievement posttest. This test of retention was administered about three weeks after the posttest.

We expected that the levels of retention of lower and higher mental processes would depend greatly on the levels to which they were mastered by the end of the course of instruction: that retention under tutoring would be at the highest levels because final achievement was very high; that retention under Mastery Learning would be high because final achievment was high; and that retention under conventional instruction would be low because final achievement was low.

Research Design

In this section we describe the sample, the subject taught and the instructional materials, the instructional treatments and the monitoring of the instructional treatments, the testing and observation schedules, and the training of the tutors, teachers, and observers.

Samples

This research was replicated three times at two sites. At the first site, the study was replicated twice with approximately 170 fourth and fifth graders from a parochial school in a blue-collar suburb of a large midwestern city. At the second site, the study was replicated with approximately 108 fifth graders from a public school in a small, working-class, middle-atlantic town. At both sites, students were randomly assigned to treatments.

Subject And Instructional Materials

The subject matter taught in this research was probability. Probabiiity was chosen because it was a new topic for the elementary students in our sample, because attractive commercial materials were available, and because a technical, sequential subject had advantages for the study of lower and higher mental processes.

In consultation with a university educator who specializes in the preparation of teachers for elementary school, a three-week course of instruction was developed from the commercial instructional materials. The commercial instructional materials used to develop this course included Probability for Intermediate Grades, by the School Mathematics Study Group (1966), and What Are My Chances?, by Shulte and Choate (1977). The curriculum for the experiment included these and other topics: the probability of a simple event, the probability of a compound event, the probability of the union of any two events, and the probability of certain, impossible, or mutually exclusive events.

The published materials included suggestions to the teacher for conducting the lessons; additional suggestions, instructions, and examples were inserted by the experimenter at various places into the instructor's copy of the instructional materials. Each student was provided with worksheets and other materials during the instruction.

Training Of Teachers, Tutors, And Observers

In what follows we describe how the teachers and tutors were trained. We also discuss the training of the observers for their various tasks and the monitoring of the instructional treatments. Training took place at both sites in the week before the experiment began. At that time, teachers, tutors, and observers were familiarized with the instructional materials, testing instruments and procedures, and other general details of the experimental design.

Training of Teachers

At both sites, the students' regular classroom teachers agreed to participate in the experiment as either Mastery or conventional teachers.

Since they were not to enhance cues, participation, reinforcement, or feedback and correction beyond what they could naturally provide in the group setting, teachers in the conventional conditions required no training. These teachers were simply introduced to the instructional materials.

The Mastery teachers were familiarized with the instructional materials, formative tests, and corrective materials. The corrective process was explained to these teachers in detail, and their questions and problems were discussed. The construction and use of the formative tests and corrective materials were been discussed in the sections "Mastery Learning" (pp. 57-59), and "Instruments for Assessing Students' Cognitive Achievement" (pp. 64-65).

Training of Tutors

At both sites, tutors were undergraduate education students participating as part of their pre-professional training.

The tutors required more extensive training than the teachers. Tutors met the experimenter each day for one week before the instruction began. During this time, the tutors were familiarized with the instructional materials, formative tests and corrective materials, and the plan of instruction and objectives of each unit. The nature of children in fourth and fifth grade was discussed, along with appropriate ways of interacting with children of that age. Most of the training involved ways and means of adapting cues, participation, reinforcement, and feedback and correction to each student's specific needs.

To develop skill in providing instructional cues, tutors were trained to recognize that different students' benefit from different sorts of cues. Tutors were instructed to summarize frequently, to take a step-by-step approach, and to provide sufficient examples for each new concept. The objective of this training was to help the tutors pace and present instruction so that each student understood the main points of each lesson.

To encourage each student's active participation, tutors were trained to ask leading questions, to elicit additional responses from the student, and to ask other students for alternate examples or answers. The purpose of this training was to help the tutors keep each student "on-task" so that the learning was firmly fixed in each student's mind.

Tutors were urged to be apprpriately generous with praise and encouragement whenever a student made progress. The purpose of this training was to help the tutor make learning a rewarding experience for each student.

Perhaps the most important part of the tutors' training was learning to manage feedback and correction effectively. Tutors were trained to provide feedback and correction throughout instruction, as well as to use the formative tests and corrective materials at the end of each instructional task. The purpose of this training was to help the tutor make each student well-prepared for each new task.

For the most part, the training of the tutors followed this format: The experimenter described a single component of instructional quality -- whether cues, participation, reinforcement, or feedback and correctives -- after which the tutors engaged in "role-playing" for an actual instructional task, some playing tutees and one playing the tutor. Role-playing was not only excellent practice in managing instruction, but also an excellent introduction instruction, as well as an excellent introduction to the lessons from the learner's point of view.

Training of Observers and the Monitoring of the Instructional Treatments

At both sites, observers were undergraduate education students participating as part of their pre-professional training. Observers were trained to execute two tasks: to estimate time-on task, to evaluate the quality of the instruction. The last task served a dual purpose: first, it determined whether the treatments were implemented as designed, and second, it served as a basis for "quality control", so that appropriate corrective action could be taken if a teacher or tutor strayed badly from the design.

In training the observers to estimate time on-task, we began by discussing various behaviors which indicate whether a student is on-task or off-task. Observers were provided with a list of these behaviors. Observers visited at least one class before the experiment began, observing time on-task according to the procedures described in the section "Time On-task" (p. 61). Where possible, pairs observed the same classroom, in order to provide a "reliability check" for each other's observations.

The training of the observers to monitor the instructional treatments began with a discussion, led by the experimenter, of the theoretical background of instructional quality. This discussion included the objectives of the instructional treatments and the behaviors of teachers, tutors, and students expected in these treatments. Observers were then introduced to the "Components Observation Instrument", which they were to use in monitoring the quality of the instruction. This instruments has been described in in the section "Instructional Processing Behaviors" (pp.

61-62). Before the experiment began, observers visited at least one class, where possible in pairs, and used the instrument to evaluate the quality of the instruction.

CHAPTER IV

RESULTS

Improving students' potential for learning has been the goal of numerous instructional approaches. Many of these approaches assume that the disadvantage of learning in a large group prevents most students from achieving at their full potential. In response to this problem, a number of approaches tailor instruction to support different learning needs. For example, Computer-Assisted Instruction provides unending drill; Mastery Learning provides systematic feedback and correction (Bloom, 1976); Advance Organizers provide introductory cues to the main points of each lesson (Ausubel, 1963); and Keller's Personalized System of Instruction provides the reinforcement of allowing students to proceed at their own pace (Keller, 1968).

Using methods for research synthesis, we can compare students' achievement under the different approaches. Under the most effective of them, Mastery Learning, the average student typically achieves at a level above approximately 80 percent of the control students. Clearly, this is the development of students' potential to quite a high level.

Nevertheless, what gives these approaches their individual success is at the same time the source of their collective limitation. Each attends to a unique learning need -- at the cost of ignoring others. We believe that students' full potential for learning can be attained only when instruction is appropriate to the specific needs of each student. To explore this idea, this research contrasted students' cognitive and affective attainments under tutorial and group approaches to instruction. Three qualities of instruction were investigated.

A. Under tutoring, the instruction was constantly adapted to the specific needs of each student.

B. Under Mastery Learning, periodic feedback and correction improved each student's ability to learn from group instruction.

C. Under conventional group instruction, the teacher was unable to adapt instruction to the specific learning needs of each member of a large group of students.

This research addressed five issues. Addressed formally, as research hypotheses, were the effects of different qualities of instruction on: (1) lower and higher mental process achievement; (2) time on-task, processing behaviors, and rate of learning; and (3) retention of lower and higher mental processes. Addressed less formally, as research questions, were: (4) the relationship between students' aptitude and their achievement under the different instructional conditions; and (5) students' affect under the different instructional conditions.

Initial Quantitative Abilities Of The Instructional Groups

This experiment was replicated three times, at two sites. At both sites, students were randomly assigned to learn probability under one of three conditions: tutoring, Mastery Learning, or conventional group instruction. In Table 4, we present the aptitude levels of the groups prior to instruction.

TABLE 4

INITIAL QUANTITATIVE ABILITIES OF THE INSTRUCTIONAL GROUPS

		SITE 1 GRADE 4 (CAT)	SITE 1 GRADE 5 (CAT)	SITE 2 GRADE 5 (SRA)
TUTORING	MEAN	110.45	114.44	28.33
	STD	12.77	13.47	13.34
	N	22	18	36
MASTERY	MEAN	112.94	107.15	27.05
	STD	10.16	12.22	12.23
	N	31	20	36
CONVENTIONAL	MEAN	112.47	108.24	29.17
	STD	13.90	13.51	12.51
	N	30	29	36
F STATISTIC		.28 N.S.	1.73 N.S.	.26 N.S.

At the first site, aptitude was estimated from the quantitative subtest of the Cognitive Abilities Test (CAT) (Thorndike and Hagan, 1978). At the second site, aptitude was estimated from the quantitative subtest of the Science Research Associates Achievement Test (SRA) (Science Research

Associates, 1978). These tests are discussed in more detail on page 54. The CAT scores in Table 4 are expressed as scaled scores and the SRA scores are expressed as raw scores.

We see that within-grades there are no statistically significant differences between the aptitude levels of the three instructional groups. Furthermore, at both sites students are quite similar to the students on which the national norms for the respective tests were calibrated. The national norm for the CAT for fourth and fifth grade is a mean of 104.40 and a standard deviation of 18.40. The national norm for the SRA for fifth grade is a mean of 27 and a standard deviation of 12.

Instructional Quality And Students' Achievement

Of all the problems facing education today, the most lamentable is that many students do not achieve to their full potential. One reason for low achievement is rooted in the traditional practice of teaching learners in large groups. Under conventional group instruction, the teacher's time and attention are so divided among a group of students that the specific needs of most students are not met. As a result, some students develop errors on each learning task. And by the end of a series of tasks, the learning of most students is so full of errors that their achievement is far below their potential. Students' potential for learning has been improved by several instructional approaches. For example, the average student who receives Advance Organizers achieves at the 58th percentile of students who learn under conventional conditions (Luiten, Ames, and Ackerson, 1980); the average student who receives Keller's Personalized System of Instruction achieves at the 69th percentile of students who learn under conventional conditions (Kulik, Kulik, and Cohen, 1978; and the average student who receives Mastery Learning achieves at the 80th percentile of students who learn under conventional instructional conditions (Block and Burns, 1977).

Students' potential for learning has improved significantly under these innovations. But none of them develop students' full potential for learning, because each enhances a single dimension of instruction -- and ignores others. The thesis of this research is that students' potential for learning will be developed to very high degrees when, as in tutoring, the instruction is fully adapted to the specific needs of each student. The first hypothesis explores students' potential for learning lower and higher mental processes under instruction adapted in different degrees to the specific needs of each student.

HYPOTHESIS 1: STUDENTS' LOWER AND HIGHER MENTAL PROCESS ACHIEVEMENT IS DETERMINED BY THE QUALITY OF THE INSTRUCTION.

Lower mental process achievement was estimated from test items at the Knowledge or Comprehension levels of the *Taxonomy of Educational Objectives* (Bloom, 1956). Lower mental processes included solving familiar problems, translating an expression from verbal to symbolic form, or identifying a fact, term, rule, or principle.

Higher mental process achievement was estimated from test items at the Application or Analysis levels of the *Taxonomy*. Higher mental processes included solving problems dissimilar from the ones encountered during instruction, or distinguishing relevant from irrelevant information in developing a solution to a problem.

Achievement was monitored on two sets of tests: (1) formative tests at the end of each instructional unit; and (2) a summative test at the end of the three week period of instruction. These instruments and lower and higher mental processes have been described in more detail on pages 64-65.

The quality of the instruction is the degree to which the instruction meets the needs of each learner for cues, participation, reinforcement, and feedback and correction. In this research, instructional quality was operationalized in three treatments: tutoring, Mastery Learning, and conventional group instruction. These treatments have been described in detail on pages 57-60, 68-70, and 70-72. In what follows we briefly summarize their important features.

Under tutoring, cues, participation, reinforcement, and feedback and correction were managed by the tutor to be as appropriate as possible to the specific needs of each student. In addition, tutored students were held to a criterion of 90 percent correct for each instructional unit.

Under Mastery Learning, initial instruction was identical to instruction under conventional conditions. However, Mastery students received feedback and correction, under the supervision of the teacher, at the end of each instructional unit. Mastery students were required to achieve a criterion of 80 percent correct for each unit.

Under conventional group instruction, the teachers lectured and led discussions for the class as a whole, using instructional materials and lesson plans prepared by the experimenter. Here there was no attention to students' specific needs beyond what flowed out of the group instruction.

The subject matter taught in this research was probability. Probability was a new topic for the students. Instructional materials, lesson plans, and other materials to aid the teachers and tutors were prepared by the experimenter. These are discussed on pages 82-83.

Our analysis of the first hypothesis will follow in three parts. First, we review the patterns of achievement expected under the first hypothesis. Second, we analyze the pattern of lower mental process achievement. Third, we analyze the pattern of higher mental process achievement.

Expected Patterns Of Achievement Under Tutoring, Mastery, And Conventional Conditions

Both for lower and for higher mental processes, we expected very different patterns of achievement under tutoring, Mastery Learning, and conventional group instruction.

Because cues, participation, reinforcement, and feedback and correction were adapted to the specific needs of each tutored student, we expected that, by the end of the first unit, achievement under tutoring would be higher and more homogeneous than under the other conditions. Furthermore, we expected that the tutored students, having mastered early tasks under the constant attention of the tutor, would, over time, achieve at increasingly higher levels with smaller variance. We expected that the final achievement of these students, for both lower and higher mental processes, would be very homogeneous and at the highest levels.

We expected that, initially, the Mastery students would achieve at a level similar to the students under conventional group instruction. However, we expected that the periodic feedback and correction received by the Mastery students would subsequently help them learn better under group instruction. Therefore, we expected that over time achievement under Mastery Learning would improve and become more homogeneous. We expected final achievement under Mastery Learning to be lower and more variable than under tutoring, but significantly higher and less variable than under conventional group instruction.

Because conventional instruction was rarely adapted to the specific needs of each student, we expected that here achievement would remain constant or decrease and achievement variance would remain constant or increase. We expected that for both lower and higher mental processes, final achievement under conventional instruction would be lower and more variable than final achievement under tutoring or Mastery Learning.

Lower Mental Process Achievement, Over Time, Under Three Qualities Of Instruction

Lower mental process achievement was estimated from test items at the Knowledge or Comprehension levels of the Taxonomy. Lower mental processes included solving familiar problems, translating expressions from verbal to symbolic form, or identifying facts, terms, rules, or principles.

In Table 5, we analyze lower mental process achievement for the three replications of this study. For each replication, Table 5 presents descriptive statistics from the formative tests and the posttest for lower mental processes under tutoring, Mastery Learning, and conventional group instruction. For each instructional unit, there were two formative tests -- the test designated "A" at the end of instruction and the test designated "B" following feedback and correction. The students under conventional group instruction received no feedback and correction following the "A" test; thus they had no "B" scores.

TABLE 5

LOWER MENTAL PROCESS ACHIEVEMENT, OVER TIME, UNDER THREE QUALITIES OF INSTRUCTION

		FT1A	FT1B	FT2A	FT2B	FT3A	FT3B	POSTTEST
Site 1 - Grade 4								
TUTORING N=22	MEAN	77.14*	92.01	84.76*	91.33	82.47*	92.08	89.01*
	STD	18.91	18.01	17.13	16.17	15.37*	12.13	12.77*
	E-S							(1.53)
MASTERY N=31	MEAN	64.03	82.36	73.11*	81.11	75.15*	82.16	73.25*
	STD	22.03	20.03	18.11	18.38	18.19	17.03	17.05
	E-S							(.73)
CONVENTIONAL N=32	MEAN	62.07	--	61.34	--	63.61	--	58.88
	STD	21.33	--	19.79	--	22.77	--	19.69
F STATISTIC		3.76*		10.56***		6.53***		57.70***
Site 1 - Grade 5								
TUTORING N=22	MEAN	80.05	91.83	86.87*	92.02	88.95*	93.66	93.85*
	STD	17.08	15.02	13.15*	12.75	11.03*	10.02	9.86***
	E-S							(1.34)
MASTERY N=30	MEAN	68.27	82.13	76.92	81.07	78.71	83.11	83.24*
	STD	19.03	16.58	15.31	14.30	14.81*	13.07	14.51
	E-S							(.78)
CONVENTIONAL N=32	MEAN	70.13	--	67.27	--	68.16	--	68.46
	STD	20.91	--	19.23	--	21.92	--	18.22
F STATISTIC		2.62		9.27***		9.66***		18.22***
Site 2 - Grade 5								
TUTORING N=36	MEAN	82.72*	91.03	83.58*	92.07	84.71*	90.77	88.47*
	STD	13.47	12.37	10.33	10.02	10.47*	9.71	7.64**
	E-S							(2.11)
MASTERY N=36	MEAN	69.36	81.39	76.32*	82.07	77.42*	81.17	79.72*
	STD	13.63	12.88	12.71	12.35	12.03	11.37	10.75
	E-S							(1.40)
CONVENTIONAL N=36	MEAN	71.13	--	67.17	--	68.55	--	62.50
	STD	14.33	--	13.71	--	16.04	--	12.28
F STATISTIC		9.82***		16.01***		13.83***		57.70***

* = $p < .05$
** = $p < .01$
*** = $p < .001$

Table 5 also presents 4 inferential statistics: (1) the F statistic and significance level from the analysis of variance of each test by quality of instruction; (2) the significance level, calculated by Tukey's HSD method, for each post-hoc comparison of tutoring and Mastery Learning with conventional instruction; (3) the significance levels for comparisons of variance under tutoring and Mastery Learning with variance under conventional instruction; and (4) the "effect-size" statistic for referring the average achievement under tutoring and Mastery Learning to the distribution of achievement under conventional instruction.

We will analyze students' lower mental processes under tutoring, Mastery, and conventional conditions for each learning task and for final achievement.

<u>The First Learning Task</u>

At the end of the first learning task, under tutoring achievement was at high levels. In two of the three replications, the average tutored student achieved significantly higher than the average control student. Furthermore, in all three replications LMP variance was smaller under tutoring than under conventional instruction. This happened because tutoring adapted instruction to the specific needs of each student. Finally, following feedback and correction, the tutored students were brought to their mastery criterion of 90 percent for the first learning task (FT1B).

As expected under random assignment, for the first task LMP achievement was very similar under Mastery Learning and conventional instruction. Moreover, LMP achievement was lower and generally more variable here than under tutoring, because these conditions did not adapt instruction to the specific needs of each student. However, in all three replications, the Mastery students were brought to their mastery criterion of 80 percent for the first learning task (FT1B).

The Second Learning Task

At the end of the second learning task (FT2A), under tutoring LMP achievement was uniformly higher and less variable than before. In all three replications, LMP achievement was statistically higher under tutoring than under conventional instruction, and in one case LMP variance was statistically smaller. This happened because the tutored students mastered the previous task at a very high level and, on the new task, received instruction adapted to their specific needs. And once again the tutored students were brought to their mastery criterion (FT2B).

Under Mastery Learning, in all three replications LMP achievement for the second task was higher than before. In two cases, LMP achievement was statistically higher under Mastery Learning than under conventional group instruction. And LMP variance was uniformly smaller under Mastery Learning. These changes occured because the Mastery students, helped by feedback and correction from the previous task, had begun to learn better under group instruction. On FT2B, the Mastery students were again brought to their mastery criterion.

Under conventional instruction, LMP means and variances were approximately the same as before. This happened because this group learned the first task at a lower level and learned the second task under instruction which was not adapted to the specific needs of each student.

The Third Learning Task

At the end of the third learning task (FT3A), in all three replications LMP achievement was statistically higher and less variable under tutoring than under conventional instruction. This happened because tutored students mastered the first two tasks to a high level and then learned the third task under the close attention of the tutor. With feedback and correction, again the tutored students reached their mastery criterion (FT3B).

In all three replications, LMP achievement was higher (in two replications significantly higher) under Mastery Learning than under conventional instruction. Furthermore, in all three replications achievement variance was lower under Mastery Learning than under conventional instruction -- in one replication statistically lower. These changes show that the lower mental processes of the Mastery students were improving under group instruction. Finally, the Mastery students were again brought to their criterion of mastery for lower mental processes (FT3B).

Under conventional instruction students did not receive the feedback and correction necessary to master lower mental processes of early tasks at high levels. Furthermore, they learned the third task under instruction which was not adapted to the specific needs of each student. Under conventional group instructions, lower mental process achievement remained approximately constant over the third task. This happened because lower mental processes were not mastered at high levels on early tasks and because the third task was learned under instruction which was not adapted to the specific needs of each student.

Final LMP Achievement

Final lower mental process achievement was, in all three replications, statistically higher and more homogeneous under tutoring than under conventional instruction. In fact, by the end of instruction, the average tutored student had mastered lower mental processes at a level above 95 percent of the control students. Under tutoring, final LMP achievement was so high because each task was mastered at a high level.

Under Mastery Learning, final LMP achievement was, in all three replications, statistically higher than under conventional instruction. Furthermore, LMP variance under Mastery Learning was uniformly lower. Under Mastery Learning, the average student mastered lower mental processes at a level above 83 percent of the control students. This happened because, over the series of tasks, the Mastery students had begun to learn more effectively under group conditions.

Under conventional conditions, where instruction was not adapted to the specific needs of each student, each new task was learned less well and thus final achievement was at low levels and highly variable.

Higher Mental Processes, Over Time, Under Three Qualities Of Instruction

In Table 6, we analyze higher mental process achievement for the three replications of this study. Table 6 follows the format of Table 5. Higher mental processes were estimated from test items at the Application or Analysis levels of the Taxonomy. For this research, higher mental processes were solving problems different from those encountered during instruction and distinguishing relevant from irrelevant information in developing solutions to problems. As before, we analyze higher mental processes for each learning task and for final achievement.

TABLE 6

HIGHER MENTAL PROCESS ACHIEVEMENT, OVER TIME, UNDER THREE QUALITIES OF INSTRUCTION

		FT1A	FT1B	FT2A	FT2B	FT3A	FT3B	POSTTEST
Site 1 - Grade 4								
TUTORING N=22	MEAN	74.21	80.21	54.55*	85.91	53.15*	88.11	56.89*
	STD	20.57	18.11	22.83	14.69	22.13*	15.15	16.61
								(1.58)
MASTERY N=31	MEAN	66.12	73.12	44.33	74.33	39.01	60.99	46.59*
	STD	26.38	21.37	24.59	19.60	15.37	15.17	19.23
	E-S							(.90)
CONVENTIONAL N=32	MEAN	58.04	--	33.93	--	36.75	--	33.00
	STD	25.51	--	22.50	--	12.68	--	15.08
F STATISTIC		2.83		4.81		6.61		11.56***
Site 1 - Grade 5								
TUTORING N=22	MEAN	84.21	90.48	74.29*	91.43	54.62*	90.77	68.68*
	STD	19.30	17.34	23.14	9.10	12.70	11.60	16.51
	E-S							(2.65)
MASTERY N=30	MEAN	74.17	78.67	46.67	73.33	42.71	72.68	53.38*
	STD	21.17	16.85	19.61	13.01	15.60	12.26	17.99
								(1.47)
CONVENTIONAL N=31	MEAN	73.27	--	43.67	--	32.82	--	34.21
	STD	20.21	--	19.56	--	14.13		13.02
F STATISTIC		2.17		15.57**		13.88**		31.18***
Site 2 - Grade 5								
TUTORING N=36	MEAN	63.13*	91.17	71.37*	93.04	76.04*	91.78	87.36*
	STD	13.59	11.62	12.26	11.33	10.67*	10.31	7.51***
	E-S							(2.11)
MASTERY N=36	MEAN	53.44	79.63	61.50*	84.44	66.14*	83.01	73.06*
	STD	13.90	12.07	12.53	12.01	12.62	11.73	11.48
	E-S							(1.21)
CONVENTIONAL N=36	MEAN	47.61	--	53.54	--	55.10	--	54.03
	STD	13.53	--	14.19	--	16.38	--	15.76
F STATISTIC		12.14***		16.94***		21.89***		71.13***

* = $p < .05$
** = $p < .01$
*** = $p < .001$

The First Learning Task

At the end of the first learning task (FT1A), in all three replications higher mental processes under tutoring were superior to higher mental processes under conventional instruction. In one case, this difference was statistically significant. In two cases, HMP achievement under tutoring was less variable than under conventional instruction. Tutored students learned higher mental processes so well on the first task because instruction was adapted to their specific needs. And following feedback and correction, the tutored students were brought to their mastery criterion for the first learning task (FT1B).

Under Mastery Learning, HMP achievement was initially lower than under tutoring and was very similar to HMP achievement under conventional instruction. This happened because the Mastery and the conventional groups learned the first task under similar conditions. But following feedback and correction, the Mastery students were brought to their criterion for the first learning task (FT1B).

The Second Learning Task

At the end of the second task (FT2A), in all three replications HMP achievement was statistically higher under tutoring than under conventional instruction. This happened because the tutored students mastered higher mental processes from the first task at a high level and learned the second task under the constant attention of the tutor.

After feedback and correction, the tutored students again reached their mastery criterion (FT2B).

Under Mastery Learning, in all three replications HMP achievement for the second task was higher (in one case significantly higher) than under conventional instruction. This happened because the Mastery students had feedback and correction for higher mental processes at the end of the previous task, which helped them learn HMP for the second task better. Following feedback and correction, the Mastery students again reached criterion (FT2B).

At the first site, HMP achievement on the second task has slipped well below the levels of achievement for the first task. Furthermore, at the first site only the tutored students of the fifth grade have reached the mastery criterion. This happened because the tests of higher mental processes were too difficult for these students. Before the study at the second site, the instruments were revised and, as a result, the pattern of HMP achievement at the second site more closely approximates the pattern we expected. In any event, despite problems with the instruments, HMP achievement under tutoring and Mastery Learning was superior to HMP achievement under conventional instruction.

The Third Learning Task

At the end of the third learning task (FT3A), in all three replications HMP achievement under tutoring was significantly higher than under conventional instruction. The tutored students achieved so well because they learned the first two tasks at higher levels and learned the third task under the constant attention of the tutor. Following feedback and correction, the tutored students were again brought to their mastery criterion for the third learning task (FT3B).

In all three replications, HMP achievement under Mastery Learning was superior to HMP achievement under conventional instruction. Mastery students learned higher mental processes so well for this task because they had begun to learn better under group instruction. Following feedback and correction, the Mastery students were again brought to criterion for the third learning task (FT3B).

Under conventional instruction, HMP achievement was again at low levels. Here students learned the first two tasks at low levels and learned the third task under instruction which was not adapted to the specific needs of each student.

Final HMP Achievement

Final HMP achievement was, in all three replications, significantly higher under tutoring than under conventional instruction. In fact, by the end of instruction the average tutored student mastered higher mental processes at a level above approximately 98 percent of the control students. The high level of final HMP achievement under tutoring is explained by the high levels of achievement over the series of tasks.

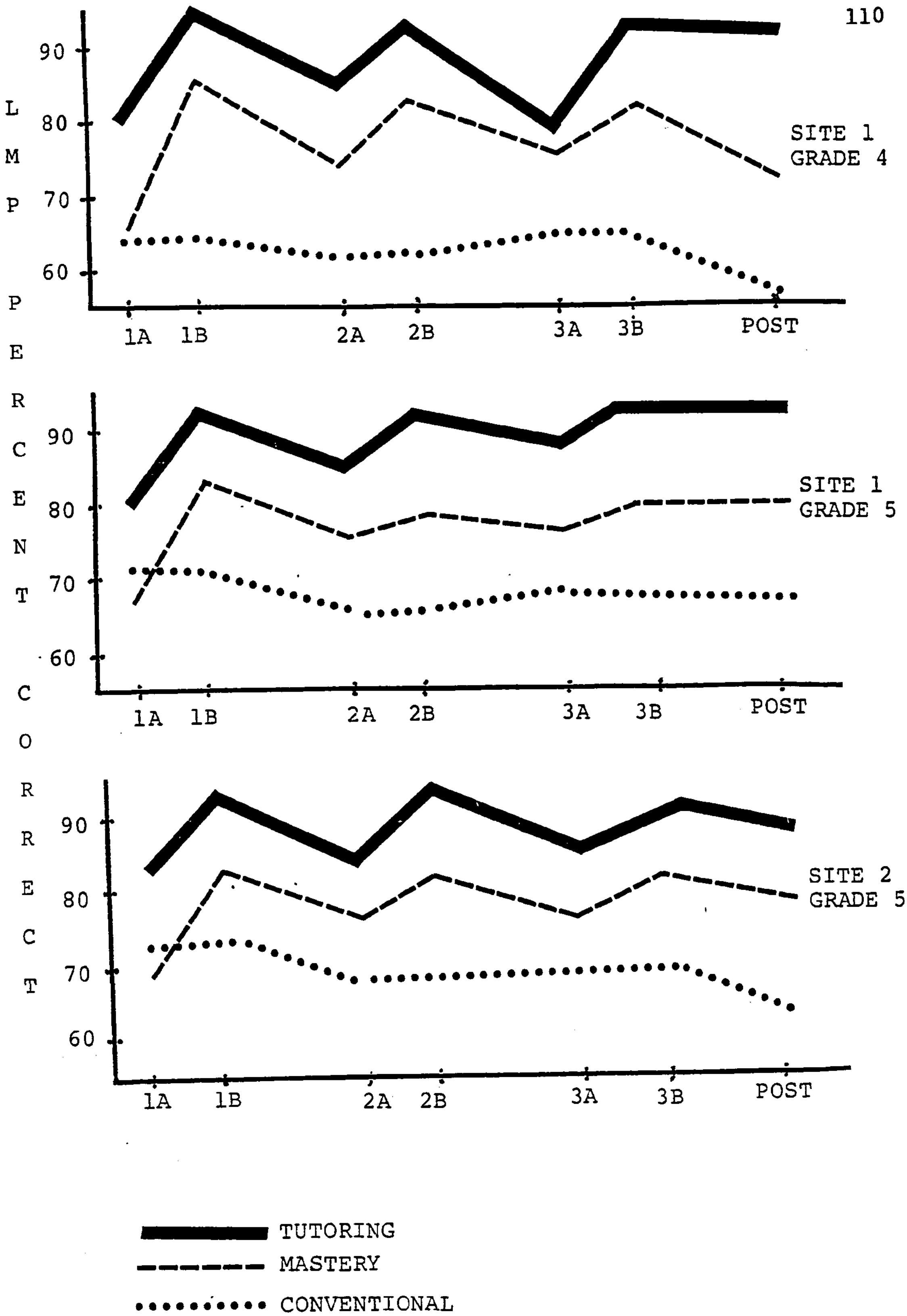
In all three replications, final HMP achievement was significantly higher under Mastery Learning than under conventional group instruction. The average Mastery student learned higher mental processes at a level above approximately 88 percent of the students under conventional instruction. Final HMP achievement was at high levels under Mastery Learning because, over the three learning tasks, Mastery students had begun to learn better under group instruction.

Finally, given the low levels of HMP achievement over the series of tasks, the low levels of final HMP achievement under conventional instruction are not surprising.

We summarize the discussion of lower and higher mental process achievement by referring to Figures 2 and 3. These figures display lower and higher mental processes under tutoring, Mastery, and conventional conditions over the series of tasks and at the end of instruction.

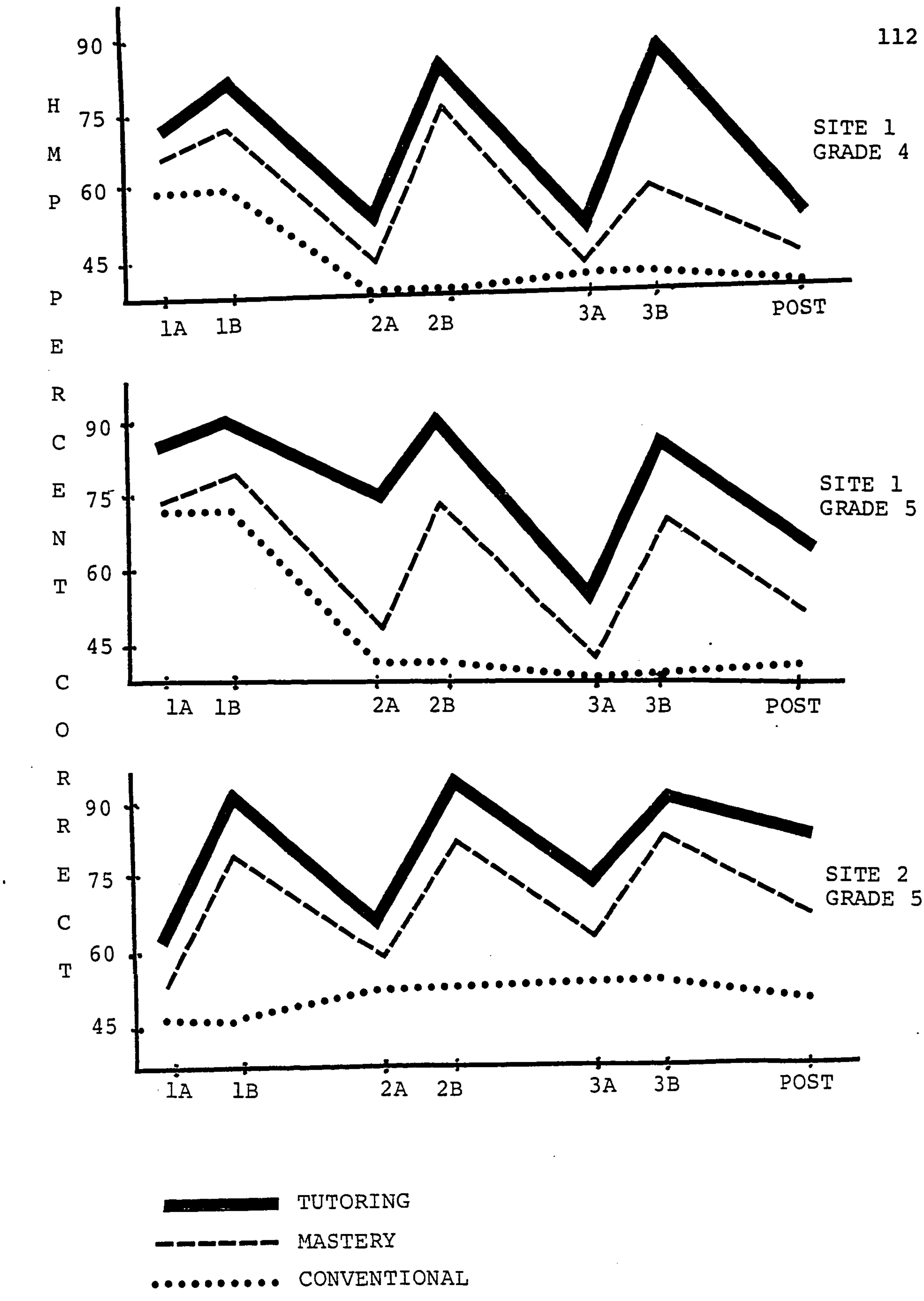
Under tutoring, achievement was initially higher than under Mastery and conventional conditions. Over the series of tasks, the achievement of the tutored students became far superior to the achievement of the students under conventional instruction. In fact, the final achievement of the average tutored student was above approximately 95 percent

Fig. 2. -- Graph of LMP achievement under tutoring, Mastery, and conventional conditions.



L M P
PERCENT CORRECT
90
80
70
60
1A 1B 2A 2B 3A 3B POST
SITE 1
GRADE 4
SITE 1
GRADE 5
SITE 2
GRADE 5
TUTORING
MASTERY
CONVENTIONAL

Fig. 3. -- Graph of HMP achievement under tutoring, Mastery, and conventional conditions.



HMP PERCENT CORRECT
90
75
60
45
SITE 1
GRADE 4
1A
1B
2A
2B
3A
3B
POST
SITE 1
GRADE 5
SITE 2
GRADE 5
TUTORING
MASTERY
CONVENTIONAL

of the control students. And under tutoring, the distribution of achievement had changed such that approximately 90 percent of the tutored students achieved at a level reached only by the top 20 percent of the control students. This happened because instruction adapted to their specific needs helped the tutored students master every task at a high level.

Under Mastery Learning, achievement was initially very similar to achievement under conventional group instruction. But because the Mastery students began to learn better under group instruction, their achievement soon became superior. At the end of instruction, the average Mastery student achieved at a level above approximately 85 percent of the students under conventional instruction. And approximately 60 percent of the Mastery students achieved at a level reached only by the top 20 percent of the control students.

Under conventional group instruction, the specific needs of most students were rarely met. As a result, each task was learned less effectively and final achievement here was considerably below final achievement under the other conditions.

In the next section, we will relate these large differences in achievement to differences between the treatments in time on-task and instructional processing behaviors. We will thus put some flesh on our assertions that the tutored students achieved at such high levels because instruction was constantly adapted to their specific needs and that the Mastery students achieved at high levels because they began to learn better under group instruction.

Instructional Quality, Students' Achievement, And Students' Learning Processes

In our examination of the first hypothesis, we demonstrated that achievement depends on the degree to which the instruction is appropriate to the specific needs of each student. More specifically, we demonstrated that achievement under tutoring and Mastery Learning is significantly superior to achievement under conventional instruction. However, achievement is not an outcome from a "black-box". Research comparing learning under Mastery and conventional conditions suggests that differences in achievement are related to differences in students' processing behaviors and levels of active participation (Hecht, 1977; Nordin, 1979). The second hypothesis examines these relationships under tutoring.

HYPOTHESIS 2: ACHIEVEMENT IS DETERMINED BY STUDENTS' LEARNING PROCESSES, WHICH, IN TURN, ARE DETERMINED BY THE QUALITY OF THE INSTRUCTION.

We have already discussed the three qualities of instruction: tutoring, Mastery Learning, and conventional.

Students' learning processes include their use of instructional time (time on-task and rate of learning) and their instructional processing behaviors (cues, participation, reinforcement, and feedback and correction). We will define use of instructional time and instructional processing behaviors more precisely at the appropriate places in the analysis.

In our analysis of the second hypothesis, we wish to emphasize instructional matters rather than cognitive psychology. For this purpose it was convenient to combine each student's lower and higher mental process scores into a total.

The second hypothesis was examined only at the second site. The analysis of the second hypothesis is guided by this question: Are differences in achievement related to differences in students' learning processes and use of instructional time under different qualities of instruction?

The second hypothesis is analyzed in two parts. First, we analyze students' processing behaviors, over the series of learning tasks, under the three qualities of instruction. Second, we analyze the relationship between achievement and use of time under the three qualities of instruction.

Students' Processing Behaviors, Over Time, Under Three Qualities Of Instruction

In this section, we analyze students' processing behaviors, over the three learning tasks, under tutoring, Mastery Learning, and conventional group instruction.

Following Bloom (1976), we define four components to students' processing of instruction. These components -- cues, participation, reinforcement, and feedback and correction -- were monitored by observation and by students' self-reports.

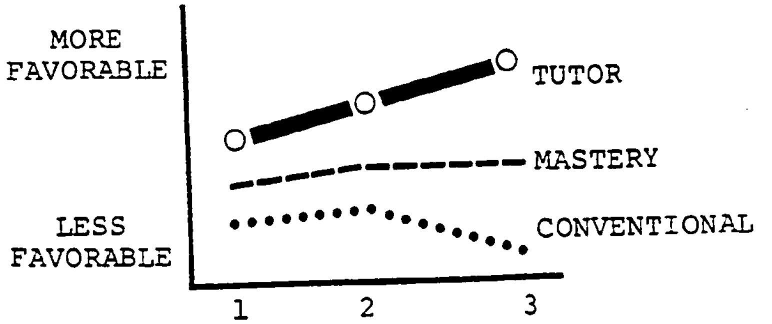
Periodically all students reported the following: (1) whether they understood the instructional cues; (2) whether they participated frequently in the learning activities; (3) whether they were rewarded during their learning; (4) whether they received adequate feedback and corrective help.

Analyzing the interactions between the instructor and each student, observers rated the following: (1) how the teacher or tutor managed instructional cues for individual learners; (2) how the teacher or tutor managed the participation of individual learners; (3) how the teacher or tutor reinforced individual learners; (4) how the teacher or tutor provided feedback and correction for individual learners.

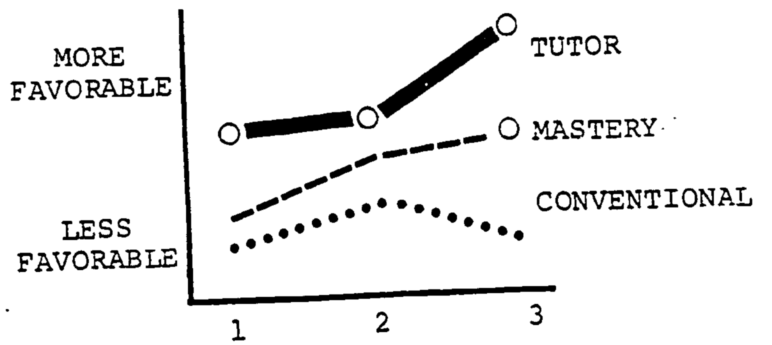
For each processing behavior, the observation and self-report scores were added to form an overall score for each student. For each processing behavior, Figure 4 displays the overall scores, over time, under tutoring, Mastery Learning, and conventional instruction. Since numerical scores of processing behaviors have little intuitive meaning, we express the vertical axis in Figure 4 as "less favorable - more favorable". An "O" marks a spot where a particular processing behavior was statistically more favorable

Fig. 4. -- Processing behaviors, over time, under tutoring, Mastery, and conventional conditions.

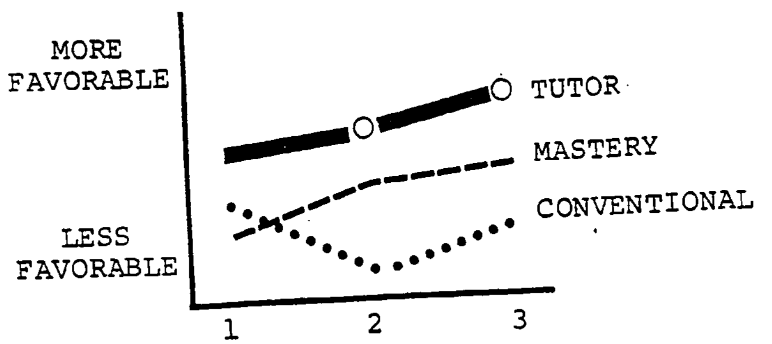
CUES



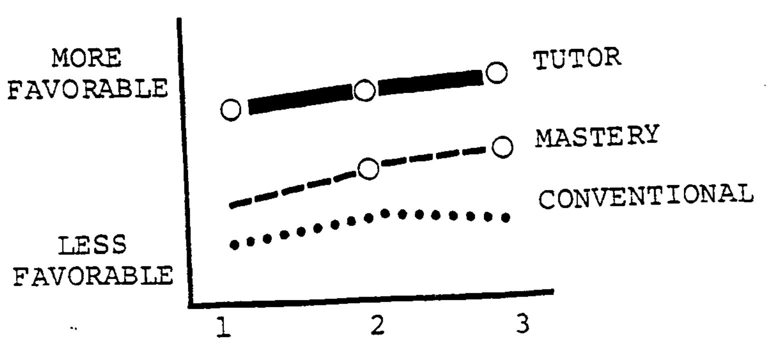
PARTICIPATION



REINFORCEMENT



FEEDBACK &
CORRECTION



under tutoring or Mastery Learning than under conventional group instruction. We will discuss differences between the treatments separately for each processing behavior.

Cues

Instructional cues indicate what are the main points of each lesson and what the students must do in learning them. Cues may be presented verbally, in writing, or through audio/visual aids. To monitor cues, observers rated the degree to which the teachers and tutors communicated the main points of each lesson to each student. And students reported whether the main points of each lesson were clear to them.

With only 3 learners, tutors were able to adapt cues to the specific needs of each -- sometimes by repetition, sometimes by provision of different cues, and often by step-by-step explanation. Consequently, for the first learning task, cues under tutoring were statistically more favorable than cues under conventional instruction. And for the tutored students, instructional cues improved over time. Observers reported that, over time, as the tutors became more familiar with the learning needs of each student, they gained skill in providing appropriate cues. Students reported that, over time, they were better understanding the main points of each lesson.

Because the Mastery and the control teachers had to instruct 30 students, under those conditions cues were initially less favorable than under tutoring. However, over time the Mastery students reported they were better understanding the main points of each lesson. This happened because these students became well-prepared for new learning tasks through feedback and correction from previous tasks.

Under conventional instruction, where the teacher could not communicate the task perfectly to each student and where the students did not receive periodic feedback and correction, cues remained at at less favorable levels than under the other conditions.

Participation

Participation is the student's active engagement in learning activities. We will discuss one dimension of participation, time on-task, later. Here we stress students' participatory behaviors. To estimate participation, observers rated the degree to which learning activities were assigned and supervised for each student. Students reported their overt participation (as in reciting aloud) and their covert participation (as in attending quietely to the discussion).

With only 3 learners, tutors easily assigned and supervised learning activities for each student. Not surprisingly, even on the first task the tutored students were participating significantly more than the control students.

And over the series of tasks, the participation of the tutored students increased, fixing the learning more firmly in their minds..

Under Mastery and conventional conditions it was more difficult for the teacher to assign and supervise adequate participation for each of 30 students. As expected, for the first task both Mastery and control students were participating less than the tutored students. As the Mastery students became increasingly well-prepared for new learning tasks, they began to participate more. This helped to fix the learning firmly in their minds. In contrast, because the control students were not well-prepared for new tasks they found learning more difficult, and began to participate less. As a result, over time learning was less firmly fixed in their minds.

Reinforcement

Reinforcement is the reward of students' successful learning or the correction of their unsuccessful learning, with the expectation that the reward or the correction will spur further successful learning. To estimate reinforcement, observers rated the degree to which each student received praise or correction. Students reported whether they found satisfaction in their learning.

With only 3 learners, tutors were easily able to praise and correct each one. Consequently, for the first task reinforcement was more favorable under tutoring than under conventional instruction. Very early, tutored students found more satisfaction in their learning. And since the tutored students achieved at very high levels over time, this plus the attention of the tutor made their learning very satisfying.

With 30 learners, the Mastery and the control teachers were unable to praise and correct each one. Consequently, for the first task reinforcement was less favorable for the Mastery and the control students than for the tutored students. As their achievement improved, Mastery students found more satisfaction in their learning. In contrast, with their achievement remaining at low levels, the control students found less satisfaction in their learning.

Feedback and Correction

When cues, participation, and reinforcement are managed well, learning will be very efficient. But inevitably errors occur. Feedback identifies these errors so they can be systematically corrected. Even under highly effective instruction, if students are to be well-prepared for successive learning tasks, a systematic process of feedback and correction is indispensable. To monitor feedback and correction, observers rated the degree to which each learner's errors were identified and corrected. Students rated whether they got enough help to understand the lesson.

With only 3 learners, the tutors were easily able to identify and correct errors as soon as they occured. Consequently, for the first task feedback and correction were significantly more favorable under tutoring than under conventional instruction. Over time, feedback and correction improved under tutoring, as the tutors became better at identifying and correcting each student's errors and as the students became accustomed to the formative testing process.

With 30 learners, the Mastery and control teachers could not identify and correct the errors of each. Consequently, under both Mastery Learning and conventional group instruction, feedback and correction were initially less favorable than under tutoring. As the Mastery students became accustomed to the formative testing process, over time they got better at identifying and correcting their errors during learning. In contrast, the constant level of feedback and correction under conventional instruction reflects the constant difficulty of identifying and correcting the errors of each of a large group of students.

In summary, we have shown in this section how differences in students processing behaviors over time help explain differences in achievement under tutoring, Mastery Learning, and conventional group instruction.

Because tutoring adapted instruction to the specific needs of each student, over time the tutored students processed instruction more efficiently. Through cues, they understood the main points of each lesson. Through participation, the main points of each lesson were firmly fixed in their minds. Through feedback and correction, their errors were controlled. Through reinforcement, their learning was a source of great satisfaction. And as a result of these efficient learning processes, achievement under tutoring was at very high levels.

Because they were well-prepared for each learning task, over time the Mastery students processed instruction more efficiently under group conditions. They began to participate more actively, to understand the main points of each lesson, to identify and correct their errors, and to find considerable satisfaction in their learning. And since their learning behaviors were efficient, the achievement of the Mastery students was at high levels.

Because the instruction was not adapted to their specific needs, over time the control students processed instruction less efficiently. They had greater difficulty understanding the main points of each lesson; they did not participate actively enough to fix the main points firmly in their minds; they did not receive sufficient feedback and correction to control their errors; and they found less satisfaction in their learning. It should not be surprising that the achievement of these students never reached high levels.

Learning Time And Achievement Under Three Qualities Of Instruction

In the previous section we saw how, over a series of tasks, differences in students' learning behaviors explain differences in achievement under tutoring, Mastery Learning, and conventional group instruction. In this section, we relate differences in achievement to differences between the instructional treatments in the amounts of time students spend actively engaged in learning. We examine three basic issues.

First, how do instructors allocate instructional time and how do students use instructonal time under tutoring, Mastery Learning, and conventional group instruction?

Second, how are differences in achievement related to differences between the treatments in students' levels of attention (time on-task)?

Third, what are the rates of learning under tutoring, Mastery, and conventional conditions?

Total Learning Time Under Three Qualities of Instruction

To lay the groundwork for the analysis of learning rates, in this section we analyze differences between the treatments in time on-task and time spent in correction. This analysis is presented in Table 7. While generally following the format of Table 5, Table 7 introduces a new statistic: the ratio, for each variable, of the tutoring and the Mastery means to the mean of the conventional group.

TABLE 7

USE OF INSTRUCTIONAL TIME
UNDER TUTORING, MASTERY, AND CONVENTIONAL CONDITIONS

		ITIME[a]	TOT[b]	ACTIVE[c]	ADDTIME[d]	TITIME[e]	TIME SPENT[f]
TUTORING N=36	MEAN	468	.82**	384**	50*	518**	434**
	STD	36	.07	42	21	43	44
MASTERY N=36	MEAN	469	.74*	347*	68	537**	415**
	STD	34	.11	39	25	38	33
CONVENTIONAL N=36	MEAN	472	.67	319	--	472	319
	STD	35	.17	52	--	35	52
F STATISTIC		.15	13***	19***	11***	26***	73***
MEAN RATIOS	T/C	1.0	1.22	1.21	--	1.10	1.36
	M/C	1.0	1.10	1.09	--	1.14	1.30

* = p .05
** = p .01
*** = p .001

[a]Time present for initial instruction (500 possible).
[b]Proportion of time on-task averaged over three units.
[c]Active learning time during initial instruction (1 x 2).
[d]Extra time for correction following formative tests.
[e]Total instructional "clock-time" (1 + 4).
[f]Estimated total active learning time (3 + 4).

Thus under ACTIVE, 1.21 = 384/319 estimates that the average tutored student spent 21 percent more time actively learning than the average control student.

The same amount of time (500 minutes) was allocated for initial instruction under all three conditions. There were no differences between the treatments in the average amounts of time students were present for initial instruction (ITIME). There were, however, significant differences in the proportions of time students were on-task during initial instruction. During initial instruction the average tutored student was on task 82 percent and the average Mastery student was on-task 74 percent -- compared to 67 percent for the average control student.

The average tutored student received 468 minutes of instruction, of which 384 were spent actively learning (ACTIVE). The average Mastery student received 469 minutes of instruction, of which 347 were spent actively learning. The average control student received 472 minutes of instruction, of which 319 were spent actively learning. In other words, during initial instruction the average tutored student spent about 21 percent more time actively learning than the average control student, and the average Mastery student spent about 9 percent more time actively learning than the average control student. These differences resulted simply because the tutored and Mastery students were more actively engaged in learning than the control students.

Tutored and Mastery students had greater active learning time not only because they were on-task more, but also because they received feedback and correction following each formative test. The average tutored student required an additional 50 minutes to complete the corrective procedures, the average Mastery student required an additional 68 minutes. Interestingly, even though the tutored students were held to a higher criterion than the Mastery students (90 percent to 80 percent), the tutored students completed the corrective activities in less time. This happened because the tutored students had initially achieved at high levels, and because the tutors managed correction more efficiently.

When time spent in correction is added to time spent for initial instruction, the average tutored student spent 10 percent more "clock-time" (TITIME) in instructional activities than the average control student. The average Mastery student spent 14 percent more "clock-time" in instructional activities than the average control student.

Lastly, when time spent for correction (ADDTIME) is added to time spent actively learning (ACTIVE), we see that the average tutored student spent about 36 percent more time actively learning than the average control student. And the average Mastery student spent about 30 percent more time actively learning than the average control student. In this section, we have shown that differencs in time on-task and extra time for correction combine to produce considerably greater active learning time under tutoring and Mastery Learning than under conventional group instruction. In the next section, we show how differences in time on-task during initial instruction are related to differences in achievement.

<u>Time On-Task and Achievement Under Three Qualities of Instruction</u>

The amount of time students are actively engaged in learning has consistently proven to be highly predictive of their achievement -- accounting for as much as 60 percent of achievement variance (Arlin, 1973; Anderson, 1973; Lahaderne, 1967; Ozcelik, 1973). This fact helps explain the large differences in achievement typically found under Mastery and conventional conditions. For instance, Anderson (1973) found that Mastery and control students were initially on-task approximately 75 percent. On the second unit, Mastery students were on-task approximately 79 percent -- compared to 65 percent for the controls. And on the final unit, while the controls dropped to 63 percent on-task, the Mastery students were on-task 83 percent. Spending so much more time actively learning, it is no surprise that the Mastery students achieved more.

Since tutoring was adapted to the specific needs of each student, we expected the tutored students to be on-task more than the other students.

We expected that the Mastery and the control students would initially be on-task about the same amount. However, we expected that as their learning processes improved, over time Mastery students would be more on-task, while the students under conventional group instruction would spend about the same proportion of time on-task.

In Table 8, we analyze achievement and time on-task under tutoring, Mastery Learning, and conventional group instruction. Table 8 follows essentially the same format as Table 5. Achievement (ACH) is percent correct from the first formative test of each unit. Percent of time on-task (TOT) was estimated from observations of each student's behaviors during instruction. Students were rated "on-task" when they were observed to be actively participating in the learning activities (p. 61).

Because tutoring was adapted to the specific needs of each student, time on-task and achievement were both significantly higher here than under conventional instruction. On the other hand, because the Mastery and control students learned the first task under group conditions, their time on-task and achievement were lower at lower levels.

On the second unit, learning behaviors under tutoring had become even more effective than before. As a result, under tutoring time on-task and achievement reached higher levels than before, significantly higher than under conventional instruction. Learning behaviors under Mastery Learning had also become more effective than before. As a

TABLE 8

ACHIEVEMENT AND TIME ON-TASK
UNDER THREE QUALITIES OF INSTRUCTION

		UNIT 1		UNIT 2		UNIT 3	
		ACH	TOT	ACH	TOT	ACH	TOT
TUTORING	MEAN	71.09**	.78**	76.33**	.82***	79.56**	.87***
n=36	STD	13.53	.09*	11.33	.07***	10.57*	.06***
MASTERY	MEAN	59.51	.68	67.52*	.75*	70.72**	.79**
n=36	STD	13.77	.13	12.62	.11**	12.33	.09***
CONVENTIONAL	MEAN	57.24	.64	59.08	.68	60.56	.66
n=36	STD	13.94	.14	13.95	.18	16.21	.20
F STATISTIC		10.51 ***	12.59 ***	16.66 ***	10.71 ***	18.54 ***	23.47 ***

* = p < .05
** = p < .01
*** = p < .001

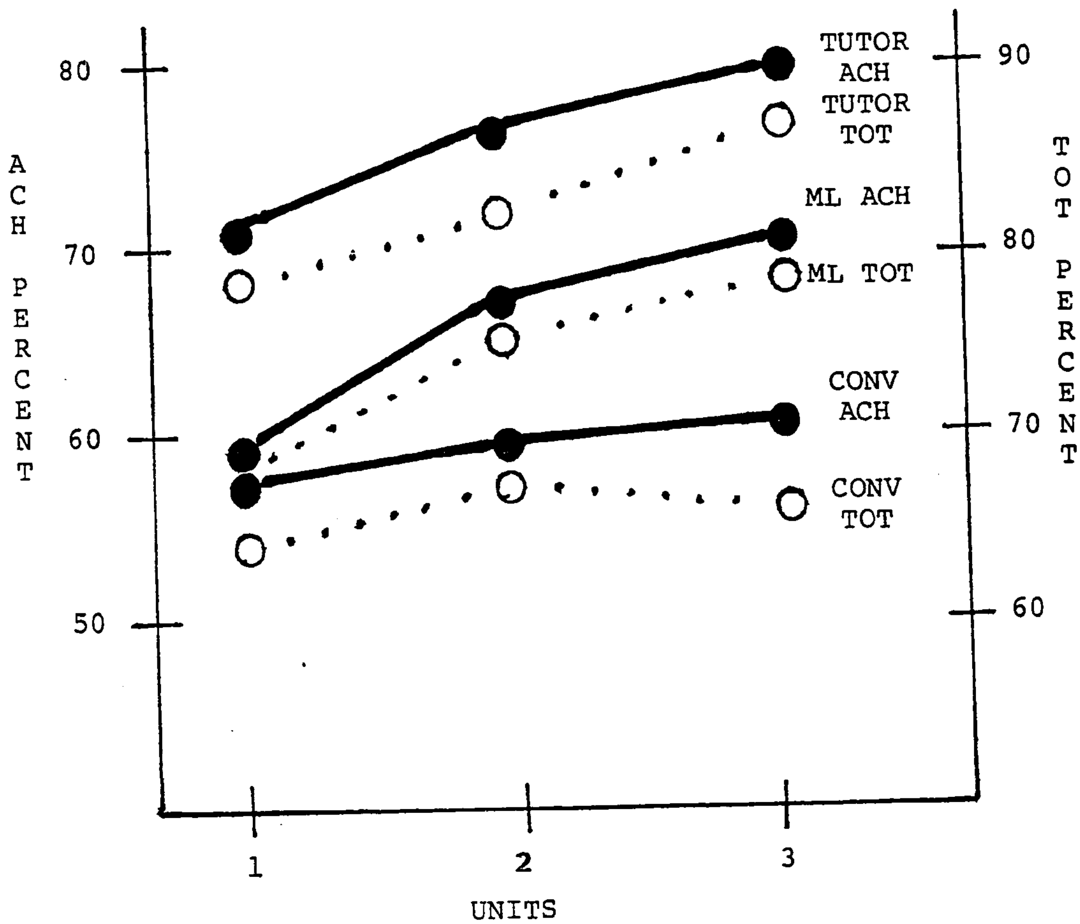
result, time on-task and achievement were now significantly higher under Mastery Learning than under conventional instruction.

On the third unit, as learning behaviors under tutoring became very effective, time on-task and achievement were significantly higher than under conventional instruction. Learning behaviors under Mastery Learning also became more effective. Thus time on-task and achievement became significantly higher than under conventional instruction. In contrast, because their learning behaviors remained less effective, the time on-task and the achievement of the control students remained at lower levels.

In Figure 5, we graph time on-task together with achievement under tutoring, Mastery, and control conditions for the three units. Figure 5 makes clear how, over time, time on-task and achievement improve under tutoring and Mastery Learning while remaining approximately constant under conventional group instruction.

In summary, as processing behaviors grow more effective under tutoring and Mastery Learning, time on-task improves, and with this achievement improves. In the next section, we further analyze the use of instructional time under tutoring, Mastery Learning, and conventional group instruction.

Fig. 5. -- Graph of achievement and time on-task under tutoring, Mastery, and conventional conditions.


80
70
60
50
ACH PERCENT
TUTOR ACH
TUTOR TOT
ML ACH
ML TOT
CONV ACH
CONV TOT
90
80
70
60
TOT PERCENT
1
2
3
UNITS

Rate of Learning Under Three Qualities of Instruction

We have seen that students under tutoring and Mastery Learning spend a great deal more time actively learning than students under conventional instruction. We will now relate these differences in active learning time to differences in final achievement. But first, in order to account for different types of active learning time (time on-task, clock-time for initial instruction, and extra time for corrective procedures), we must develop some conceptual and computational machinery.

Following Carroll (1963), we express final achievement as the ratio of two time parameters:

degree of achievement = TIME SPENT/TIME NEEDED.

TIME SPENT is time spent actively learning. It can be calculated either as "clock-time" or as "time on-task". We will see the difference shortly.

TIME NEEDED estimates the rate of learning. It is expressed as:

TIME NEEDED = TIME SPENT/TEST SCORE.

When TIME SPENT is calculated as "clock-time", TIME NEEDED estimates the amount of clock-time needed to learn a task to a level of 100 percent, given the actual level of time on-task. This we call the CLOCK-TIME LEARNING RATE.

When TIME SPENT is calculated as amount of "time on-task", TIME NEEDED estimates the amount of time on-task needed to learn a task to a level of 100 percent. This we call the TIME ON-TASK LEARNING RATE. The difference between the two rates is that the former includes all instructional time while the latter includes only time spent actively learning.

The CLOCK-TIME LEARNING RATE and the TIME ON-TASK LEARNING RATE are the tools we need to relate differences in achievement to differences between the treatments in the amounts of time students are actively learning.

In Table 9, we relate differences in final achievement to differences between the treatments in amounts of time students spent in learning. We note that the tutored and the Mastery students spent somewhat more time in learning than the control students -- 10 percent more and 14 percent more, respectively. However, average final achievement was much higher under tutoring and Mastery Learning: approximately 87 percent and 75 percent, respectively -- in contrast to approximately 57 percent under conventional instruction.

Tutored and Mastery students spent only slightly more time in instruction than the control students. Yet the tutored and Mastery students achieved at significantly higher levels than the controls. The reason for this is explained by the pattern of learning, over time, under tutoring and Mastery Learning.

TABLE 9

ACHIEVEMENT AND ACTIVE LEARNING TIME
UNDER THREE QUALITIES OF INSTRUCTION

		FINAL[a] ACH	CLOCK-TIME[b] SPENT	TIME SPENT[c] ON-TASK	CLOCK-TIME[d] LEARNING RATE	TIME ON-TASK[e] LEARNING RATE
TUTORING N=36	MEAN	86.58**	518**	434**	607**	505**
	STD	7.55	43	44	77	70
MASTERY N=36	MEAN	75.19**	537**	415**	721**	559*
	STD	11.13	38	33	83	87
CONVENTIONAL N=36	MEAN	57.08	472	319	835	615
	STD	14.27	35	52	147	120
F STATISTIC		62.16***	27***	72***	41***	12***
MEAN RATIOS	T/C	1.52	1.10	1.36	1.38	1.22
	M/C	1.32	1.14	1.30	1.16	1.10

* = $p < .05$
** = $p < .01$
*** = $p < .001$

[a]Percent correct.
[b]Time for initial instruction plus correctives.
[c]Amount of initial instruction spent on-task.
[d]Clock-time needed to learn task to 100 percent correct (2/1).
[e]Time on-task needed to learn task to 100 percent correct (3/1).

On each unit, tutoring adapted instruction to each learner's specific needs. Consequently, on each unit achievement under tutoring was at high levels. With initial achievement at high levels, relatively little extra time was needed for correction. As a result, final achievement under tutoring was very high in relation to the total amount of time used.

After the first unit, Mastery students began to learn better under group instruction. This happened because these students received feedback and correction which made them well-prepared for each new unit. Since achievement was improving and correction was managed efficiently, final achievement under Mastery Learning was high in relation to the total amount of time used.

The learning rates demonstrate the extent to which time was used more efficiently under tutoring and Mastery Learning than under conventional instruction. The CLOCK-TIME LEARNING RATE estimates how much instructional time would be required under a given treatment for the average student to learn probability to a level of 100 percent correct. This estimate is 607 minutes under tutoring and 721 minutes under Mastery Learning. In contrast, to learn to the same level the averge control student would have required 835 minutes of instruction. Put another way, to learn probability to 100 percent the average tutored student would have needed approximately 17 percent more instructional time and the average Mastery student approximately 35 percent more instructional time than the amounts they actually spent. In contrast, to learn to the same level the average control student would have needed approximately 77 percent more instructional time than the amount actually spent.

The TIME ON-TASK LEARNING RATE estimates how much active learning time would be required under a given treatment for the average student to learn probability to a level of 100 percent correct. This estimate is 505 minutes under tutoring and 559 minutes under Mastery Learning. In contrast, to learn to the same level the average control student would have required 615 minutes of time on-task. Put another way, the average tutored student could have learned probability to 100 percent in approximately 16 percent more time on-task and the average Mastery student in approximately 35 percent more time on-task than the amounts they actually spent. In contrast, to learn to the same level the average control student would have required approximately twice as much time on-task as was actually spent.

We did not examine use of instructional time in such detail only to demonstrate that while control students were still struggling to learn, the tutored and the Mastery students could have been playing hopscotch or watching television. The point of these findings is that, as instruction becomes adapted to the specific needs of each student, more is learned per unit of time -- whether that unit is clock-time or time on-task. Or in other words, as instruction becomes adapted to the specific needs of each student, learning becomes not just effective, but efficient.

Instructional Quality And Students' Retention Of Lower And Higher Mental Processes

Research on instruction has looked very closely at final achievement, less closely at retention. In reviewing research on Mastery Learning, Block and Burns (1977) found only 7 studies comparing retention under Mastery and non-Mastery conditions. These studies contained 20 comparisons of retention under the Mastery and non-Mastery conditions. In 11 comparisons, retention was significantly higher under Mastery than under non-Mastery conditions. In the other 9 comparisons, retention was higher, but not significantly higher under the Mastery conditions. This suggests that when final achievement is at high levels retention will also be at high levels.

Very few studies have examined the mental processes retained under different instructional conditions. One study suggests that Mastery students retain significantly more lower mental processes, but not significantly more higher mental processes, than students in non-Mastery conditions (Poggio, 1976). We have been unable to locate a single study examining the levels of mental processes retained under tutoring.

This research recognizes that a full understanding of the effects of instructional conditions must include knowledge of how those instructional conditions affect retention. This research is unique in examining retention of lower and higher mental processes under instruction which is adapted to the specific needs of each student. The third hypothesis was formulated to examine this relationship.

HYPOTHESIS 3: STUDENTS' RETENTION OF LOWER AND HIGHER MENTAL PROCESSES IS DETERMINED BY THE QUALITY OF THE INSTRUCTION.

We have described tutoring, Mastery Learning, and conventional group instruction before. Retention of lower and higher mental processes was estimated from an instrument which was a parallel form of the achievement posttest. The test of retention was administered approximately 3 weeks after the posttest. In these 3 weeks, students received no instruction in probability, the subject taught in this research.

We expected that retention of lower and higher mental processes would greatly depend on the level at which they were mastered at the end of instruction. In this sense, we expected that the third hypothesis would be satisfied to the degree that the first hypothesis was satisfied.

In Table 10 we analyze retention of lower and higher mental processes under tutoring, Mastery Learning, and conventional group instruction. For purposes of comparison, we repeat in Table 10 the posttest results. Table 10 reveals that there are large and statistically significant differences in retention under the different instructional conditions.

The average tutored student retained lower mental processes at a level above approximately 96 percent of the students under conventional instruction. And 88 percent of the tutored students retained lower mental processes at a level reached by only the top 20 percent of the control students.

Under tutoring, higher mental processes were retained at even higher levels. The average tutored student retained higher mental processes at a level above approximately 98 percent of the control students. And 96 percent of the tutored students retained higher mental processes at a level reached by only the top 20 percent of the control students.

Under Mastery Learning, the average student retained lower mental processes at a level above approximately 84 percent of the control students. And 57 percent of the Mastery students retained lower mental processes at a level reached by only the top 20 percent of the control students. Furthermore, the average Mastery student retained higher mental processes at a level above approximately 87 percent of the control students. And 64 percent of the Mastery

TABLE 10

FINAL ACHIEVEMENT AND RETENTION
UNDER THREE QUALITIES OF INSTRUCTION

		POST	RETENTION
Lower Mental Processes			
TUTORING N=36	MEAN	88.47**	85.28**
	STD	7.64**	8.70*
	E-S	(2.11)	(1.71)
MASTERY N=36	MEAN	79.72**	76.81**
	STD	10.75	10.96
	E-S	(1.40)	(1.01)
CONVENTIONAL N=36	MEAN	62.50	64.58
	STD	12.28	12.29
F STATISTIC		57.70***	34.20***
Higher Mental Processes			
TUTORING N=36	MEAN	87.36**	87.22**
	STD	7.51***	9.37**
	E-S	(2.11)	(1.99)
MASTERY N=36	MEAN	73.06**	74.72**
	STD	11.48*	11.39
	E-S	(1.21)	(1.13)
CONVENTIONAL N=36	MEAN	54.03	58.33
	STD	15.76	14.49
F STATISTIC		71.13***	53.03***

* = $p < .05$
** = $p < .01$
*** = $p < .001$

students retained higher mental processes at a level reached by only the top 20 percent of the control students.

The results in Table 10 demonstrate that, under tutoring and Mastery Learning, both final achievement and retention of lower and higher mental processes are at high levels.

In Figures 6 and 7, we plot LMP and HMP posttest and retention scores for each student. These plots indicate that there is a strong relationship between final achievement and retention of lower and higher mental processes. For both lower and higher mental processes, retention correlates approximately .75 with final achievement. This indicates that students brought to high levels of final achievement tend to retain that achievement at high levels.

For a closer look at the relationship between final achievement and retention we divided the distribution of scores into quadrants. The upper-right quadrant includes students whose posttest and retention scores were both 80 or better. Interestingly, most of the students who scored high on the posttest (to the right of the vertical line) scored high on retention (above the horizontal line). This further demonstrates that students brought to high levels of final achievement tend to retain that achievement at high levels. A few control students and a handful of Mastery students were high on both final achievement and retention. By far the majority of students who were high on both learned under tutoring.

Fig. 6. -- Final achievement and retention of lower mental processes under tutoring, Mastery, and conventional conditions.

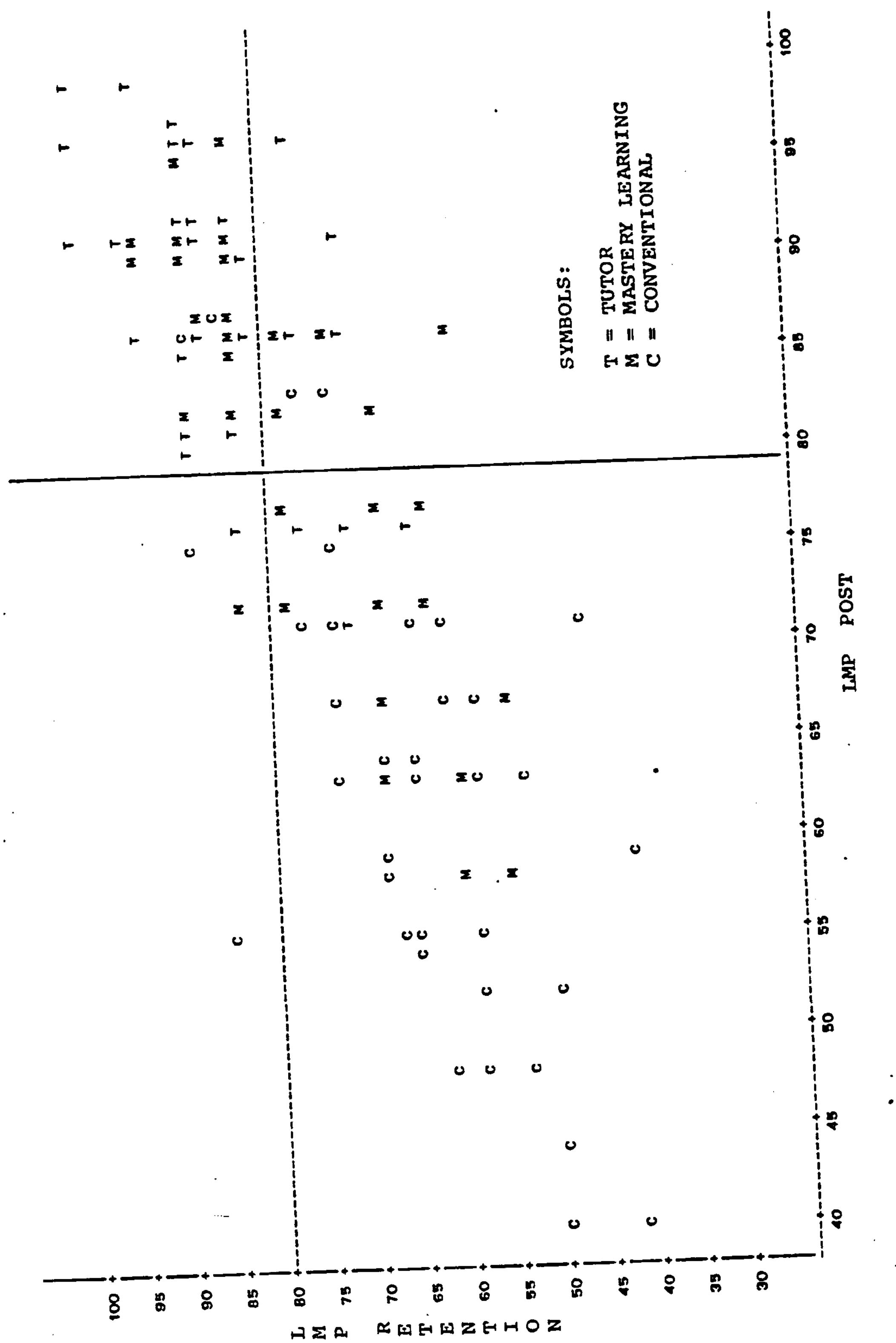
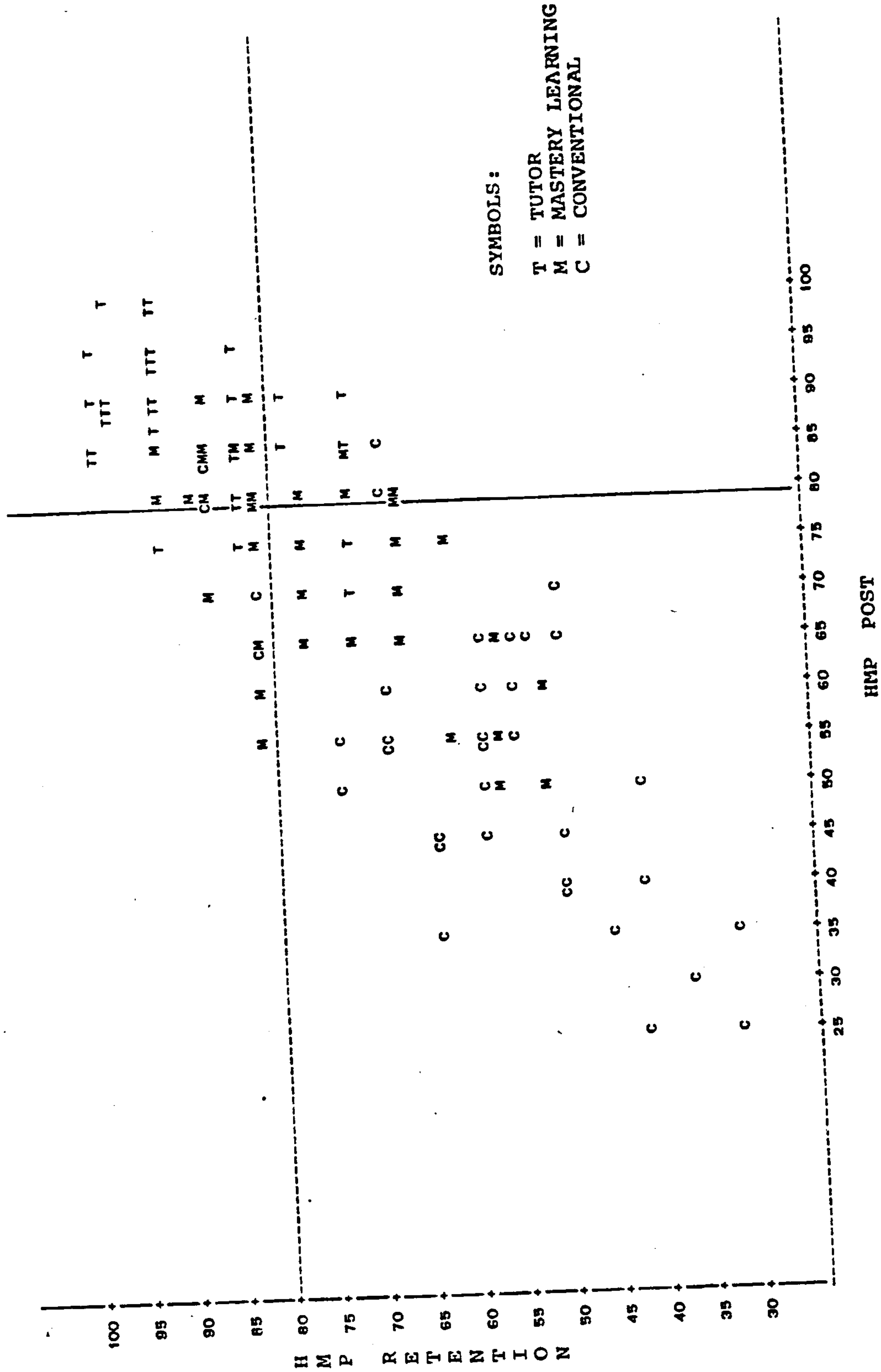

SYMBOLS:
T = TUTOR
M = MASTERY LEARNING
C = CONVENTIONAL
LMP POST
LMP RETENTION

Fig. 7. -- Final achievement and retention of higher mental processes under tutoring, Mastery, and conventional conditions.


SYMBOLS:
T = TUTOR
M = MASTERY LEARNING
C = CONVENTIONAL
HMP POST
25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
HMP RETENTION
100 95 90 85 80 75 70 65 60 55 50 45 40 35 30

On the basis of the analyses in Table 10 and the plots in Figures 6 and 7, the third hypothesis is affirmed. We conclude that students' retention of lower and higher mental processes is determined by the level of their final achievement, which, in turn, is determined by the quality of the instruction.

Instructional Quality And The Relationship Between Aptitude And Achievement

Research on instruction has consistently demonstrated (as we are reminded by the testing industry) that certain generalized cognitive traits are excellent predictors of achievement. The correlation between achievement and intelligence, ability, or aptitude tends to be .5 or better (Lavin, 1965). However, a growing body of research indicates that, under certain instructional conditions, these traits become almost unrelated to achievement. For example, Levin (1975) found that the correlation between ability and achievement was lower under Mastery Learning than under conventional instruction. Froemel (1980) found that, over six months, the correlation between ability and achievement remained almost constant under conventional instruction, but steadily decreased under Mastery Learning.

In the previous studies, the relationship between aptitude and achievement was contrasted under Mastery and conventional conditions. This research went further in examining how the association between aptitude and achievement can be reduced under improved instruction. This research examined the relationship between aptitude and achievement under tutoring, as well as under conventional and Mastery conditions.

At the first site, aptitude was estimated from the quantitative subtest of the Cognitive Abilities Test (CAT). At the second site, aptitude was estimated from the quantitative subtest of the Science Research Associates Achievement Test (SRA). These instruments estimate computational skills and knowledge and facility with mathematical symbols, concepts, and relations.

Because tutoring was adapted to the specific needs of each student, we expected that under tutoring the association between aptitude and achievement would become very weak. Because Mastery Learning provided periodic feedback and correction, we expected that here the association between aptitude and achievement would become weak. Because conventional instruction neither adapted instruction to specific needs nor provided periodic feedback and correction, we expected that here the association between aptitude and achievement would become increasingly stronger. Put another way, we expected that tutored and Mastery students would achieve at higher levels than control students of the same aptitude. Furthermore, we expected that, under tutoring and Mastery Learning, students of lower aptitude and students of higher aptitude would achieve at very similar levels, while under conventional instruction students of higher aptitude would achieve at considerably higher levels than students of lower aptitude.

Our analysis of the relationship between aptitude and achievement is in two parts. First, we present the correlations, over time, between aptitude and achievement under the three qualities of instruction. Second, we compare the final low and high mental process ahievement of students of low aptitude and students of high aptitude under each quality of instruction.

Table 11 presents the correlations, over time, between aptitude and lower and higher mental process achievement under tutoring, Mastery Learning, and conventional group instruction.

Under conventional group instruction, the association between aptitude and achievement tends to increase over time, becoming quite strong at the end. The exception is for final HMP achievement in fourth grade, where the association is quite weak. This may have happened because achievement in that grade was so near the "floor". Ignoring that case, aptitude accounts for between 20-50 percent of final achievement variance under conventional group instruction. The association between aptitude and achievement tends to be weaker, over time, under tutoring and Mastery Learning than under conventional instruction. The chief exception for tutoring is the high correlation for final LMP achievement at grade 5 of the first site. The chief

TABLE 11

CORRELATIONS BETWEEN APTITUDE AND ACHIEVEMENT
UNDER THREE QUALITIES OF INSTRUCTION

		UNIT 1	UNIT 2	UNIT 3	FINAL
	Aptitude and LMP achievement				
SITE 1 GRADE 4	TUTORING	.27	.24	.31	.32
	MASTERY	.35	.37	.44	.50
	CONVENTIONAL	.42	.50	.48	.71
SITE 1 GRADE 5	TUTORING	.23	.42	.22	.78
	MASTERY	.31	.27	.26	.26
	CONVENTIONAL	.30	.48	.38	.50
SITE 2 GRADE 5	TUTORING	.30	.29	.23	.18
	MASTERY	.43	.33	.28	.33
	CONVENTIONAL	.38	.40	.45	.52
	Aptitude and HMP achievement				
SITE 1 GRADE 4	TUTORING	.26	.25	.34	.35
	MASTERY	.33	.26	.21	.61
	CONVENTIONAL	.44	.63	.62	.26
SITE 1 GRADE 5	TUTORING	.25	.59	.17	.44
	MASTERY	.33	.22	.23	.34
	CONVENTIONAL	.35	.52	.30	.44
SITE 2 GRADE 5	TUTORING	.33	.30	.25	.24
	MASTERY	.40	.36	.27	.31
	CONVENTIONAL	.42	.35	.51	.67

exception for Mastery Learning is the high correlation for final HMP achievement at grade 4. Ignoring these anomalies, aptitude accounts for as little as 3 to 20 percent of final achievement variance under tutoring, and for 10 to 25 percent of final achievement variance under Mastery Learning.

The correlational evidence in Table 11 demonstrates that under conventional instruction the association between aptitude and achievement is quite strong, under tutoring and Mastery Learning considerably weakened. We can see this from a different perspective in Table 12.

Table 12 analyzes the final LMP and HMP achievement of students of lower and higher aptitude under each quality of instruction. Students above the aptitude median of each instructional group were classified as high aptitude; students below the aptitude median were classified as low aptitude. Two striking facts emerge in Table 12.

In all three replications, differences in achievement between students of low and high aptitude are much less under tutoring and Mastery Learning than under conventional instruction. Tutoring was adapted to the specific needs of both low and high aptitude students. As a result, the difference in final achievement between tutored students of low and high aptitude was very small. Through periodic feedback and correction, Mastery students of both low and high aptitude were well-prepared for each new task. As a result, the difference in final achievement between Mastery students of low and high aptitude was small. Conventional instruction

TABLE 12

ACHIEVEMENT
OF LOWER AND HIGHER APTITUDE STUDENTS
UNDER THREE QUALITIES OF INSTRUCTION

		LOWER MENTAL PROCESS		HIGHER MENTAL PROCESS	
		LOWER APTITUDE	HIGHER APTITUDE	LOWER APTITUDE	HIGHER APTITUDE
TUTORING [a]	MEAN	85.85	92.17	53.80	59.25
	STD	15.13	10.52	17.20	16.12
MASTERY	MEAN	69.25	77.25	42.41	50.77
	STD	18.75	15.08	20.42	18.12
CONVENTIONAL	MEAN	53.20	64.56	30.17	36.33
	STD	19.07	20.13	16.35	13.25
TUTORING [b]	MEAN	92.69	95.01	66.23	71.13
	STD	8.19	8.65	17.56	15.73
MASTERY	MEAN	80.13	86.35	49.50	57.26
	STD	15.15	13.14	19.35	16.77
CONVENTIONAL	MEAN	63.81	73.11	28.87	39.52
	STD	19.11	17.33	14.85	11.19
TUTORING [c]	MEAN	86.79	90.15	85.27	89.45
	STD	8.65	6.11	8.07	6.95
MASTERY	MEAN	77.83	81.65	70.77	75.05
	STD	12.34	8.55	12.36	10.33
CONVENTIONAL	MEAN	57.75	67.25	48.83	59.23
	STD	11.01	13.45	16.45	14.89

[a] Site 1 - Grade 4.

[b] Site 1 - Grade 5.

[c] Site 2 - Grade 5.

did not meet each learner's specific needs, nor did it provide systematic feedback and correction. As a result, here students of high aptitude achieved considerably above students of low aptitude.

Second, in all three replications low aptitude students under tutoring and Mastery Learning learned more than high aptitude students under conventional instruction. Under tutoring, the final achievement of low aptitude students was at such high levels because, under instruction adapted to their specific needs, these students learned each task to a high level. Under Mastery Learning, the final achievement of low aptitude students was at high levels because periodic feedback and correction made these students able to learn new tasks better under group instruction.

Instructional Quality And Students' Affect

It is often found that, as their achievement in a subject improves, students become more interested in the subject, come to value it more highly, and develop greater confidence in their ability to learn it (Block, 1970; Arlin, 1973; Anderson, 1973; Ozcelik, 1973; Levin, 1973). We expected achievement in probability to improve significantly under tutoring and Mastery Learning. We also expected that over time, as their achievement reached higher levels, the tutored and the Mastery students would develop more positive affect towards probability. In contrast, we expected that over time, as their achievement remained at lower levels or decreased, the control students would develop very negative affect toward probability.

We examined three dimensions of students' affect toward probability. We estimated students' interest in probablity from their desire to learn more about it. We estimated students' attitude toward probability from the value they placed on it in comparison to other subjects. Lastly, we estimated students' self-concept in relation to probability from the way they saw themselves as competent or incompetent learners of this subject.

Affect was examined only at the second site. Interest, attitudes, and self-concepts regarding probability were monitored by students' self-reports before instruction, at the end of each learning task, and after the students had been informed of their final achievement.

Table 13 presents the analysis of affect, over time, under tutoring, Mastery Learning, and conventional group instruction. The affect scores analyzed in Table 12 are composites of the interest, attitude, and self-concept scores for each student. A higher score means more positive affect.

As we expect under random assignment, affect toward probablity was initially the same in all three treatments. By the end of the first task, as their achievement became significantly higher than the achievement of the control students, the affect of the tutored students toward

TABLE 13

STUDENTS' AFFECT, OVER TIME, UNDER THREE QUALITIES OF INSTRUCTION

		PRETEST	UNIT 1	UNIT 2	UNIT 3	POST
TUTORING N=36	MEAN	21.34	25.23*	28.90*	30.09**	33.66**
	STD	8.65	8.13	8.15	7.72	8.05
MASTERY N=36	MEAN	23.77	23.15	25.42	27.35*	30.33*
	STD	9.29	8.43	8.07	8.61	9.11
CONVENTIONAL N=36	MEAN	22.47	20.08	23.83	22.41	24.41
	STD	8.27	8.38	7.82	9.11	11.56
F STATISTIC		.70	3.50*	3.77*	7.55***	8.05***

* = $p < .05$
** = $p < .01$
*** = $p < .001$

probability was significantly more positive than the affect of the control students. The affect of the Mastery and the control students was quite similar, because both these groups learned the first task under similar conditions.

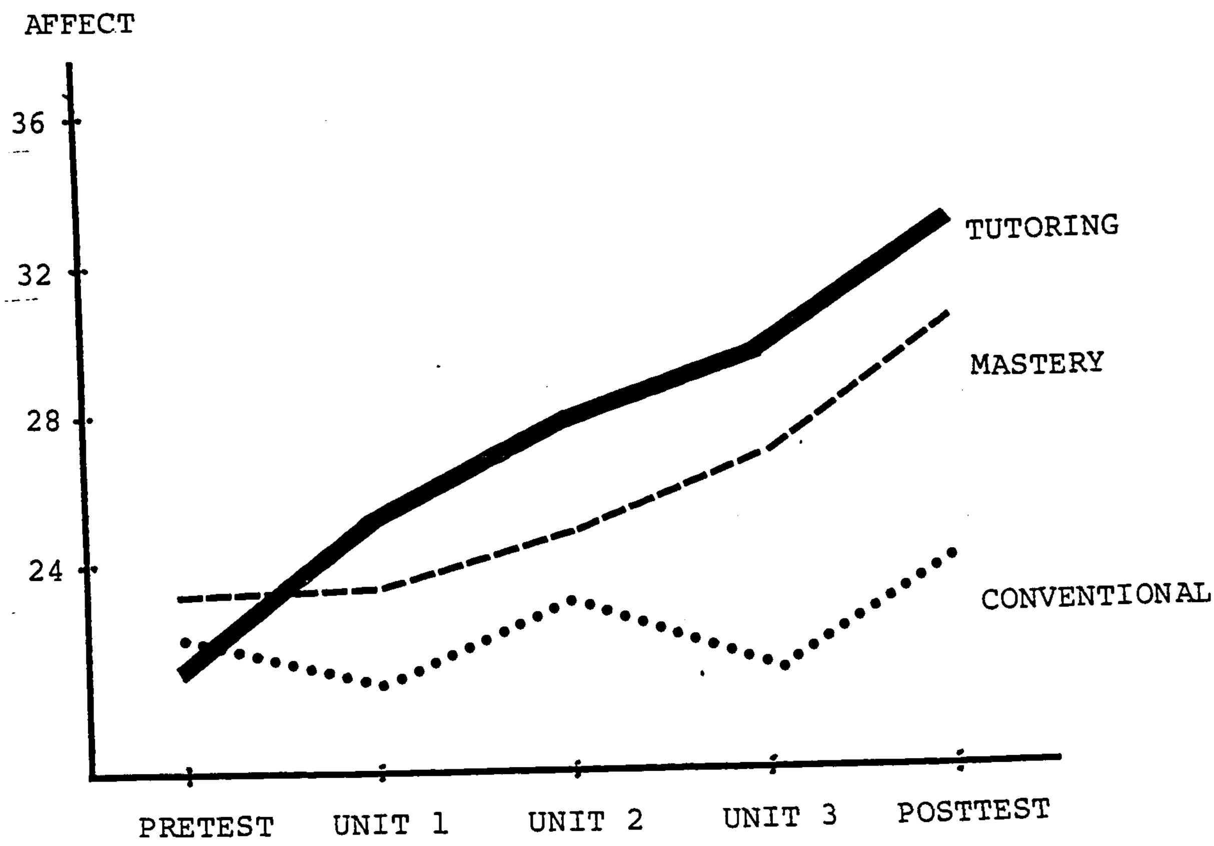
By the end of the second unit, the affect of the tutored students was even more positive. This happened because their achievement had improved from the level of the first unit. The affect of the Mastery students was more positive, but not statistically more positive than the affect of the control students.

By the end of the third unit, the achievement of the tutored students had risen still higher and their affect had grown still more positive. The affect of the Mastery students was now statistically more positive than the affect of the control students.

The differences on the affective posttest were the largest of all. The affective posttest was completed after the students had been informed of their final achievement. Just as final achievement under tutoring and Mastery Learning was considerably higher, final affect under tutoring and Mastery Learning was statistically more positive than under conventional instruction.

The levels of affect from Table 13 are plotted in Figure 8. Figure 8 shows the dramatic improvement in affect toward probability under tutoring and Mastery Learning, while under conventional instruction affect toward probability remains at less positive levels.

Fig. 8. -- Graph of affect, over time, under tutoring, Mastery, and conventional conditions.


AFFECT
36
32
28
24
TUTORING
MASTERY
CONVENTIONAL
PRETEST
UNIT 1
UNIT 2
UNIT 3
POSTTEST

In Figure 9 we show the differences between the treatments in the proportions of students who responded positively to three representative items from the affective posttest. One item sampled students' interest in further learning of probability; the second sampled students' attitude towards probability in comparison with other subjects; and the third sampled students' self-concept about their learning in probability.

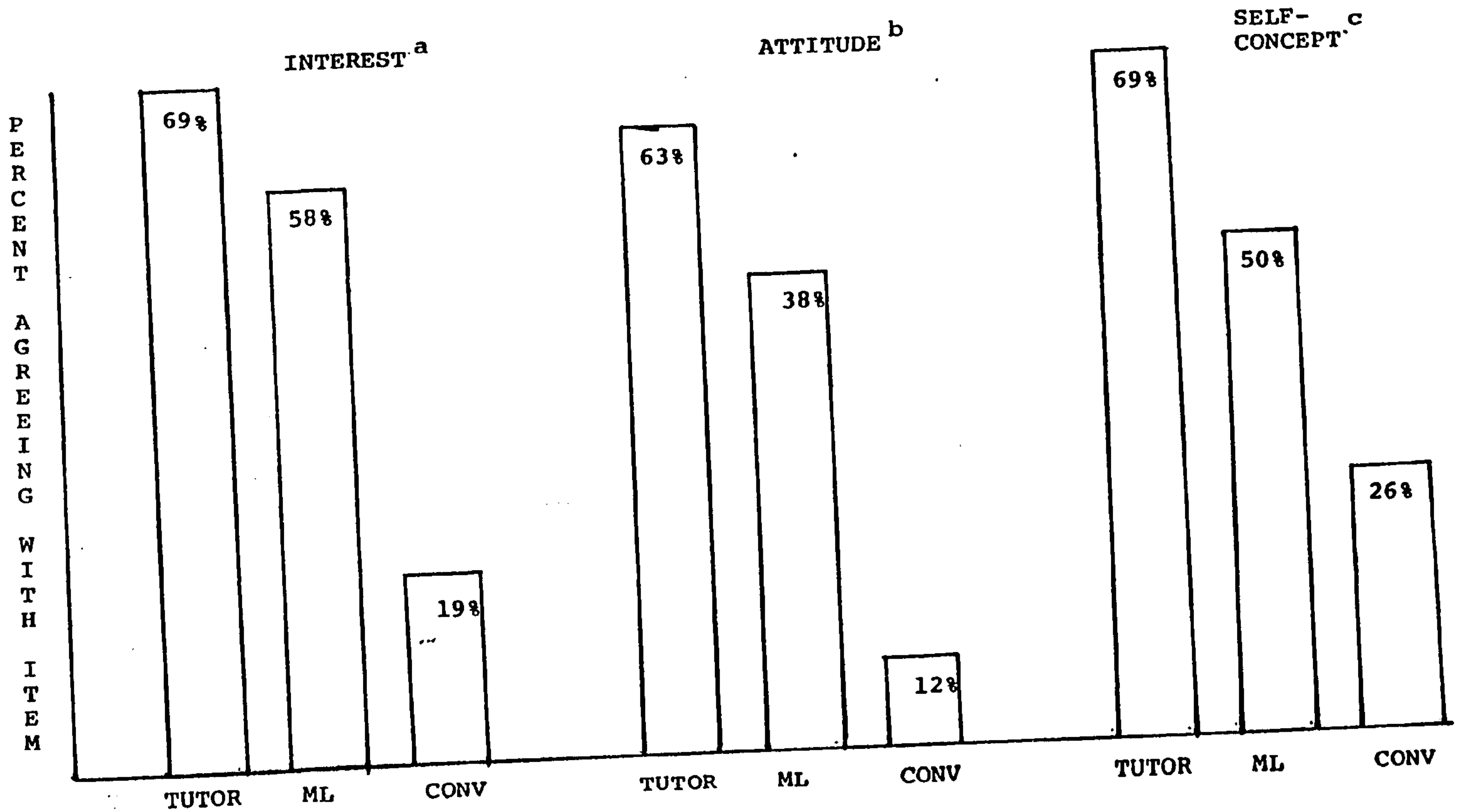
After the three weeks of instruction, over two-thirds of the tutored students and over half of the Mastery students desired to learn more about probability. Only one-fifth of the control students wanted to learn more about probability.

Almost two-thirds of the tutored students and two-fifths of the Mastery students reported that probability was the subject they liked most. Only one-tenth of the control students reported that probability was the subject they liked the most.

Approximately two-thirds of the tutored students and half of the Mastery students reported that they were doing very well in probablity. Only one-fourth of the control students reported that they were doing very well in probability.

We conclude from the evidence in this section that, under tutoring and Mastery Learning, not only does achievement in a subject tend to be very high but affect towards that subject tends to be very positive.

Fig. 9. -- Responses to certain affective items under tutoring, Mastery, and conventional conditons.



[a] I would like to learn more about probability.
[b] The subject I like most is probability.
[c] I think I am doing very well in probability.

CHAPTER V

SUMMARY, LIMITATIONS, AND CONCLUSIONS

Purpose Of This Research

Teaching students in large groups is the most common instructional arrangement throughout the world. This remains true despite the fact that large groups so divide the teacher's time and attention that even skillful teachers can not meet the specific needs of each student. Students who do not receive instruction appropriate to their needs are likely to develop errors on each learning task. As a result, when students are taught in groups most accumulate so many errors that their final achievement is at very low levels.

In attempting to overcome the disadvantages of group instruction, various approaches tailor instruction to support different learning needs. For example, Computer-Assisted Instruction provides unending drill; Mastery Learning provides systematic feedback and correction (Bloom, 1976); Advance Organizers provide introductory cues to the main points of each lesson (Ausubel, 1963); and Keller's Personalized System of Instruction provides the reinforcement of allowing students to proceed at their own pace (Keller, 1968).

Using methods for research synthesis, we can compare students' achievement under these different approaches. Under the most effective of them, Mastery Learning, the average student typically achieves at a level above approximately 80 percent of the control students. Clearly, this is the development of students' potential to quite a high level.

These approaches are successful because each enhances a particular dimension of instruction. However, in so doing equally important dimensions are ignored. This makes it unlikely that students' potential for learning could ever be fully developed under any one of these approaches. The purpose of this research was to investigate students' potential for learning under instruction which is fully adapted to each student's specific learning needs.

To explore this idea, this research contrasted students' cognitive and affective attainments under tutorial and group approaches to instruction. Three qualities of instruction were investigated.

A. Under tutoring, the instruction was fully adapted to the specific needs of each student.

B. Under Mastery Learning, periodic feedback and correction improved each student's ability to learn under group instruction.

C. Under conventional instruction, the teacher was unable to adapt instruction to the specific needs of each member of a large group of students.

Conceptual Framework

The conceptual framework of this research was derived, with some modification, from Bloom's (1976) theory of school learning. The model for this research states that students' achievement is determined by their learning processes and that these learning processes are, in turn, determined by the quality of the instruction. The model predicts that, when instruction is appropriate to each student's specific needs, most students will learn each task at a high level. When this happens, final achievement will be at very high levels. Furthermore, the model predicts that when final achievement is at high levels, retention will also be at high levels. Whenever achievement is at high levels, students' affect toward their learning will be very positive. Lastly, the model predicts that when instruction is appropriate for each students' specific needs students of low aptitude will learn as well as students of high aptitude.

Research Issues

This research addressed five major issues. The first was whether instruction adapted to each learner's specific needs produces significantly higher achievement than conventional instruction. The second was whether students' learning processes are significantly more effective under superior instruction than under conventional instruction. The third was whether students under superior instruction retain their achievement at high levels. The fourth was whether, under superior instruction, students of low aptitude learn as well as students of high aptitude. The fifth was whether students' affect towards learning is significantly more positive under superior instruction than under conventional instruction.

Sample

This study was replicated three times, at two sites. The first site included approximately 170 fourth and fifth graders from a parochial school in a blue-collar suburb of a large midwestern city. The second site included 108 fifth graders from a public school in a small, working-class, middle-atlantic town.

At both sites, tutors were undergraduate education students participating as part of their pre-professional training. The Mastery and the conventional groups were taught by the students' regular mathematics teachers.

In all three replications, students were randomly assigned to learn probability under one of three conditions: tutoring, Mastery Learning, or conventional group instruction.

Subject And Instructional Materials

The subject taught in this research was probability. Probability was chosen because it was a new topic for the students in our sample, because attractive commercial materials were available, and because a technical, sequential subject was appropriate for studying lower and higher mental processes.

A three-week, three-unit course was developed from the commercial materials. Topics in this course included the following: the probability of a simple event, the probability of a compound event, the probability of the union of any two events, and the probability of certain, impossible, or mutually exclusive events.

Instructional Treatments

In the model for this research, students' cognitive and affective outcomes are determined by the quality of the instruction. The quality of the instruction is the degree to which cues, participation, reinforcement, and feedback and correction are appropriate to the specific needs of each learner. We operationalized instructional quality in three treatments.

Conventional Group Instruction

Here, teachers lectured and led discussions. Lesson plans were provided by the experimenter, but on occasion these were abandoned in favor of the teacher's own strategies. While instructional activities most often involved the whole class, for some activities students were formed into groups.

The demands of instructing a group of learners limited the time and attention teachers devoted to individual learners. Beyond what flowed out of the group instruction, cues, participation, reinforcement, and feedback and correction were not adapted to the specific needs of each student. And at no time were students tutored individually by the teacher outside class. Finally, here tests were used only to record students' achievement, not as a basis for feedback and correction. In our model, these conditions represented a "low" quality of instruction.

Mastery Learning

Instruction under Mastery Learning was very similar to instruction under the conventional conditions. However, there was one important difference. At the end of each instructional unit, Mastery students completed a formative test. Students who did not reach 80 percent correct on this test were assigned corrective work. Students were retested following correction, and any students who still had not reached the criterion were assigned further corrective work. The goal of this process was to bring as many students as possible to mastery of each instructional unit.

Tutoring

Tutors were trained, by the experimenter, to make instruction as appropriate as possible to the specific needs of each student.

In our model, tutoring represented the optimal quality of instruction. Instruction under tutoring was fundamentally different from instruction under the Mastery and the conventional conditions. Each tutor was responsible for three learners. Tutors provided instructional cues appropriate for each student's learning style. Tutors kept each student in active participation during learning activities. Tutors praised and encouraged each student's successful efforts. Most importantly, tutors provided feedback and correction during instruction and at the end of instruction based on formative tests. Tutored students were required to reach a criterion of 90 percent correct for each instructional task.

Variables

Aptitude

At the first site, aptitude was estimated from the quantitative subtest of the Cognitive Abilities Test. At the second site, aptitude was estimated from the quantitative subtest of the Science Research Associates Achievement Test. These instruments estimate computational skills and knowledge and facility with mathematical symbols, concepts, and relations.

Time On-Task

Time on-task was the amount of time students were actively engaged in learning. Percent of time on-task was estimated from observations of each student's behaviors during instruction. Students were rated "on-task" when they were observed to be actively participating in the learning activities.

Rate of Learning

Rate of learning was calculated for each student from measures of the student's achievement in relation to the student's time on-task.

Instructional Processing Behaviors

We defined four components to students' processing of instruction. These components -- cues, participation, reinforcement, and feedback and correction -- were monitored, over the series of learning tasks, by observation and by students' self-reports.

Instructional cues were verbal or written indications of the main points of each lesson and what the students had to do in learning them. Instructional cues determined whether the lessons were understood.

Participation was the student's active engagement in learning activities. The amount of active participation indicated the opportunity students had to fix the learning firmly in their minds.

Reinforcement was the reward of students' successful learning or the correction of their unsuccessful learning, with the expectation that the reward or the correction would spur further successful learning.

Feedback identified errors in learning so that they could be systematically corrected. Feedback and correction were most important in determining whether students were well-prepared for successive learning tasks.

Instructional processing behaviors were monitored by students' self-reports and by observation over the series of tasks.

Achievement Outcomes

Lower Mental Processes

Lower mental process achievement was estimated from test items at the Knowledge or Comprehension levels of the *Taxonomy of Educational Objectives* (Bloom, 1956). Lower mental processes included solving familiar problems, translating expressions from verbal to symbolic form, or identifying facts, terms, rules, or principles.

Higher Mental Processes

Higher mental process achievement was estimated from test items at the Application or Analysis levels of the *Taxonomy*. Higher mental processes included solving problems different from those encountered during instruction and distinguishing relevant from irrelevant information in developing solutions to problems.

Monitoring Lower and Higher Mental Processes

Lower and higher mental processes were monitored on three sets of instruments. Formative tests monitored students' achievement at the end of each instructional task and, for tutored and Mastery students, were the basis for feedback and correction. Final lower and higher mental process achievement was monitored on the posttest. Lastly, three weeks after the end of instruction, retention of lower and higher mental processes was monitored at the second site.

Affective Outcomes

Affective outcomes included interest, attitudes, and self-concepts in regard to probablity, the subject taught in this research. We estimated students' interest in probablity from their desire to learn more about it. We estimated students' attitude toward probability from the value they placed on it in comparison with other subjects. Lastly, we estimated students' self-concept in relation to probability from whether they saw themselves as competent or incompetent learners. Interest, attitudes, and self-concepts regarding probability were monitored by self-report before instruction, at the end of each learning task, and after the students had been informed of their final achievement.

Instructional Quality And Students' Achievement

Students' potential for learning has been improved by a number of instructional approaches. For example, under Advance Organizers the average student achieves at the 58th percentile of students who learn under conventional instruction (Luiten, Ames, and Ackerson, 1980); under Keller's Personalized System of Instruction the average student achieves at the 69th percentile of students who learn under conventional instruction (Kulik, Kulik, and Cohen, 1978; and under Mastery Learning the average student achieves at the 80th percentile of students who learn under conventional instruction (Block and Burns, 1977).

Students' potential for learning has improved significantly under each of these approaches. But each of these approaches enhances only a single dimension of instruction -- and ignores others. As a result, students' potential for learning can not be fully developed under any of these approaches. The thesis of this research was that students' potential for learning will be developed to very high degrees when the instruction is fully adapted to the specific needs of each student. The first hypothesis explored students' learning of lower and higher mental processes under instruction adapted in different degrees to the specific needs of each student: conventional group instruction, Mastery Learning, and tutoring.

HYPOTHESIS 1: STUDENTS' LOWER AND HIGHER MENTAL PROCESS ACHIEVEMENT IS DETERMINED BY THE QUALITY OF THE INSTRUCTION.

The cognitive characteristics of the students under the three instructional conditions were very similar at the beginning of instruction. By the end of instruction, dramatic differences had emerged. The final achievement of the average tutored student was at a level above approximately 95 percent of the control students. And under tutoring, the distribution of achievement had changed such that approximately 90 percent of the tutored students achieved at a level reached only by the top 20 percent of the control students.

The final achievement of the average Mastery student was at a level above approximately 85 percent of the students under conventional instruction. And approximately 60 percent of the Mastery students achieved at a level reached only by the top 20 percent of the control students. These differences held for both lower and higher mental processes.

The high levels of final achievement under tutoring and Mastery Learning are explained by the pattern of achievement under these conditions over time. Very early, achievement was significantly higher and less variable under tutoring than under conventional instruction. This happened because tutoring adapted instruction to the specific needs of each learner. And under the tutor's constant attention, over time the achievement of the tutored students reached the highest levels.

Under Mastery Learning, feedback and correction brought most students to a high level for the first learning task. This helped Mastery students learn succeeding tasks better under group instruction, so that, over time, their achievement reached significantly higher levels than the achievement of the control students.

Under conventional instruction, the specific needs of most students were not met. Nor did these students receive systematic feedback and correction to learn each task at a high level before proceeding to the next task. As a result, over the series of tasks students' achievement was significantly lower and more variable under conventional instruction than under tutoring and Mastery Learning.

Instructional Quality, Students' Learning Processes, And Students' Achievement

We did not undertake this research to demonstrate that achievement is higher under tutoring and Mastery Learning than under conventional instruction. We had a more important purpose: to demonstrate that students receiving superior instruction achieve at very high levels because they process instruction very effectively.

We define students' processing of instruction to include their time on-task, their rate of learning, and certain of their mental and physical behaviors during instruction. Research has shown that under mastery conditions students are on-task more (Anderson, 1973) and learn faster (Block, 1970; Arlin, 1973) than students under non-mastery conditions. Furthermore, Hecht (1979) has shown that, over time, Mastery students learn better under group instruction; that is, Mastery students use cues, participation, reinforcement, and feedback and correction more effectively under group conditions. Nordin (1979) has shown that instruction specifically designed to enhance cues, participation, both cues and participation, or feedback and correction has positive effects on students' behaviors and subsequently on students' achievement.

The model for this research predicts that the quality of the instruction determines the students' learning processes, and that these learning processes then determine the students' achievement. The first hypothesis examined the direct effects of the quality of the instruction on the students' achievement. The second hypothesis examined the effects of the quality of the instruction on the students' learning processes.

HYPOTHESIS 2: ACHIEVEMENT IS DETERMINED BY STUDENTS' LEARNING PROCESSES, WHICH, IN TURN, ARE DETERMINED BY THE QUALITY OF THE INSTRUCTION.

Processing Behaviors And Achievement Under Three Qualities Of Instruction

Processing behaviors relate to cues, participation, reinforcement, and feedback and correction.

Each tutor managed the learning of only three students. This allowed instruction to be adapted to the specific learning needs of each one. As a result, the tutored students processed instruction significantly better than the control students. Compared to the students under conventional instruction, the tutored students participated more actively, better understood the main points of each lesson, corrected their errors more effectively, and found more satisfaction in their learning. And as a result of these efficient processing behaviors, the tutored students achieved at significantly higher levels than the students under conventional instruction.

Learning conditions were identical under the Mastery and the conventional conditions: one teacher managed the learning of approximately 30 students. However, Mastery students received feedback and correction which helped them learn each task at a high level.

Because they were well-prepared for each new learning task, over time the Mastery students processed instruction more efficiently under group conditions. They began to participate more actively, to understand the main points of each lesson, to identify and correct their errors, and to find considerable satisfaction in their learning. And since their learning behaviors were efficient, the Mastery students achieved at significantly higher levels than the the students under conventional instruction.

Under conventional instruction, the teacher's time and attention were divided among 30 students. Because the instruction was not adapted to their specific needs, over time the control students processed instruction less efficiently. They had greater difficulty understanding the main points of each lesson; they did not participate actively enough to fix the main points firmly in their minds; they did not receive sufficient feedback and correction to control their errors; and they found less satisfaction in their learning. It is thus no surprise that the achievement of these students was significantly lower and more variable than the achievement of the tutored and the Mastery students.

Learning Time And Achievement Under Three Qualities Of Instruction

Time On-Task and Achievement

Each tutor managed the learning of only three students. As a result, on the first unit learning behaviors under tutoring were so effective that time on-task and achievement were both significantly higher than under conventional instruction. On the other hand, because the Mastery and control students learned the first unit under group conditions, their time on-task and achievement were at lower levels.

On the second unit, learning behaviors under tutoring had become even more effective than before. As a result, under tutoring time on-task and achievement reached higher levels than before, levels significantly higher than under conventional instruction. Learning behaviors under Mastery Learning had also become more effective than before. As a result, time on-task and achievement were now significantly higher under Mastery Learning than under conventional instruction.

On the third unit, as learning behaviors under tutoring became very effective, time on-task and achievement were significantly higher than under conventional instruction. Learning behaviors under Mastery Learning also became more effective. Thus time on-task and achievement became significantly higher under Mastery Learning than under conventional instruction. In contrast, under conventional instruction learning behaviors remained less effective. As a result, time on-task and achievement remained significantly lower under conventional instruction than under tutoring and Mastery Learning.

Rates of Learning

Because of extra time for correction, the average tutored student spent approximately 10 percent more time in instruction than the average control student -- the average

Mastery student spent approximately 14 percent more time than the average control student. These differences were statistically significant.

It is enlightening to compare rates of learning in terms of the estimated amount of time needed to learn probability to a level of 100 percent correct. To learn to this level, the average tutored student would have needed an additional 17 percent more instructional time beyond the amount actually spent. The average Mastery student would have needed an additional 35 percent more instructional time beyond the amount actually spent. The average control student would have needed an additional 77 percent of instructional time beyond the amount actually spent.

These results should not be interpreted as indicating absolute differences in rates of learning under the different qualities of instruction. The proper interpretation of these results is that, in comparison with conventional instruction, whatever extra time is spent in learning under tutoring and Mastery Learning is amply repaid in achievement.

Instructional Quality And Students' Retention Of Lower And Higher Mental Processes

Research on instruction has looked very closely at final achievement, less closely at retention. In reviewing research on Mastery Learning, Block and Burns (1977) found only 7 studies comparing retention under Mastery and non-

Mastery conditions. However, in all 7 studies both final achievement and retention were higher under the Mastery conditions. This suggests that when final achievement is at high levels retention will also be at high levels.

Very few studies have examined the mental processes retained under different instructional conditions. One study suggests that students under Mastery conditions retain significantly more lower mental processes, but not significantly more higher mental processes, than students under non-Mastery conditions (Poggio, 1976). We have been unable to locate a single study examining the levels of mental processes retained under tutoring.

This research recognizes that a full understanding of the effects of instructional conditions must include knowledge of how those instructional conditions affect retention. This research is unique in examining retention of lower and higher mental processes under instruction which is adapted to the specific needs of each student. The third hypothesis was formulated to examine this relationship.

HYPOTHESIS 3: STUDENTS' RETENTION OF LOWER AND HIGHER MENTAL PROCESS ACHIEVEMENT IS DETERMINED BY THE QUALITY OF THE INSTRUCTION.

Under tutoring and Mastery Learning, both final achievement and retention of lower and higher mental processes were at high levels. In fact, levels of retention, for both lower and higher mental processes, were significantly higher under tutoring and Mastery Learning than under conventional instruction. This indicates that when final achievement is at high levels, for most students that high level of achievement is retained.

Instructional Quality And The Relationship Between Aptitude And Achievement

Research on instruction has consistently demonstrated that generalized cognitive traits such as ability, aptitude, and intelligence are excellent predictors of achievement. Over many studies, these traits tend to correlate .50 or better with achievement (Lavin, 1965). However, a growing body of research indicates that, under under improved instruction, these traits become less related to achievement. For example, Levin (1975) found that the correlation between ability and achievement was lower under Mastery Learning than under conventional instruction. Froemel (1980) found that, over six months, the correlation between ability and achievement remained almost constant under conventional instruction, but steadily decreased under Mastery Learning.

In the previous studies, the relationship between aptitude and achievement was contrasted under Mastery and conventional conditions. This research went further -- this research examined the relationship between aptitude and achievement under tutoring, as well as under conventional and Mastery conditions.

Under conventional instruction, the association between aptitude and achievement increased over time -- here aptitude accounted for 20 to 50 percent of final achievement variance. Under Mastery Learning, the association between aptitude and achievement decreased over time -- here aptitude accounted for 10 to 25 percent of final achievement variance. Under tutoring, the association between aptitude and achievement became very weak over time -- here aptitude accounted for 3 to 20 percent of final achievement variance.

We did more than examine the statistical association between aptitude and achievement under the different treatments. For each treatment, we compared the final achievement of students of low aptitude with the final achievement of students of high aptitude. Students above the aptitude median of each treatment were classified as high aptitude; students below the aptitude median were classified as low aptitude.

In all three replications, differences in achievement between students of low and high aptitude were much less under tutoring and Mastery Learning than under conventional instruction. This happened under tutoring because instruction was adapted to the specific needs of tutored students of both low and high aptitude. This happened under Mastery Learning because these students became well-prepared, through feedback and correction, for each new task. Conventional instruction did not meet each learner's specific needs, nor did it provide systematic feedback and correction. As a result, here students of high aptitude achieved considerably above students of low aptitude.

What is especially noteworthy, in all three replications the low aptitude students receiving tutoring and Mastery Learning achieved at higher levels than the high aptitude students receiving conventional instruction.

Instructional Quality And Students' Affect

It is frequently found that, as their achievement in a subject improves, students become more interested in the subject, come to value it more highly, and develop greater confidence in their ability to learn it (Block, 1970; Arlin, 1973; Anderson, 1973; Ozcelik, 1973; Levin, 1973). We found that achievement in probability did improve significantly under tutoring and Mastery Learning. We also expected that over time, as their achievement reached higher levels, the tutored and the Mastery students would develop more positive affect towards probability. In contrast, we expected that over time, as their achievement remained at lower levels or decreased, the control students would develop very negative affect toward probability.

We examined three dimensions of students' affect toward probability. We estimated students' interest in probablity from their desire to learn more about it. We estimated students' attitude toward probability from the value they placed on it in comparison to other subjects. Lastly, we estimated students' self-concept in relation to probability from the way they saw themselves as competent or incompetent learners of this subject.

As expected under random assignment, initial affect toward probablity was the same in all three treatments. By the end of the first task, as achievement became significantly higher under tutoring than under conventional instruction, the tutored students' affect toward probability was also significantly more positive. The Mastery and conventional groups learned the first task under similar conditions. As a result, students' affect was similar under these conditions.

By the end of the second unit, the affect of the tutored students was even more positive. This happened because their achievement had further improved over the level of the first unit. The affect of the Mastery students was more positive, but not statistically more positive than the affect of the students under conventional instruction.

By the end of the third unit, the achievement of the tutored students had risen still higher and their affect had grown still more positive. The affect of the Mastery students was now statistically more positive than the affect of the students under conventional instruction.

The affective posttest was completed after the students had been informed of their final achievement. Just as final achievement under tutoring and Mastery Learning was considerably higher, final affect under tutoring and Mastery

Learning was statistically more positive than under conventional instruction.

Limitations Of This Research

We undertook this research to contrast students' potential for learning under tutorial and group approaches to instruction. To do this, we created a more powerful design than is typically found in educational research. Three features of the design are especially noteworthy. First, the study was replicated three times. Second, in each replication students were assigned randomly to treatment. Third, the number of students involved was quite large -- approximately 270. Because of these features, we believe that this research was a valid investigation of fourth and fifth graders' potential for learning probability.

However, in order to do the study at all we had to enforce some limitations. This research was conducted in one subject, for three weeks, with students very close in age. To demonstrate that these findings apply to most school learning, this research has to be replicated with instruction in many different subjects. To demonstrate that these findings apply to most students, this research has to be replicated with students of different ages. To demonstrate the full effects of superior instruction on students' potential for learning, this research has to be replicated over a much greater length of time.

Implications Of This Research

The central finding of this research was that, under tutoring, most students achieve at very high levels. Despite this, we do not suggest that the way to overcome low achievement is to shrink the classroom to the size of one instructor and one student. Tutoring may never be a practical medium for instruction in schools. This finding should stimulate a search for methods of group instruction which approximate the effectiveness of tutoring.

In this research, not only did most tutored students achieve at very high levels, but most achieved at high levels on higher mental processes. The implications of this finding extend beyond the learning of probability. The important implication is that most students can learn higher mental processes as the quality of the instruction improves.

Tutoring developed both lower and higher mental processes to very high levels. But the effect of tutoring was not only on the levels of students' learning. Tutoring also increased students' respect for learning, their desire for further learning, and their confidence that new learning would be successful. This implies that most students can be motivated to learn when instruction is adapted to their specific needs.

Perhaps the most important implication of this research is that the student's potential for learning can not be accurately predicted from the student's home environment, from tests of the student's aptitude, or from the student's prior achievement under conventional instruction. The student's full potential for learning can properly be estimated only from the student's learning under the most effective instructional conditions that can be devised.

APPENDIX

PROFILES OF ACHIEVEMENT UNDER TUTORING, MASTERY, AND CONVENTIONAL CONDITIONS

In this appendix, I analyze statistically the profiles of achievement under tutoring, Mastery Learning, and conventional instruction. In doing this, I have chosen between two suggestions offered by John Bormuth. The first was that a formal investigation of the achievement profiles would help to explain how the effects of the treatments unfold over time. The second was that the achievement profiles should be investigated in relation to certain characteristics of the tests.

This second issue reflects Bormuth's continuing interest not only in the operational approach to constructing achievement tests, but also in the implications of that approach for evaluation (Bormuth, 1970). To pursue this properly would require a great deal of background and analysis -- more than we can include here. I analyze the first issue in hope of throwing new light on the nature of learning under the different instructional conditions -- this remains true to the original purpose of this dissertation.

In order to analyze the LMP and HMP profiles statistically, we treat our data as a split-plot, repeated measures design. This name reflects the fact that the subjects were split so that each subject was measured repeatedly under one and only one treatment.

This design is described in standard textbooks, such as Kirk (1965). This design allows us to investigate three hypotheses. The first is whether the profiles of the different treatments are parallel. The second is whether the profiles of the different treatments are at the same "height". The third is whether the profiles are flat. The last two are interpreted if the first is affirmed.

Profiles Of Lower Mental Processes Under Three Qualities Of Instruction

Figure 10 displays the profiles for lower mental processes in the three replications of this study. Scores plotted in Figure 10 are from the first formative test of each unit and the posttest. Within each replication, the LMP profiles look approximately the same. We detect a modest improvement, over time, under tutoring and Mastery Learning, and a relatively flat profile under conventional instruction. More importantly, at all times the LMP profiles are at higher levels under tutoring than under conventional instruction. And after the first unit, the LMP profiles are at higher levels under Mastery Learning than under conventional instruction.

These impressions are confirmed statistically in Table 14. In only the third replication is the departure from parallelism significant, and that departure is relatively small. However, it does not follow from the fact that the

Fig. 10. -- Profile of lower mental process achievement under tutoring, Mastery, and conventional conditions.

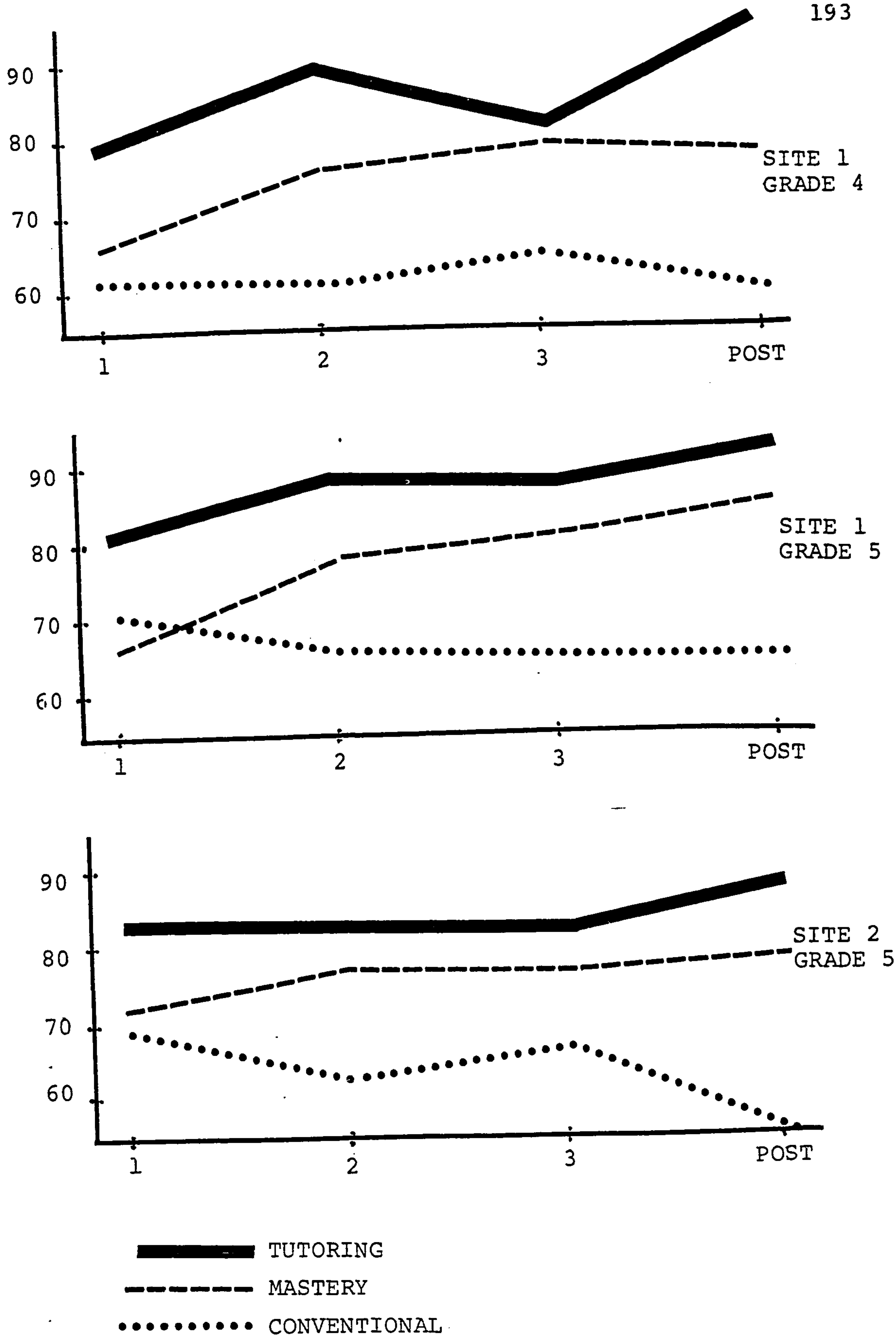

90
80
70
60
SITE 1
GRADE 4
1
2
3
POST
90
80
70
60
SITE 1
GRADE 5
1
2
3
POST
90
80
70
60
SITE 2
GRADE 5
1
2
3
POST
TUTORING
MASTERY
CONVENTIONAL

TABLE 14

PROFILE ANALYSIS
OF LOWER MENTAL PROCESSES

Site 1 -- Grade 4

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F
TREATMENT	123.95	2	61.97	32.79***
SUBJECTS WITHIN GROUPS ERROR	155.00	82	1.89	
UNIT	6.72	3	2.24	1.09
TREATMENT X UNIT	12.20	6	2.03	.99
UNIT X SUBJECTS WITHIN GROUPS	503.76	246	2.05	

Site 1 -- Grade 5

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F
TREATMENT	95.47	2	47.73	24.46***
SUBJECTS WITHIN GROUPS ERROR	158.08	81	1.95	
UNIT	20.34	3	6.78	3.47*
TREATMENT X UNIT	22.99	6	3.83	1.96
UNIT X SUBJECTS WITHIN GROUPS	475.45	243	1.96	

Site 2 -- Grade 5

SOURCE	SUM SQUARES	DF	MEAN SQUARE	F
TREATMENT	116.57	2	58.29	61.58***
SUBJECTS WITHIN GROUPS ERROR	99.37	105	0.95	
UNIT	2.51	3	.84	.87
TREATMENT X UNIT	15.52	6	2.59	2.68*
UNIT X SUBJECTS WITHIN GROUPS	304.15	315	.97	

* = $p < .05$
** = $p < .01$
*** = $p < .001$

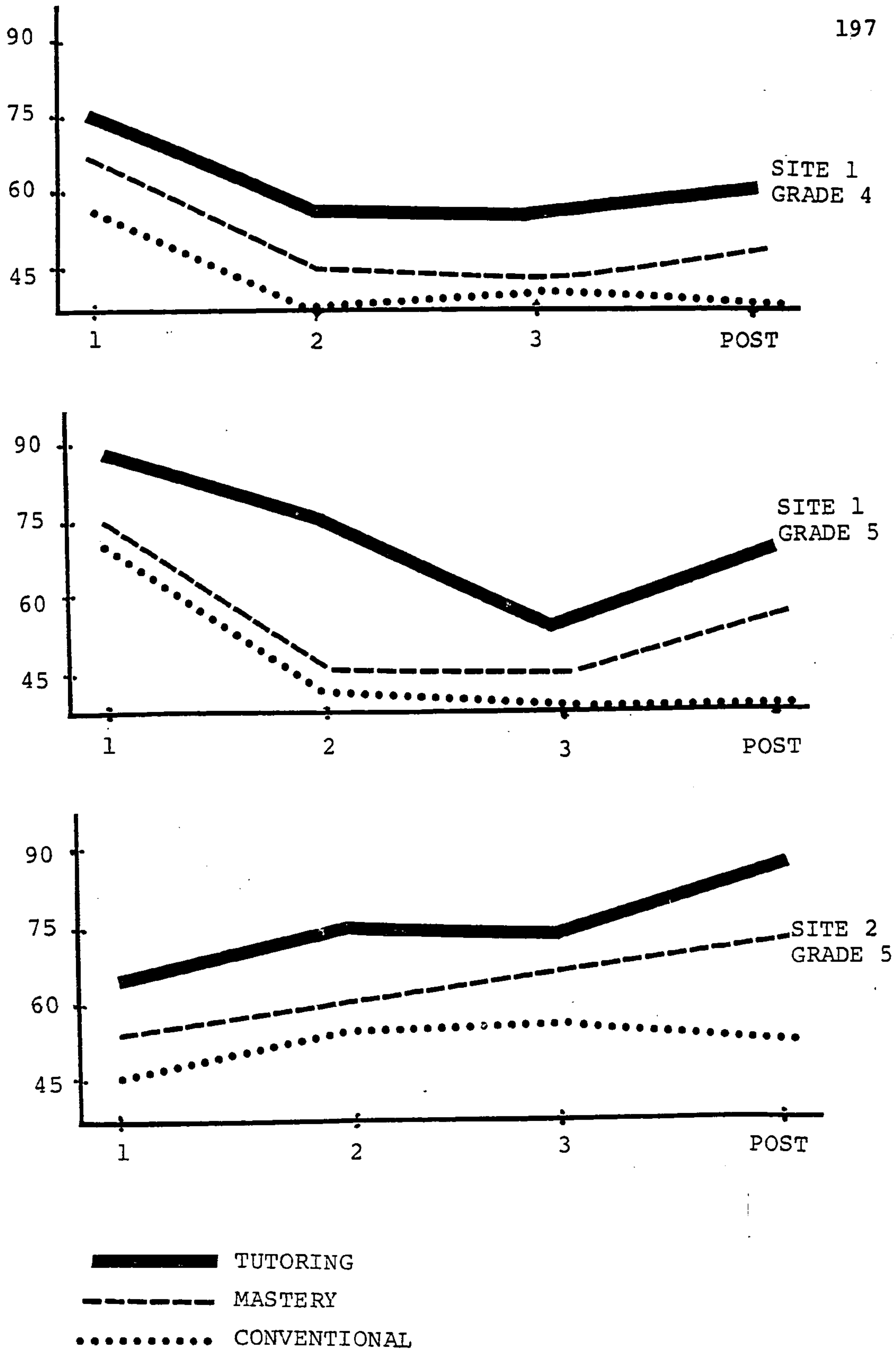
LMP profiles are statistically parallel that lower mental processes can not be learned at an increasing rate under tutoring and Mastery Learning. Here, the LMP profiles improve relatively slowly under tutorig and Mastery Learning because initial levels of learning were relatively high.

In the first two replications, the absence of significant TREATMENT X UNIT interaction means that the TREATMENT and UNIT effects can be interpreted. In both the TREATMENT effect is highly significant. This simply affirms that the tutored and the Mastery groups are at higher levels than the controls. Interestingly, the profiles in the first replication are statistically flat and in the second replication statistically not flat (significant UNIT effect). In the latter case, the tutored and the Mastery groups improved somewhat over time while the control group remained at about the same level (although the improvement under tutoring and ML was not large enough to cause the parallelism hypothesis to be rejected!).

Profiles Of Higher Mental Processes Under Three Qualities Of Instruction

Figure 11 displays the profiles for higher mental processes in the three replications of this study. Looking closely at Figure 11, we suspect that in the second and third replications the profiles are different. In the second replication, the profiles for tutoring and for Mastery Learning rise sharply at the end -- while the profile for conventional instruction remains at about the same level.

Fig. 11. -- Profile of higher mental process achievement under tutoring, Mastery, and conventional conditions.


90
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GRADE 4
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SITE 1
GRADE 5
90
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SITE 2
GRADE 5
TUTORING
MASTERY
CONVENTIONAL

In the third replication, the profiles for tutoring and for Mastery Learning increase over time -- while the profile for conventional instruction remains at about the same level. And even though there is a drop in the first two replications, at all times the profiles for tutoring and for Mastery Learning are at higher levels than the profile for conventional instruction.

In Table 15 we analyze the HMP profiles statistically. In the second and third replications, the TREATMENT X UNIT interaction is indeed statistically significant. Unfortunately, in the second replication there is a decreasing profile. This has little to do with the treatments. The drop occurred, at the first site, because the tests were too difficult.

In the first replication, the profiles are statistically parallel. There too the TREATMENT and UNIT effects are significant, indicating, first, that the tutored and the Mastery profiles are at higher levels than the control profile and, second, that the profiles are indeed decreasing.

The pattern we wanted to see emerged in the third replication: Under tutoring and Mastery Learning higher mental processes improved at a statistically faster rate than under conventional instrucion.

TABLE 15

PROFILE ANALYSIS
OF HIGHER MENTAL PROCESSES

Site 1 -- Grade 4

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F
TREATMENT	57.52	2	28.76	15.31***
SUBJECTS WITHIN GROUPS ERROR	154.07	82	1.88	
UNIT	139.44	3	46.48	31.82***
TREATMENT X UNIT	4.01	6	.67	.46
UNIT X SUBJECTS WITHIN GROUPS	359.40	246	1.46	

Site 1 -- Grade 5

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F
TREATMENT	89.16	2	44.58	29.22***
SUBJECTS WITHIN GROUPS ERROR	123.56	81	1.52	
UNIT	205.82	3	68.61	47.38***
TREATMENT X UNIT	20.54	6	3.42	2.36*
UNIT X SUBJECTS WITHIN GROUPS	351.84	243	1.45	

Site 2 -- Grade 5

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F
TREATMENT	94.37	2	47.19	105.04***
SUBJECTS WITHIN GROUPS ERROR	47.17	105	.45	
UNIT	51.66	3	17.22	37.37***
TREATMENT X UNIT	20.07	6	3.35	7.26***
UNIT X SUBJECTS WITHIN GROUPS	145.13	315	.46	

* = $p < .05$
** = $p < .01$
*** = $p < .001$

Summary

This analysis demonstrated that there are indeed statistical differences in the profiles of lower and higher mental process achievement under tutoring, Mastery Learning, and conventional instruction. For two reasons we are not able to able to affirm statistically that, in all cases, lower and higher mental processes were improving faster under tutoring and Mastery Lerning than under conventional istruction. First, initial levels of lower mental processes were so high that there wasn't room for much improvement. Second, the problem with the tests at the first site caused HMP scores to drop after the first unit.

Perhaps the main point here is that a full description of the course of learning under different instructional conditions must include profile analysis, as well as observations of students' use of time and their processing behaviors.

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