The Behavior Analyst 1999, 22, 5–16 No. 1 (Spring)

Is the Learn Unit a Fundamental Measure of Pedagogy?

R. Douglas Greer
Columbia University Teachers College

Sally Hogin McDonough
The Fred S. Keller School

We propose a measure of teaching, the *learn unit*, that explicitly describes the interaction between teachers and their students. The theoretical, educational research, and applied behavior analysis literatures all converge on the learn unit as a fundamental measure of teaching. The theoretical literature proposes the construct of the *interlocking operant* and embraces verbal behavior, social interaction, and translations of psychological constructs into complex theoretical respondent–operant interactions and behavior–behavior relations. Research findings in education and applied behavior analysis on engaged academic time, opportunity to respond, active student responding, teacher–student responding, student–teacher responding, tutor–tutee responding, tutee–tutor responding, and verbal episodes between individuals all support a measure of interlocking responses. More recently, research analyzing the components of both the students' and teachers' behavior suggests that the learn unit is the strongest predictor of effective teaching. Finally, we propose applications of the learn unit to other issues in pedagogy not yet researched and the relation of learn units to the verbal behavior of students.

Key words: operant, three-term contingency, opportunity to respond, pedagogical measurement unit, interlocking operants, cost-benefit analyses

Education requires a measure that contacts the fundamental act of teaching—one that includes the behavior of the teacher or teaching device and the behavior of the student. We argue that measurement is needed to provide both a moment-to-moment measure for the teacher and predictions of long-term outcomes of teaching. The identification and acceptance of a measure that predicts teacher effectiveness will determine strong practices and effective practitioners. We believe that the research literature has converged on just such a measure of pedagogy.

The identification of, and the quest for, direct fundamental measures are more common in the natural sciences than in the social sciences. The identification of measures that contact the fundamental dimensions of the world, including behavior, typically functions to produce rapid progress in the sciences (Mach, 1960; Skinner, 1938, 1953). One of the characteristics of behavior analysis that aligns it with the natural sciences is a preference for direct measures of behavior as opposed to artifacts of or inferences about behavior (Greer, 1983; Johnston & Pennypacker, 1992; Sidman, 1960). Measures of constructs such as IQ, locus of control, personality, or engaged academic time are examples of measures that are not direct, whereas the operant and the respondent are direct and fundamental measures of behavior.

At present, much of education relies on measures of artifacts of behavior or inferences about behavior such as ratings of students, teachers' perceptions, engaged academic time, and the presence or absence of services such as contact hours of teaching or the number of periods taught (Brophy & Good, 1986; Hamburg, 1992; Stallings, 1980, 1985). Indirect measures do not relate

We gratefully acknowledge the assistance of Kent Johnson, Richard Malott, and an unidentified reviewer for their comments on earlier drafts of this paper. Of course, we alone are accountable for our musings and theoretical extrapolations.

Reprints and correspondence should be directed to the first author at Box 76, Teachers College, Columbia University, New York, New York 10027 (E-mail: dgreer3872@aol.com).

to the specific behaviors that occur during instruction, nor do they show the moment-to-moment behavior changes of the student. Educational research, together with research in behavior analysis, however, support convergence on what we propose is a fundamental measure of pedagogy: the learn unit.

A Fundamental Unit of Pedagogy

The learn unit consists of the interlocking operants of instruction that incorporate particular student and teacher interactions that predict whether student behavior will be controlled by particular stimuli and setting events (Greer, 1994a). The learn unit is present when student learning occurs in teaching interactions and is absent when student learning does not occur in teaching interactions. It is a countable unit of teacher and student interaction that leads to important changes in student behavior. That is, the behavior of the student comes under the control of the target discriminative stimulus (S^D) within the motivational conditions in which the behavior will produce a particular consequence to form a discriminated operant. For this to happen, the teacher must respond in certain ways to the presence of the student and to the resulting behavior or its absence. In effect, the teacher "learns" from the response of the student; that is, the teacher learns what to do next just as a researcher follows the organism's behavior in a laboratory (Sidman, 1960). Thus, the learn unit captures the behaviors of both the teacher and the student that are needed to produce a particular outcome.

A basic scenario for the interlocking three term contingencies of the teacher and student is illustrated in Table 1. The S^D for the teacher to present an S^D to the student is the student's attentive behavior. Presentation of an S^D by the teacher to the student is the teacher's response and the S^D for the student's response. The behavior or behavioral product of the student to his or her S^D serves as a consequence for the teacher as well as an S^D for the teacher's next response to the student (e.g., reinforcement of the correct response or correction of an incorrect response), and the teacher's response is the consequence for the student. The completion of this single learn unit functions as a consequence for the teacher's later responses. The learn unit is a measure of the symbiotic relationship between the behavior of a teacher and a student.

Although we are not tied to the *learn unit* as the term for the explicit interaction between the teacher and student we describe, it does seem appropriate because the behaviors of the student and the teacher change based on the behavior of the other party. Both stand to learn from the interaction. This symbiotic learning relationship is characteristic of our inductive science; Skinner wrote that the pigeon knows best, and Keller paraphrased this advice when he stated that "the student knows best" (Keller, 1968; Skinner, 1938). Thus, we think the interactive nature of effective teaching is communicated by our term. Other terms may have more appeal. Regardless of the term that is eventually used, it is the identification of the unit that is important, and current research and theory support such a unit.

Supporting Literature

Theory. The potential explanatory role of interlocking operants or operant episodes has been suggested by others. Staats (1981) used interlocking operants as well as respondent–operant relations to interpret complex psychological constructs as behavioral interactions. Goldiamond (1974) described verbal episodes that incorporated interlocking operants in his analysis of systems. Patterson (1982) identified reciprocal operant relations between the behaviors of children and parents in his research on parenting. Bijou (1970) suggested this perspective in his seminal paper on applying behavior analysis to the classroom.

TABLE 1

Example of complex learn units

Event	Likely functional components
Correct responses	
1. Attending student	S^D for teacher behavior
2. The teacher says "write a 5-page composition comparing and contrasting the characters in two of Shakespeare's tragedies." The teacher provides the student with a list of 10 critical variables to include in the composition.	Teacher behavior S^D for student behaviors Consequence for student attending
3. The student includes 10 critical variables correctly throughout the composition and returns paper to the teacher.	Student behaviors Consequence for teacher behavior S^D for teacher behaviors
4. The teacher reads the composition and identifies the variables with check marks. The teacher returns the corrected composition to the student for review. The teacher records the student's responses.	Teacher behavior Consequences for student behavior S^D for student behavior
5. The student reviews the composition and the teacher's responses to each of the 10 critical variables. Completion of several learn units.	Student behavior Consequence for teacher behavior Consequence for student behavior
Incorrect responses	
1. Attending student	S^D for teacher behavior
2. The teacher says "write a 5-page composition comparing and contrasting the characters in two of Shakespeare's tragedies." The teacher provides the student with a list of 10 critical variables to include in the composition.	Teacher behaviors S^Ds for student behavior Consequence for student attending
3. The student includes 5 of the 10 critical variables correctly throughout the composition.	Student behaviors Consequences for teacher behavior S^Ds for teacher behavior
4. The teacher reads the composition and identifies the correct 5 variables with check marks. The teacher indicates 5 missed variables on the front of the composition. The teacher returns the corrected composition to the student for review and revisions. The teacher records the student's initial responses.	Teacher behavior Consequences for student behavior S^Ds for student behavior
5. The student reviews the teacher's responses and revises the composition to include all 10 variables. The teacher notes each of the 10 critical variables. Completion of several learn units.	Student behavior Consequences for teacher behavior Consequences for student behavior

Skinner (1957) suggested that interlocking verbal operants were part of the multiple control of conversation—what he termed *verbal episodes* between individuals. Moreover, he suggested that interlocking verbal episodes can occur when one talks to oneself aloud or covertly. In both of these cases the individual acts as a speaker and a listener. Each role involves a complete verbal three-term contingency. Research with young children confirmed Skinner's theory of interlocking verbal operants in children's self-talk or in their conversations with peers (i.e., conversational units) (Donley & Greer, 1993; Lodhi & Greer, 1989).

Applied behavior analysis. The convergence on the interlocking operants as an explanatory process is evident in the early analyses of the relationship between the behaviors of teachers and students. R. V. Hall, Lund, and Jackson (1968) showed the powerful effects of teacher attention on student behavior. They changed teachers' consequences to students as an independent variable, and the behavior of students changed.

Their study was followed by many others that replicated the effect of teachers' consequences (Greer, Dorow, & Miller, 1976; Greer, Dorow, Wachhaus, & White, 1973; Madsen, Becker, & Thomas, 1968).

Subsequent studies treated the student behaviors as the independent variable and the teachers' behaviors as the dependent variable. Sherman and Cormier (1974) found that when they changed 1 student's behavioral consequences to a teacher's behaviors, correlated changes occurred in the behavior of the teacher. Polirstok and Greer (1977) found that the interactions of 4 teachers with a student were changed as a function of changing the behavioral consequences of the student delivered to the teachers. Changes in and the maintenance of tutor interactions with tutees (e.g., use of contingent praise) were found to be a function of tutee behaviors following tutor reinforcement operations (Greer & Polirstok, 1982; Polirstok & Greer, 1986). Thus, changes in the behavior of students could change teachers' behavior just as changes in the behavior of teachers can change students' behaviors. The relations between the operants of each party are reciprocal: They are interlocking under the conditions described in this and other research.

The Presence and Absence of Learn Units in Educational Practice

In well-designed classroom instruction, as in the operant chamber, the responses of learners are shaped by design via planned exercises or are captured by capitalizing on an incidental situation to instruct or create operant units. The design of the instruction and behaviors of the teacher result in the student responding effectively in settings in which the operant is needed in the world at large (Schwartz, 1994; Stokes & Baer, 1977). Some teacher strategies draw on changes in the motivational conditions associated with the student's learning, as when the teacher uses an interrupted chain or a brief motivational tactic to enhance an item or event used in a reinforcement operation (Hart & Risley, 1980; Michael, 1983; Schwartz & Greer, 1995). When one can manipulate establishing operations as part of the instructional process, there is no need to wait for the optimum moment. Such instructional design has all of the advantages of incidental instruction, in which the contextual or motivational situations are ideal, and all of the advantages of massed instruction, in which the number and rate of learning opportunities are sufficient to allow the student to become fluent (Greenwood, Hart, Walker, & Risley, 1994).

Learn units and programmed instruction. Programmed instruction, one of the few early educational innovations that was shown to be reliably effective (Stephens, 1967), is an example of how the learn unit can be used for instruction independent of the presence of the teacher (Holland & Skinner, 1961; Skinner, 1968). An automated and learner-controlled sequence of steps called *frames* leads the student to construct target responses. When responses are initially incorrect, the student is required to correct the response before moving on. The frames include the student's response and that portion of the learn unit emitted by the teacher in nonautomated instruction. The student then observes his or her responses with reinforcement operations, corrections, or analogues of reinforcement (Malott, 1989). Some early teaching machines had candy or token delivery attachments to increase the probability that consequences would function to reinforce (Skinner, 1968), especially in those instances in which the students' correct responses were not reinforced by observing their responses.

Scripted instruction and learn units. Operant units are provided for teachers when they present instruction from scripted sequences based on logical analyses (Engelmann & Carnine, 1982) or in scripted instruction based on task analyses (Greer, 1986). These scripts specify teacher behavior, student behavior and its measurement in some cases, as well as the teaching sequence of steps and the instructional objectives. Scripts for teaching can specify learn units with students individually or with groups of students. For example, the direct instruction curricula provide scripts for teachers that specify learn unit presentations (see Becker, 1992, for a review of the research on direct instruction).

Incidences and nonincidences of learn units in common practice. Instruction is presented in less exacting formats in much of the instruction presently done in schools (Fisher & Berliner, 1985; Greenwood, Carta, Arreaga-Mayer, & Rager, 1991; Greenwood et al., 1994; Greer, 1994a, 1996b). Although most teachers instruct without regard for the operant, learn units (or their absence) can be observed in most if not all educational settings. For example, a teacher may spot a student having difficulty with a specific operation. The teacher may then ask the student a series of "leading" questions (i.e., antecedents) followed by student responses that the teacher either corrects or reinforces (Albers & Greer, 1991; Ingham & Greer, 1992; Lamm & Greer, 1991; Selinske, Greer, & Lodhi, 1991). When the teacher corrects or reinforces the student, operants occur.

The presence or absence of learn units can be observed in any instructional setting. A trained observer, using procedures from the research literature, can monitor the presence or absence of the written, gestural, graphic, or vocal three-term contingencies of both parties (Greer, 1994a; Ingham & Greer, 1992). An observer can also determine whether the operants of each party interlock (Ingham & Greer, 1992). In order to interlock, the joint operants must occur in sequence and in a timely fashion. The number and rate of interlocking operants between a teacher and student provide a measure of teaching that predicts instructional outcomes.

Research shows that learn units (i.e., those that are done for planned instruction or even incidental ones) are found in effective instruction in various forms or functions and are not found in ineffective instruction. Learn units, or their lack, are observable in preschool classrooms, graduate classes, tutoring settings, group lectures, lecture discussions, courses that use the personalized system of instruction, automated instruction, one-minute timings, one-to-one instruction, laboratory courses, writing exercises, and problem-solving projects in various behavioral topographies (e.g., spoken, written, or otherwise). What makes instruction effective is a high rate of learn units.

In some lectures or lessons, the teacher presents an extensive set of antecedents, and then at some point students are questioned. If the teacher reinforces the student responses, an operant unit may be acquired. Research, to date, shows that unless teachers are trained to do so, they provide infrequent learn units (Greenwood et al., 1994; Greer, 1994a; Madsen et al., 1968). Thus, the difference between instruction that plans for learn units and more typical instruction is the frequency of learn units. Without a high frequency of learn units, new discriminative stimulus control for students is unlikely (Diamond, 1992; Greenwood, Delquadri, & Hall, 1989; Greer, 1994a; Heward, 1994; Ingham & Greer, 1992; Kirby & Shields, 1972).

The Educational Literature and Fine-Grained Analyses

In addition to this more general support of interlocking contingencies, data from multiple sources have provided fine-grained analyses of what effective teachers do. Heward (1994) provided a detailed review of how these disparate research findings converged and need not be reviewed in detail here.[1] The re-

[1] Heward (1994) provides a description of the research concerned with engaged time, on task, engaged academic time, and active student responding, relative to opportunity to respond. These latter measures are not direct measures of behavior or behavior outcomes, because the def-

search showed that teachers who (a) presented higher rates of student responding and (b) also provided consequences for student behaviors had students with higher numbers of correct responses than did teachers who did not emit these behaviors (Albers & Greer, 1991; Greenwood et al., 1991; Greer, 1996a; Stallings, 1980, 1985). More recent research found that effective instruction is characterized by the following teaching behaviors:

1. Teacher consequences to students occur in the form of either a reinforcement operation or a correction operation contingent on the student's response, or lack thereof, and the teacher's S^D presentation for the student must be unambiguous (Albers & Greer, 1991; Diamond, 1992; Ingham & Greer, 1992).

2. The student must observe (e.g., see, hear, touch, taste, smell, or a combination) the S^D to which he or she responds in correction or reinforcement operations (Hogin, 1996).

3. The student must respond or have the opportunity to do so (Fisher & Berliner, 1985; Greenwood et al., 1991, 1994; Heward, 1994).

4. Better student performance results from faster rates of intact learn-unit presentations (Carnine & Fink, 1978; Ingham & Greer, 1992; Linhart-Kelly & Greer, 1999).

5. Greater numbers of learn-unit presentations, as opposed to presentations that are not learn units, result in significantly more correct responses and higher numbers of instructional objectives for students (Greer, McCorkle, & Williams, 1989; Heward, 1994; Ingham & Greer, 1992; Selinske et al., 1991).

6. Replacing teacher–student interactions that are not learn units with interactions that are learn units increases correct responses from four to seven times over baselines (Albers & Greer, 1991; Diamond, 1992; Ingham & Greer, 1992; Selinske et al., 1991).

In the studies cited above, the various components of the learn unit were experimentally manipulated, and learn units were compared to teacher presentations that were not learn units. The results of all of these studies, taken together, affirmed that the presence of learn units resulted in educationally significant increases in correct responding and the attainment of significantly more educational objectives. Thus, we have found in the above-cited studies and in others (Dorow, McCorkle, Williams, & Greer, 1989; Greer, 1994a, 1994b; Greer et al., 1989; Lamm & Greer, 1991; Singer & Greer, 1997) that learn units are stronger predictors of student learning. Based on our reading of the research, learn units are the strongest known physical dimensions of effective teaching. Unlike measures of engaged time, active student responding, or teacher measures that do not incorporate specific student responses to instruction or the related teacher behaviors, learn units are direct measures of student and teacher behaviors. They are the natural fractures of the teaching process rather than by-products of effective teaching.

Preliminary Findings and Suggested Research

Although evidence for the utility of the learn unit is robust for the instruction found in the existing research, there remain unanswered questions about the application of the learn unit. In the following section we propose extrapolations of our findings to the use of the learn unit for other and more advanced instruction as well as recent research that suggests that these extrapolations are justified.

---

initions of engaged time or on task are inferences from the behavior of students. A student could be passively staring at a page of material and still be recorded as being actively engaged. Fisher and Berliner (1985) edited a volume devoted to research on instructional time that makes the case for something like the learn unit. Interested readers will find both sources to be necessary components in the evolution from the measurement of by-products to the measurement of outcomes and behavioral processes via the learn unit.

Student progress and changes in the location and frequency of learn units. We propose that the frequency of learn units and the need for a learn unit in the chain of student responses required to maintain the student's progress are correlated with the existing verbal repertoires of the student. Skinner (1957) proposed several categories of verbal behavior, and we extend them to identify students' repertoires in terms of prelistener, listener, speaker, speaker–listener exchanges, speaker as own listener, reader, writer, and self-editor (see Greer, 1996b, for an extended treatment). The role of the existing verbal repertoires as they relate to learn units is illustrated by the contrast in the frequency of learn units needed to maintain the progress of students who have speaker repertoires, compared with students who have advanced combinations of speaker, reader, and writer repertoires. Responses to presentations of each flash card or word may call for a learn unit initially when the student is learning textual responding. However, once the student has mastered reading the discrete words, the responses to all of the words in a long prose passage or list of words constitute a learn unit. The learn unit for a student initially learning the words consists of each word or even each morpheme. However, for a student who has already mastered the individual words at a slow rate, and for whom the goal is mastery with a rate-of-responding criterion, a learn unit consists of correctly responding to all of the words on the flash cards or page within a predetermined unit of time.

Students may require an instructional history of many learn units prior to independently accomplishing tasks that involve chaining together numerous responses. As the extent of independent responding increases, the student's need for teacher-controlled learn units declines. That is, the learn unit at Level 1 is the phonetic sound, at Level 2 is the word, at Level 3 is the sentence, and at Level 4 is the paragraph. Each advance leads to greater numbers of S^D-response-consequence units that the student emits successfully before a learn unit is required from the teacher. Our view of this is consistent with Catania's statement that what an organism learns is the S^D, the behavior, and the consequence (Catania, 1998). Those subcomponent responses of the student that do not require teacher responses will consist of operants previously mastered and even student-controlled learn units (i.e., the student functions as his or her own reader and writer, or self-edits at the sophistication of the eventual target reader). The student with advanced verbal repertoires will require fewer interactions with the teacher.

We hypothesize that learn units are required more frequently in the initial levels of instruction for a particular repertoire and become less frequent and less needed as the component operants comprising the repertoire are mastered. The operants that are mastered come under the control of the immediate contingencies for the student. At that point, learn units are needed only in those instances when the responses are not within the control of the natural contingencies. A kind of naturalistic thinning of the teacher's reinforcement and correction operations accrues as the student advances. However, if the complexity of the task occurs before the student has mastered the subcomponents of the repertoire, or before the student is fluent, as our recent study on the effects of rate of responding on maintenance suggests, the student will flounder (Lindhart-Kelly & Greer, 1999). We have known for some time that the shaping of chains of behavior is best accomplished by inserting prosthetic reinforcers at progressively later points in the chain of behaviors (Skinner, 1938). The process involved in shaping chains of behavior is closely aligned with the progressive process involved in determining the need for learn units.

Thus, we believe that learn units are required at different points in the student's responding based on his or her verbal sophistication (e.g., whether he or she has repertoires of speaker, listener, reader, writer, or self-editor). Also, learn units change in frequency based on what the student has mastered to date. It is probably just as important to omit the presentation of learn units when a student has mastered certain repertoires as it is to insert a learn unit when it is needed by the student.

Learn units and adduction. K. R. Johnson and Layng (1994) have proposed that more complex skills emerge as a function of certain levels of fluency with component skills in a process they describe as adduction. Thus, a particular rate of correct responding may determine when and what type of learn unit is needed or not needed. If the components are not fluent operants for the individual student, then learning complex repertoires is simply not feasible. It is quite possible that rate of responding may prove to be an empirically derived criterion for identifying the optimum moment to shift learn units from component to more complex chains of behavior (Lindsley, 1992). Rate of learn units, rate of responding, and the progress of students through more complex repertoires are probably closely tied to the phenomenon of adduction proposed by K. R. Johnson and Layng (1992, 1994).

Learn units and delayed consequences. In the case of delayed consequences, it appears that when the student observes the S^D and his or her correct response along with the teacher's consequence in written form (i.e., check mark, smiling face, positive written statement), a learn unit occurs. When the student is incorrect, he or she observes the S^D, the incorrect response, a prompt for a correct response (i.e., "did you forget to —"), or an X mark, and then redoes the problem until it is correct. The student's observation of the written components of the response and those of the teacher simply makes the consequences immediate. The effect is verbally mediated (Hogin, 1996) rather than delayed. The fact that the data show that the effects are the same for written responses whether the consequence is immediate or delayed for the student does not imply an invented cognitive entity; the student's behaviors are simply under the immediate control of the textual stimuli (Skinner, 1957). The textual effect may be that of an indirect-acting contingency or reinforcement analogue, as described by Malott (1989).

The learn unit as an analytic tool. One of the serendipitous outcomes of the systematic implementation of learn units in schools that use the Comprehensive Application of Behavior Analysis to Schooling (CABAS®) has been the development of teachers who can function as strategic behavior analysts or in some cases as strategic scientists of instruction (Greer, 1996b; Keohane, 1997). In these schools, the teachers and other professionals monitor all of their learn units and their students' responses to learn units. At the same time, the teachers receive instruction devoted to the progressively more complex application of behavior analysis to decisions about teaching (Greer, 1996b). Much of that instruction involves teaching teachers how to perform contingency analyses and functional analyses of instruction using the learn unit. These teachers learn to make decisions about which tactics from the research in behavior analysis need to be applied given a specific student's data pattern and history. When these decisions call for applications of existing research-based tactics, the teachers are functioning as applied behavior analysts. In those cases in which existing tactics do not work and the teachers introduce new procedures that they test through functional analyses, the teachers function as scientists.

For example, a series of technical questions can be asked about the related components of the student's operant, the student's instructional history, or existing establishing operations. The probable answers to those questions suggest, in turn, tactics from the literature that might be effective. If the probable source of the problem suggests that the child is not responding to a particular stimulus, a simultaneous prompting procedure can be used (P. Johnson, Schuster, & Bell, 1996; Woolery, Holcombe, Billings, & Vassilaros, 1993). If the problem is a particular listener response, when other listener responses are present, behavioral momentum procedures can be used (Ducharme & Worling, 1994). If the problem is motivational, an additional establishing operation can be used (e.g., brief motivational procedures, interrupted chain, incidental presentations) (G. Hall & Sundberg, 1987; Schwartz, 1994; Sundberg, 1993). Alternatively, if the responses of the student are presumed to be related to some other response because the topographies of the responses are similar, when in fact the responses are functionally independent (e.g., tacting vs. manding, or exemplar production vs. exemplar identification), the teacher needs to teach the separate functions for the vocal verbal form (Chase, Johnson, & Sulzer-Azaroff, 1985; Donahoe & Palmer, 1994; Greer, 1986; Lamarre & Holland, 1985; Lindsley, 1991).

Is there any evidence to suggest that teachers who are taught to use the learn unit to make these analyses produce better outcomes for their students? Keohane (1997) compared the number of learn units required by students before their teachers learned to use the learn unit to analyze the probable causes for student problems, as described in the preceding paragraph. During baseline the teachers, who were already advanced in the application of behavior analysis, made errors in up to 25% of the cases in which decisions were needed. After baseline, when the teachers were taught to use the analytic decision process described above, the teachers made only one error in decisions about changing interventions with the students. The data for some students (target students) were used to train the teachers to use the learn-unit decision process involving scientific rule-governed behavior. Other students (generalization students) were used to test for the teachers' generalization of decision accuracy. The teachers' correct decisions about the choice of, and changes in, tactics resulted in significantly fewer learn units required by the target and generalization students to achieve educational objectives than during baseline. A follow-up probe, 1 year later, showed that 2 of the teachers had made no errors in subsequent applications with both sets of students, and the 3rd teacher made one error throughout the entire year. Of course, this finding and the other theoretical extensions of the learn unit call for replications and new research.

Existing and Proposed Functions of Learn Units

Based on the research to date and our extrapolations from the data, we conclude that the learn unit is a fundamental measure of instruction. It is a measure that predicts students' learning (i.e., the achievement of instructional objectives). It can be used to discriminate between effective and ineffective teaching. It provides a database for what teachers need to learn in order to be effective (i.e., a scientifically based curriculum for teacher training). Together with the rules for solving instructional problems through contingency analyses as described by Keohane (1997), it provides a tool for making decisions about what tactics are needed when standard "best practices" are not working.

The learn unit represents the most valid measure of instruction to date. It also serves as a means for analyzing learning difficulties and tailoring existing scientifically based tactics for particular instructional problems. If the research findings and our extrapolations are maintained, the learn unit is a fundamental component of a science of pedagogy. The learn unit also provides a measure of interaction between two individuals, and like the conversational unit (Lodhi & Greer, 1989), provides a direct measure of social interaction. Thus, the learn-unit construct suggests other analyses of interlocking operants that can provide the means to a more social account in the science of behavior (Guerin, 1994).

The learn unit provides researchers in pedagogy with a standard measure of instructional effectiveness. We suggest that the fundamental function of the learn unit provides a new perspective on what constitutes valid educational practice, whether that practice occurs in schools, corporations, medical facilities, or universities. Investigators can relate learn units and costs in order to provide cost-benefit analyses. Individuals who design automated learner-controlled instruction can provide instruction consistent with what we know about the need for learn units. One can train teachers to incorporate learn units rather easily and inexpensively through classroom instruction (Albers & Greer, 1991; Ingham & Greer, 1992). Ineffective teaching can be identified, and more important, the instruction can be dramatically improved. We need no longer refer to how many hours of instruction are best; instead, we can point to the number and types of learn units that are needed to produce important outcomes for students, whether the students are at the prespeaker stage or at advanced stages of self-editing. Perhaps most important, the learn unit suggests important new questions to ask about pedagogy and verbal interaction from a functional perspective.

REFERENCES

Albers, A., & Greer, R. D. (1991). Is the three term contingency trial a predictor of effective instruction? *Journal of Behavioral Education, 1,* 337–354.

Becker, W. (1992). Direct instruction: A twenty year review. In R. West & L. Hammerlynck (Eds.), *Design for educational excellence: The legacy of B. F. Skinner* (pp. 25–52). Longmont, CO: Sopris West.

Bijou, S. (1970). What psychology has to offer education—now! *Journal of Applied Behavior Analysis, 3,* 65–71.

Brophy, J., & Good, T. (1986). Teacher behavior and student achievement. In I. M. C. Wittrock (Ed.), *Handbook on research on teaching* (3rd ed., pp. 328–375). New York: Macmillan.

Carnine, D. W., & Fink, W. T. (1978). Increasing rates of presentation and the use of signals in elementary classroom teachers. *Journal of Applied Behavior Analysis, 11,* 35–46.

Catania, A. C. (1998). *Learning* (4th ed.). Upper Saddle River, NJ: Prentice Hall.

Chase, P. N., Johnson, K. R., & Sulzer-Azaroff, B. (1985). Verbal relations within instruction: Are there sub-classes of the intraverbal? *Journal of the Experimental Analysis of Behavior, 43,* 146–154.

Diamond, D. (1992). *Beyond time on task: Comparing opportunities to respond and learn units to determine an accurate means of measuring educational gains.* Unpublished paper, Teachers College, Columbia University, New York.

Donahoe, J. W., & Palmer, D. C. (1994). *Learning and complex behavior.* Boston: Allyn and Bacon.

Donley, C. R., & Greer, R. D. (1993). Setting events controlling social verbal exchanges between students with developmental delays. *Journal of Behavioral Education, 3,* 387–401.

Dorow, L. G., McCorkle, N., Williams, G., & Greer, R. D. (1989). *Effects of setting performance criteria on the productivity and effectiveness of teachers.* Paper presented at the annual meeting of the Association for Behavior Analysis, Nashville, TN.

Ducharme, J. M., & Worling, D. E. (1994). Behavioral momentum and stimulus fading in the acquisition and maintenance of child compliance in the home. *Journal of Applied Behavior Analysis, 27,* 639–648.

Engelmann, S., & Carnine, D. (1982). *Theory of instruction: Principles and applications.* New York: Irvington.

Fisher, W. F., & Berliner, D. C. E. (Eds.). (1985). *Perspectives on instructional time.* New York: Longham.

Goldiamond, I. (1974). Towards a constructional approach to social problems. *Behaviorism, 2,* 1–84.

Greenwood, C. R., Carta, J. J., Arreaga-Mayer, C., & Rager, A. (1991). The behavior analyst consulting model: Identifying and validating naturally effective instructional models. *Journal of Behavioral Education, 1,* 165–192.

Greenwood, C. R., Delquadri, J., & Hall, R. V. (1989). Longitudinal effects of classwide peer tutoring. *Journal of Educational Psychology, 81,* 371–383.

Greenwood, C. R., Hart, B., Walker, D. I., & Risley, T. (1994). The opportunity to respond and academic performance revisited: A behavioral theory of developmental retardation and its prevention. In R. Gardner, III, P. M. Sainato, J. O. Cooper, W. L. Heward, J. Eschelman, & T. A. Grossi (Eds.), *Behavior analysis in education: Focus on measurably superior instruction* (pp. 213–224). Pacific Grove, CA: Brooks/Cole.

Greer, R. D. (1983, January). Contingencies of the science and technology of teaching and

prebehavioristic research practices in education. *Educational Researcher, 12,* 3–14.
Greer, R. D. (1986). *Teaching operations for verbal behavior.* Yonkers, NY: CABAS® and the Fred S. Keller School.
Greer, R. D. (1994a). The measure of a teacher. In R. Gardner, III, D. M. Sainato, J. O. Cooper, W. L. Heward, J. Eschelman, & T. A. Grossi (Eds.), *Behavior analysis in education: Focus on measurably superior instruction* (pp. 225–248). Pacific Grove, CA: Brooks/Cole.
Greer, R. D. (1994b). A systems analysis of the behaviors of schooling. *Journal of Behavioral Education, 4,* 255–264.
Greer, R. D. (1996a). *Acting to save our schools (1984–1994).* In W. Ishaq & J. Cautela (Eds.), *Contemporary issues in behavior therapy: Improving the human condition* (pp. 137–158). New York: Plenum.
Greer, R. D. (1996b). The educational crisis. In M. A. Mattaini & B. A. Thyer (Eds.), *Finding solutions to social problems: Behavioral strategies for change* (pp. 113–146). Washington, DC: American Psychological Association.
Greer, R. D., Dorow, L. G., & Miller, M. A. (1976). Graduate student initiated responses as a function of teacher approval. In R. D. Greer & L. Dorow (Eds.), *Specializing education behaviorally* (pp. 275–295). Dubuque, IA: Kendall/Hunt.
Greer, R. D., Dorow, L. G., Wachhaus, G., & White, E. (1973). Adult approval and students' music selection behavior. *Journal of Research in Music Education, 21,* 293–299.
Greer, R. D., McCorkle, N. P., & Williams, G. (1989). A sustained analysis of the behaviors of schooling. *Behavioral Residential Treatment, 4,* 113–141.
Greer, R. D., & Polirstok, S. R. (1982). Collateral gains and short term maintenance in reading and on-task responses by inner city adolescents as a function of their use of social reinforcement while tutoring. *Journal of Applied Behavior Analysis, 15,* 123–139.
Guerin, B. (1994). *Analyzing social behavior.* Reno, NV: Context Press.
Hall, G., & Sundberg, M. (1987). Teaching mands by manipulating conditioned establishing operations. *The Analysis of Verbal Behavior, 5,* 41–53.
Hall, R. V., Lund, D., & Jackson, D. (1968). Effects of teacher attention on study behavior. *Journal of Applied Behavior Analysis, 1,* 1–12.
Hamburg, D. A. (1992). *Today's children: Creating a future for a generation in crisis.* New York: Times Books.
Hart, B., & Risley, T. R. (1980). In vivo language intervention: Unanticipated general effects. *Journal of Applied Behavior Analysis, 13,* 407–432.
Heward, W. L. (1994). Three "low tech" strategies for increasing the frequency of active student response during group instruction. In R. Gardner, III, D. M. Sainato, J. O. Cooper, W. L. Heward, J. Eschelman, & T. A. Grossi (Eds.), *Behavior analysis in education: Focus on measurably superior instruction* (pp. 283–320). Pacific Grove, CA: Brooks/Cole.
Hogin, S. (1996). *Essential contingencies in correction procedures for increased learning in the context of the learn unit.* Unpublished doctoral dissertation, Columbia University, New York.
Holland, J. G., & Skinner, B. F. (1961). *The analysis of behavior.* New York: McGraw-Hill.
Ingham, P., & Greer, R. D. (1992). Changes in student and teacher responses in observed and generalized settings as a function of supervisor observations. *Journal of Applied Behavior Analysis, 25,* 153–164.
Johnson, K. R., & Layng, T. V. (1992). Breaking the structuralist barrier: Literacy and numeracy with fluency. *American Psychologist, 47,* 1475–1490.
Johnson, K. R., & Layng, T. V. (1994). The Morningside model of generative instruction. In R. Gardner, III, D. M. Sainato, J. O. Cooper, W. L. Heward, J. Eschelman, & T. A. Grossi (Eds.), *Behavior analysis in education: Focus on measurably superior instruction* (pp. 283–320). Pacific Grove, CA: Brooks/Cole.
Johnson, P., Schuster, J., & Bell, J. (1996). Comparison of simultaneous prompting with and without error correction in teaching science vocabulary words to high school students with mild disabilities. *Journal of Behavioral Education, 6,* 437–458.
Johnston, J., & Pennypacker, H. (1992). *Strategies and tactics of human behavioral research* (2nd ed.). Hillsdale, NJ: Erlbaum.
Keller, F. S. (1968). Goodbye, teacher . . . *Journal of Applied Behavior Analysis, 1,* 79–80.
Keohane, D. (1997). *A functional relationship between teachers use of scientific rule governed strategies and student learning.* Unpublished doctoral dissertation, Columbia University, New York.
Kirby, F. D., & Shields, F. (1972). Modification of arithmetic response rate and attending behavior. *Journal of Applied Behavior Analysis, 5,* 79–84.
Lamarre, J., & Holland, J. G. (1985). The functional independence of mands and tacts. *Journal of the Experimental Analysis of Behavior, 43,* 5–19.
Lamm, N., & Greer, R. D. (1991). A systematic replication of CABAS in Italy. *Journal of Behavioral Education, 1,* 427–444.
Lindhart-Kelly, R., & Greer, R. D. (1999). *A functional relationship between mastery with a rate requirement and maintenance of learning.* Manuscript submitted for publication.
Lindsley, O. R. (1991). Precision teaching's unique legacy from B. F. Skinner. *Journal of Behavioral Education, 1,* 253–266.
Lindsley, O. R. (1992). Precision teaching: Discoveries and effects. *Journal of Applied Behavior Analysis, 25,* 51–57.
Lodhi, S., & Greer, R. D. (1989). The speaker

as listener. *Journal of the Experimental Analysis of Behavior, 51,* 353–359.

Mach, E. (1960). *The science of mechanics* (T. J. McCormack, Trans.). Lasalle IL: Open Court.

Madsen, C. H. J., Becker, W. C., & Thomas, D. R. (1968). Rules, praise, and ignoring: Elements of elementary classroom control. *Journal of Applied Behavior Analysis, 1,* 139–150.

Malott, R. W. (1989). The achievement of evasive goals: Control by rules describing indirect acting contingencies. In S. C. Hayes (Ed.), *Rule-governed behavior: Cognition, contingencies, and instructional control* (pp. 269–322). New York: Plenum.

Michael, J. (1983). Distinguishing between discriminative and motivational functions of stimuli. *Journal of the Experimental Analysis of Behavior, 37,* 149–155.

Patterson, G. R. (1982). *Coercive process.* Eugene, OR: Castela.

Polirstok, S. R., & Greer, R. D. (1977). Remediation of a mutually aversive interaction between a problem student and four teachers by training the student in reinforcement techniques. *Journal of Applied Behavior Analysis, 10,* 573–582.

Polirstok, S. R., & Greer, R. D. (1986). A replication of collateral effects and a component analysis of a successful tutoring package for inner-city adolescents. *Education and Treatment of Children, 9,* 101–121.

Schwartz, B. (1994). *A comparison of establishing operations for teaching mands.* Unpublished doctoral dissertation, Columbia University, New York.

Schwartz, B. S., & Greer, R. D. (1995). *Inducing and expanding the mand repertoires of pre-schoolers: A comparison of three establishing operations.* Unpublished paper, Columbia University, New York.

Selinske, J., Greer, R. D., & Lodhi, S. (1991). A functional analysis of the comprehensive application of behavior analysis to schooling. *Journal of Applied Behavior Analysis, 13,* 645–654.

Sherman, J., & Cormier, M. (1974). An investigation of the effect of student behavior on teacher behavior. *Journal of Applied Behavior Analysis, 7,* 11–21.

Sidman, M. (1960). *Tactics of scientific research.* New York: Basic Books.

Singer, J., & Greer, R. D. (1997, May). *A functional analysis of the role of the correction operation in the learn-unit.* Paper presented at the annual meeting of the Association for Behavior Analysis, Chicago.

Skinner, B. F. (1938). *The behavior of organisms.* New York: Appleton-Century-Crofts.

Skinner, B. F. (1953). *Science and human behavior.* New York: Macmillan.

Skinner, B. F. (1957). *Verbal behavior.* Cambridge, MA: B. F. Skinner Foundation.

Skinner, B. F. (1968). *The technology of teaching.* New York: Appleton-Century-Crofts.

Staats, A. W. (1981). Paradigmatic behaviorism, unified theory construction methods, and the zeitgeist of separatism. *American Psychologist, 36,* 239–256.

Stallings, J. (1980). Allocated academic learning time revisited, or beyond time on task. *Educational Researcher, 9,* 11–16.

Stallings, J. A. (Ed.). (1985). *Instructional time and staff development.* New York: Longham.

Stephens, J. M. (1967). *The process of schooling.* New York: Holt, Rinehart, & Winston.

Stokes, T. F., & Baer, D. M. (1977). An implicit technology of generalization. *Journal of Applied Behavior Analysis, 10,* 349–367.

Sundberg, M. L. (1993). The application of establishing operations. *The Behavior Analyst, 16,* 211–214.

Woolery, M., Holcombe, A., Billings, S. S., & Vassilaros, M. A. (1993). Effects of simultaneous prompting and instructive feedback. *Early Education and Development, 4,* 20–31.