DOCUMENT RESUME

ED 108 006 CG 009 813

AUTHOR Anderson, Lorin W.
TITLE Time to Criterion: An Experimental Study.
PUB DATE [75]
NOTE 19p.; Presented at the Annual Meeting of the American Educational Research Association (Washington, D.C., March 30-April 3, 1975)

EDRS PRICE MF-$0.76 HC-$1.58 PLUS POSTAGE
DESCRIPTORS *Individual Differences; *Instructional Design; Junior High School Students; *Learning Processes; *Memory; *Motivation; Research Projects; Secondary Education; Speeches

ABSTRACT

The purpose of the study was to investigate the magnitude of individual differences in time-to-criterion and the stability of these differences. Time-to-criterion was defined in two ways: the amount of elapsed time required to attain the criterion level and the amount of on-task time required to attain the criterion level. Ninety students were randomly assigned to either a mastery learning strategy in which all students were helped to attain the 85 percent criterion level or to one of two control classes. All students learned a three-unit sequence of programmed material in matrix arithmetic. The results of the study indicated that time-on-task-to-criterion and elapsed time-to-criterion are alterable to the extent that the ratio of the necessary time-on-to-criterion for the fastest student to the slowest student on the final unit was approximately one to one and two-fifths. Implications for schooling and school learning are discussed. (Author)

Time to Criterion: An Experimental Study

Lorin W. Anderson

University of South Carolina

Abstract

The purpose of the study was to investigate the magnitude of individual differences in time-to-criterion and the stability of these differences. Time-to-criterion was defined in two ways: the amount of elapsed time required to attain the criterion level and the amount of on-task time required to attain the criterion level. Ninety students were randomly assigned to either a mastery learning strategy in which all students were helped to attain the 85 per cent criterion level or to one of two control classes. All students learned a three-unit sequence of programmed material in matrix arithmetic. The results of the study indicated that time-on-task-to-criterion and elapsed time-to-criterion are alterable to the extent that the ratio of the necessary time-on-task-to-criterion for the fastest student to the slowest student on the final unit was approximately one to one and two-fifths. Implications for schooling and school learning are discussed.

Time to Criterion: An Experimental Study

Introduction

Recent innovations in both instructional design and educational measurement have led to a juxtaposition of two concepts in school learning: time and amount learned. In contrast to the tendency to set a fixed amount of time per learning task, alternative learning strategies (such as Bloom's "mastery learning" and Individually Prescribed Instruction) have set fixed achievement criteria and provided students with varying amounts of time and help to permit virtually all students to attain mastery of these educational objectives.

What seems to be involved in this juxtaposition is a trade-off of variables. Whereas in the more conventional strategies the variable is achievement, the variable in these alternative strategies is time. The purpose of this study is to examine more closely the nature of this trade-off. One commonly held notion is that a certain amount of student variation in achievement is exchanged for an equal amount of student variation in time-to-criterion and that this student variation in time-to-criterion is a relatively stable variation. This is bhe belief that underlies one critic's statement that an alternative strategy with fixed achievement objectives for all students is not feasible since "it would extend the education of some youngsters until they are oldsters" (Cronbach, 1967, p. 25).

As one examines the nature of time-to-criterion more closely one sees that there are two conceptions of time which can be differentiated. During the period of time that is allotted to the student for learning a particular

task, the student spends a portion of that time working on learning and a portion of that time doing things which are not relevant to the task. The amount of time that the student is in the presence of the learning task can be called "elapsed time." The amount of elapsed time can be divided into two parts: time-on-task (the amount of time the student is involved in learning) and time-off-task (the amount of time the student is not involved in learning). With these definitions and distinctions in mind it is possible to further explore the variable time-to-criterion in school learning.

The main purpose of the study is to investigate the following hypothesis. If students are helped to learn the earlier learning units in a three unit sequence to a pre-set criterion level, they will spend approximately the same of amount of time-on-task to attain the criterion level on a final unit, despite student differences in general ability. That is to say, it is hypothesized that student differences in time-on-task to criterion are alterable and can be minimized over a sequence of learning units given appropriate learning strategies.

Prior Research

Relatively few studies have conducted to investigate time-to-criterion as a variable in school learning. The studies which have been conducted fall into one of two categories: those that investigate the magnitude of student variation in time-to-criterion and those that investigate the stability of time-to-criterion over a series of learning tasks.

Carroll and Spearritt (1967) examined 96 sixth grade students learning a single programmed unit of imaginary second language (MIDIMO). The sample was stratified with respect to intelligence: high, medium, and low. The

criterion level was set at 100 per cent correct. They found a range of time-to-criterion of one to four, i.e., it took the slowest student four times as long as the fastest student to reach the criterion.

Block (1970) investigate fourteen eighth grade students learning a three unit sequence of matrix arithmetic. The criterion level was set at 85 per cent on a content-referenced test. The range of time-to-criterion on the initial unit was approximately 1 to 3.4.

Arlin (1973) studied 37 eleventh grade students learning a seven unit sequence of imaginary science. The criterion level was set at 85 per cent correct. The range of time-to-criterion for the initial unit was approximately 1 to 7.

In combination these studies lend support to Carroll's (1970) estimate that the range of time-to-criterion in school learning research is approximately one to five.

The time-to-criterion in the above studies can best be described as elapsed time-to-criterion. Time-to-criterion was measured by having the students write down the clock time they had begun to learn and the clock time they had completed the learning, i.e., the time that they were in the presence of the instructional material.

Only two studies were found that investigated the alterability of time-to-criterion over several successive units. One possible reason for this lack of empirical research seems to be the tendency for researchers to view learning units in isolation in contrast to viewing a single learning unit in the context of a series of learning units. Since very few units in school learning can be thought of as being isolates there seems to be a need to examine a series or sequence of discrete learning units and the consequences of learning (or not learning) each unit on the learning

of successive units.

Both studies which were located did conclude that the range of elapsed time-to-criterion decreased over a series of related units when virtually all students were helped to attain the criterion level on prior units. Block (1970) found a decrease over a three unit sequence from 1 to 3.4 to 1 to 2.1. Note, however, that Block had a very small sample (n = 14). Arlin (1973) found a decrease over a seven unit sequence from 1 to 7 to 1 to 4. Further study of this problem seems appropriate especially when time-on-task-to-criterion is substituted for elapsed time-to-criterion.

Sample

The subjects were taken from a middle-class suburb of a Midwestern community. Lorge-Thorndike verbal intelligence scores ranged from 87 to 135. Ninety eighth grade students were randomly assigned to one of three classes of thirty students each. Because of absences 26, 27, and 29 students completed the entire experiment.

Procedures

The material to be learned consisted of a three unit sequence of programmed material in matrix arithmetic (Block, 1970). The first unit was composed of the basic terminology of matrices, the second unit contained material on special types of matrices, and the third unit consisted of material on matrix operations (addition and subtraction). Eighty minutes of class time were allotted for each of the units.

The three classes learned under two different strategies. The first class used mastery learning techniques while the other classes were termed control classes. The students in the mastery learning class were given additional time and help to attain a pre-set 85 per cent criterion level (85ML). The students in one of the control classes were not given the

additional time and help nor were they required to attain a pre-set criterion level (C1). The students in the other control class were given enough additional time and help to reach a 75 per cent criterion level. A matrix arithmetic pre-test was administered on the first day of the study. The mean per cent correct for the three classes on the pre-test was 7.6, 8.9, and 7.9, respectively. The difference among the classes was not significant.

All students were given the programmed text and a unit formative test. The students were instructed to write the time on the clock on their programmed booklets and begin working. After the students finished the booklet, they wrote the time they finished and picked up the formative test. They wrote the time they began on the formative test, took the formative test, and wrote the time they completed the test. All three classes proceeded in the same manner up to this point.

In the mastery learning class (85ML) a student-tutor corrected the formative tests as they were completed by the students. Students who did not attain the 85 per cent level were asked to complete review exercises based on the items that were incorrect. The number of review exercises to be completed was determined by the difference between the number of items correct on the formative test and the criterion level of seventeen correct out of twenty items. The student wrote the time he began working on the review exercises and the time he finished. He was then given a parallel form of the formative test (a review test) and was to to answer the items which were keyed to the particular review exercises performed. Once again the student wrote the time he began the test and the time he finished. If the student still did not attain the specified criterion level (combining the number correct on the formative test with the additional correct on the review test), he repeated the review-corrective process a third time

with student-tutorial help and a parallel set of test items. The tutor wrote on the student's paper the time he began tutoring the student and the time he completed the tutoring. Every student in the mastery class was able to attain the 85 per cent criterion level with no more than two review-corrective periods. The students in the second control group were given only one corrective period and were allowed to attain only the 75 per cent level on the combination of formative tests and review tests on the units. The students in the first control group were finished for the class period after they had taken the formative test.

The same procedure was followed for each of the three learning units in the sequence.

Variables

There were three major variables in the study: elapsed time, time-on-task and achievement. Elapsed time refers to the amount of clock time that passed between the beginning and end of the actual learning time. It was calculated for each student by subtracting the starting time from the completion time in every learning segment, i.e., the original learning time plus any additional review learning time, and combining the various segments. No testing time was included in the computation of elapsed time.

Time-on-task refers to the time during which the student is actively involved in learning. Two types of behaviors are relevant to the student's active involvement in learning. The student may be engaged in on-task behaviors (e.g., writing) that are, in fact, observable, or he may be engaged in on-task behaviors that are unobservable (e.g., thinking). The instrument used to estimate the per cent of time-on-task, therefore, included two

components in an attempt to obtain measurements on both types of on-task behaviors.

The first component was a classroom observation instrument. An observer watched a randomly pre-selected student for six seconds and coded his behavior as on-task or off-task. He then watched the second student in the row for a six second period, coded his behavior, and looked to the third study. This same procedure was followed until the entire class was appropriately coded. The observer then took a second coding sheet, began with a randomly pre-selected student, and repeated the above procedure. This procedure was continued until the end of the class period. As a check on the objectivity of the classroom observation instrument, a second observer was present in each class for a period of 30 minutes during the study. The inter-observer agreement for the observers on the three on-task and one off-task categories was 83 per cent, 87 per cent, 75 per cent, and 82 per cent. (See Anderson, 1973, for a description of the categories.) The per cent of overt time-on-task for each student was estimated by dividing the number of on-task observations by the total number of observations.

The second component of the time-on-task instrument was based on a stimulated recall technique developed by Bloom (1953). After every two scans of the classroom by the observer, the students were asked to stop working and write in a sentence or two what they were thinking just prior to being told to stop. The students' thoughts were then classified by two judges as being task relevant or task irrelevant. The inter-judge agreement was 89 per cent. The per cent of covert time-on-task was estimated by dividing the number of thoughts classified by the judges as task relevant by the total number of thoughts classified.

The per cent of time-on-task was computed by taking the arithmetic average of the per cent of covert and overt time-on-task. Finally, the amount of time-on-task was computed by multiplying the per cent of time-on-task by the amount of elapsed time.

Achievement on each unit was defined as the total number correct on a combination of the formative test and the review tests. For the purpose of testing the hypothesis, sixteen of twenty items correct, or eighty per cent, was designated as the criterion level. Eighty per cent was used as the criterion level in order to produce samples which were large enough to be meaningful.

The formative tests were composed of 20 items which required the learner to supply the correct answer. The items were based on a unit table of specifications table. The items tested the taxonomic levels of knowledge, comprehension, and application (Bloom, 1956).

Results

The hypothesis was investigated in two ways. First, the amount of time-on-task necessary to reach or surpass the criterion level by three different groups of learners on each of the three learning tasks was examined. These three groups were chosen in the following manner. Group 1 consisted of students in the two control classes who attained scores at or above the criterion on the formative test taken after the original amount of initial elapsed time. In other words, these students did not need nor receive additional time or help on the unit. Group 2 consisted of students in the 85ML class who were able to attain the criterion score or higher on the specific unit's formative test. Group 3 was composed of students in the 85ML class who required additional elapsed time on the

particular learning unit. Some of these students may have attained the criterion level in original amounts of learning time in other learning units. It is important to note that the groups are not invariant across all learning units. In other words, for each unit a new Group 1, Group 2, and Group 3 were formed based on the students who attained the criterion level on that particular unit.

In fact, if we examine Groups 2 and 3, both of whom were in the 85ML class, some interesting findings emerge. Of those six students who were able to attain the criterion level in the original elapsed time in the first unit only three were able to attain the criterion score in original elapsed time on unit two. Further, only two students were able to attain mastery on all three units without extra time and help. On the other hand, twelve of the students in the 85ML class required additional help on all three learning units, although as shall be seen, not as much extra time and help in the third unit as in the first unit.

Three groups were used in the analysis because any more groups would have reduced the groups to extremely small numbers.

Table 1 shows the means, standard deviations, and orthogonal contrast of the total amount of time-on-task needed by the three different groups of students to reach the criterion level in units one, two, and three. The contrasts of interest are: Group 1 versus Group 2, since both groups required no additional elapsed time to attain the criterion; and the combined group (Group 1 plus Group 2) contrasted with Group 3, since Group 3 was the only group that required additional elapsed time to attain the criterion on that particular unit.

Insert Table 1 About Here

An examination of the means of the first unit shows that the two groups that attained the criterion level in the original amount of elapsed time are quite similar in the amount of time-on-task required. The students in the 85ML class who were able to attain mastery only with the allottment of additional amounts of elapsed time and help required approximately 66 per cent more on-task time on the average than did their classmates who were able to attain mastery in the original amount of elapsed time. An examination of the contrasts shows that there was no significant difference between the two "original elapsed time" groups. There was a significant difference between the combined group and the "additional elapsed time" group ($p < .001$).

In the second unit a similar pattern is observed although there is one important difference. Once again there was no significant difference between the two "original elapsed time" groups. However, while the difference between the combined group and the "additional elapsed time" group was still significant, it was less marked than in unit one. The "additional elapsed time" group required approximately 30 per cent more time-on-task on the average than their peers in the 85ML class.

In the third unit this trend continues. There was no significant difference among the three groups. The "additional elapsed time" group did not differ significantly from the combined group on the amount of on-task time-to-criterion. The "additional elapsed time" group required only approximately five per cent more time-on-task than did their 85ML classmates.

As added support for the above finding it can be noted that the standard deviations of the two subgroups of the 85ML class were quite similar. The distributions of the necessary on-task time-to-criterion of the two subgroups were almost identical.

A second way of examining the hypothesis is to examine the individual differences within the 85ML class in the amount of elapsed time and time-on-task to reach criterion over the three-task sequence.

Table 2 shows the range of elapsed time and time-on-task-to-criterion for the 29 students in the 85ML class. The range was then converted into a ratio of fastest student's time-to-criterion to the slowest student's time-to-criterion.

Insert Table 2 About Here

There was a fairly large discrepancy between the ratio of elapsed time-to-criterion and the ratio of time-on-task-to-criterion in the first unit. While it appeared that the slowest student needed approximately three and one-half times as much "time" to attain the criterion when elapsed time was used as the time measure, it appeared that the slowest student required only twice as much "time" when time-on-task was the "time" indicator.

Also, the ratios of both elapsed and on-task time-to-criterion decreased as the students progressed from unit to unit. In unit three it can be seen that while the slowest student still needed twice as much elapsed time as the fastest student, he needed only one and two-fifths as much time-on-task.

The above findings lend much support to the hypothesis. The 85 per cent criterion mastery learning strategy was successful in producing students who were quite similar in the amount of on-task time necessary to reach the criterion on the final task.

Conclusions and Implications

Two major conclusions can be derived from this study. First, the amount of necessary time-on-task-to-criterion can be altered by an effective learning strategy. Second, students with varying amounts of general ability can become quite similar in the amount of time-on-task they require to learn a particular learning task after a series of preparatory tasks.

This would imply that if equality of learning outcomes is a desired goal in certain instances in education, it can be achieved by designing learning situations that allow for inequalities in the characteristics which the students bring to the task. In other words, if, as is true in virtually all learning situations, students enter with unequal characteristics and are presentad with a learning situation in which all are given an equal amount of elapsed time and instructional help, the students will spend differing amounts of their time on-task, and the result will be students with unequal leaving characteristics. One might recognize this as the basic argument of mastery learning advocates since Bloom's (1968) original paper.

The present study, however, has added an important dimension to the previous argument. By complementing inequality in learner characteristics with inequality in instructional time and help in early units, we can approach student equality in later units, not only in the achievement level attained, but also in the amount of on-task time needed to attain

the criterion level.

Thus, over a series of sequential school learning units, the argument is as follows. Students enter a particular learning sequence with unequal characteristics. Some of these characteristics are relevant to the learning sequence and some are not. Unequal amounts of time and help are provided for students to learn each unit to a relatively high level. After a number of units students will approach equality in the amount of time-on-task they need to spend to reach the criterion level in successive units. Further, and in a more practical vein, teachers will need to allot less and less additional elapsed time since students will spend a greater per cent of their time on-task (Anderson, 1974).

Two points are important to make in conclusion. First, one cannot look for equality in achievement or necessary on-task time on the early, or preparatory, learning tasks since the students will enter these with a variety of characteristics which are relevant to the particular learning sequence. It is only after students have been provided with the necessary entering characteristics over several tasks in preparation for the later tasks or units that one can judge whether or not there is equality of learning both in time-to-criterion and the criterion level attained.

Finally, it is not possible to judge equality of learning time-to-criterion with measures of elapsed time. It is only a fair comparison to make when students have spent equal amounts of time on-task, not equal hours of elapsed time in the classroom.

References

Anderson, L. W. Time and school learning. Unpublished Ph.D. Dissertation, University of Chicago, 1973.

_____. Student involvement in learning and school achievement. Paper presented at the American Educational Research Association Annual Meeting, Chicago, April 15-19, 1974.

Arlin, M. Learning rate and learning rate variance under mastery learning conditions. Unpublished Ph. D. Dissertation, University of Chicago, 1973.

Block, J. H. The effects of various levels of performance on selected cognitive, affective, and time variables. Unpublished Ph. D. Dissertation, University of Chicago, 1970.

Bloom, B. S. (Ed.) Taxonomy of educational objectives, handbook I: Cognitive domain. New York: David McKay, 1956.

Bloom, B. S. Thought processes in lectures and discussions. Journal of General Education, 1953, 7, 160 - 169.

_____. Learning for mastery. Evaluation Comment, 1968, 1(2).

Carroll, J. B. Problems of measurement related to the concept of learning for mastery. Educational Horizons, 1970, 48, 71 - 80.

_____, and Spearritt, D. A study of a 'Model of school learning.' Harvard University: Center for Research and Development on Educational Differences, 1967.

Cronbach, L. J. How can instruction be adapted to individual differences? In R. Gagne (Ed.) Learning and individual differences. Columbus, Ohio: C. E. Merrill Books, 1967.

Table 1

Means, Standard Deviations, and Orthogonal Contrasts of the Amount of Time-on-Task Needed by Three Different Groups on Three Successive Units to Reach the 80% Criterion Level

Group	N	Mean	Stand.Dev.	Contrasts and Significance G1 - G2	(G1 + G2)/2 - G3
Unit 1					
1: Students from control classes	9	9.71	1.79	1.53ns	-4.57***
2: Ss from 85ML class who reached level in original elapsed time	6	8.18	0.47		
3: Ss from 85ML class who needed additional elapsed time	23	13.69	2.01		
Unit 2					
1: Ss from control classes	10	12.04	3.78	1.57ns	-2.53*
2: Ss from 85ML class who reached level in original elapsed time	7	10.47	0.74		
3: Ss from 85ML class who needed additional elapsed time	22	13.61	1.85		
Unit 3					
1: Ss from control classes	15	17.55	2.57	1.03ns	-1.23ns
2: Ss from 85ML class who reached level in original elapsed time	13	18.58	1.61		
3: Ss from 85ML class who needed additional elapsed time	16	19.30	1.43		

Note. -- The following convention for level significance is used: .05 level = *; .01 level = **; and .001 level = ***.

Table 2

Range of Elapsed Time and Time-on-Task to Criterion in the 85ML Class

Time Measure	Range of Minutes to Criterion	Ratio
	Unit 1	
Elapsed Time	9 to 31	1 to 3.4
Time-on-Task	7.8 to 16.5	1 to 2.1
	Unit 2	
Elapsed Time	10 to 28	1 to 2.8
Time-on-Task	9.7 to 17.4	1 to 1.9
	Unit 3	
Elapsed Time	16 to 33	1 to 2.1
Time-on-Task	16.0 to 22.3	1 to 1.4