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ABSTRACT

Several tenets of mastery learning were examined in this study in the context of college level instruction. When students learn for mastery: (1) retention test scores should exhibit small variability and should be unrelated to aptitude; (2) test items which are classified into high and low cognitive behavior subscales should be unrelated to aptitude. The first tenet was partially supported as the relationship between retention and aptitude was uniformly low across three units of instruction, and variability of retention tests was not restricted. No relationship between performance on both high and low cognitive subscales and aptitude was observed. (Author)

EFFECTS OF LEARNER VARIABLES ON RETENTION AND TWO LEVELS OF COGNITIVE MATERIAL WHEN LEARNING FOR MASTERY

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Although there are many examples of mastery learning in operation at present, the basic principles utilized have been expressed and examined following the Model of School Learning proposed by Carroll (1963) and have incorporated in the strategies proposed by Bloom (1968). Mastery learning is purported to allow for high levels of performance from students regardless of measured aptitude (Block, 1971). That is to say, most students can attain a high level of achievement in the classroom if mastery learning is employed, regardless of the students' prior academic achievement or performance on aptitude tests. Furthermore, it can be argued that if students are normally distributed with respect to aptitude for a particular subject matter prior to instruction, nearly all students under a mastery system will perform at a level normally attained by a relatively small number of students in a nonmastery class in which the traditional group-paced, norm-referenced procedures are employed.

Several studies have reported findings based on comparisons between mastery and nonmastery instructional groups. Mastery groups have generally attained higher levels of achievement and typically express a more favorable attitude toward learning under the mastery learning strategy (Kim, 1971; McMichael & Corey, 1969;

Sheppard & MacDermott, 1970). Sjogren (1967) examined the tendency of mastery students to retain instructional material as a result of mastery learning, yet, he did not analyze retention scores across measured aptitude levels for the sample of students employed. A distribution of retention scores for such a group of mastery learners would necessarily approach a normal distribution if aptitude were a potent variable. In fact, only limited research has been conducted examining the influence of aptitude upon retention of instructional material in a classroom learning enviornment. This research offers little assistance in the understanding of the effects of specific instructional sequences such as Mastery Learning or PSI (Personalized Student Instruction) on retention when a uniformly high degree of learning was demonstrated.

The issue concerning the relationship between aptitude and retention must also be examined in light of the cognitive level of the material presented. The ability of students to learn and retain instructional material may be related differentially according to the cognitive complexity of the material. While only a few studies deal with the cognitive complexity of the learning tasks in a mastery based setting, these studies may provide the basis for an alternate theory of student performance under such learning paradigms. Gagne and Paradise (1961) reported a study in which learning rates and aptitude were studied, finding that aptitude in fact predicted rate of learning and that the acquisition of low-level congnitive material was necessary for the learning of higher-level material when cognitive hierarchies exist in the material. Airasian (1969) reported that cognitive hierarchies could be reliably established through experts' agreements with regard to cognitive level. The Airasian study suggested that subjects who missed a certain percentage of lower cognitive level items also missed a greater percentage of high-level cognitive items. The nature of these results suggest that hierarchies of cognitive complexity exist and can be readily identified and validated. It is possible that student performances across these cognitive levels is fundamentally uniform and not necessarily a function of aptitude, particularly in mastery learning.

The primary objectives of the present investigation were to examine the following hypotheses regarding mastery instruction: (a) retention of achievement should exhibit decrements as a direct function of the length of the retention interval rather than as a function of scholastic aptitude, (b) variability of retention scores as well as postinstructional mastery scores should be uniformly low as a consequence of the mastery learning strategy, and (c) students should perform uniformly across postinstruction, and retention periods, regardless of the cognitive complexity of the tasks or measured scholastic aptitude of the students.

Method

Subjects

Sixty-five students enrolled in a junior level educational psychology course participated in this study. These students were similar to the general college population with respect to American College Test scores (mean ACT=21.9; S.D.=3.2) and scholastic grade point average (mean GPA=4.20; S.D.=.39). Of the 65 Ss, all were education majors and 50 were females.

Materials

To assess student achievement, three parallel exams were designed and constructed for each unit. These forms were considered criterion-referenced in that they (a) represented well defined achievement domains which were explicated through the use of instructional objectives and (b) contained a prespecified criterion level of 70% for the purpose of determining mastery or non-mastery status for each S. Objective type test items were written to represent these instructional objectives, and the items were then randomly assigned to each form. The mean item difficulty level for each unit across forms was .589. Subsequent analysis confirmed the equivalency of forms with regard to item difficulty, and internal consistency estimates for the test forms ranged from .79 to .89 with a median value of .85.

To investigate the cognitive complexity of the test items, three instuctors of the course who were familiar with Bloom's cognitive taxonomy (Bloom, 1956) were asked to classify each test item into one of two categories: low or high cognitive, in which low cognitive questions were defined as "knowledge level". (see Figure A)

Place Figure A about here

A high percentage (88%) of interjudge concurrence was found between any pair of judges, and descrepancies in classification were resolved in conference. Consequently, two subscales were constructed for all unit tests utilized in this study.

Procedure

Each student enrolled in the course received a course syllabus explaining the conduct of the course and the underlying rationale of mastery learning as well as a list of instuctional objectives prior to instruction of each unit. For each unit of instruction, Ss were administered one of the parallel forms preceding instruction; following instruction; and during a final examination period at the end of the school term. The retention test was unannounced and administered during the period normally used for instructional evaluation. Therefore, the results were interpreted as retention measures without the effects of review or practice. Each S took the pre and post instructional mastery tests for each unit but was administered only one of three retention tests. The retention tests were administered randomly to Ss by randomizing the order in which they were distributed to the Ss.

For data analysis purposes, the independent variable of scholastic aptitude was defined as a linear combination of ACT scores and college GPA. Both measures have been widely accepted as indicators of how well students may be expected to do in traditional classroom settings.

Results and Discussion

All students involved in this study performed beyond the criterion level established as a consequence of the mastery learning strategy employed. When students failed to achieve the desired level of competency, prescriptive-remedial instruction was provided and re-tests were administered until mastery was demonstrated by all students. These results generally support the findings of previous studies (Airasian, 1967; Biehler, 1970) which demonstrate mastery level achievement is attainable by most of the instructional population.

Place Table 1 about here

To investigate the first research hypothesis, a two-way analysis of variance with repeated measures on the first factor was performed according to procedures discussed in Winer (1971). The results, shown in Table 1, indicate that differences of a major magnitude occurred for pre to post to retention periods for each of the units. Calculating the strength of association for each of the units, eta-squares were uniformly high (.70, .67, .59), indicating a high degree of practical significance of the differences between ordered pairs in unit one using a Newman-Kuels procedure, all differences were statistically significant at the .01 level. Thus, substantial gains were made as a result of learning for mastery. Retention was significantly higher than preinstruction levels but also significantly lower than the mastery level. For the four week retention interval, all possible pairs were statistically significant ($p < .01$) as in the case with unit one. For the shortest retention period, in unit three, significant differences ($P < .01$) were observed between preinstruction status and mastery status and between preinstruction status and retention status. However, the differnce between mastery status and retention were non-significant ($P > .05$) for unit three. Therefore, it appears that retention does in fact relate directly with the length of the retention interval.

As a result of examining the second aspect of the first hypothesis, that of the effects of aptitude upon retention, it must be noted that no statistical interaction was observed between the repeated measure (pre, post, retention) and that of aptitude. Since aptitude was artificially dichotomized for the purposes of using the two-way repeated measures ANOVA, the relation between aptitude and achievement was also viewed in terms of regression.

Table 2 contains product-moment correlation coefficients computed between aptitude and scores for each of the three treatment conditions (preinstruction, postinstruction, and retention) for the three instructional units studied. The results presented

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Place Table 2 about here
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in Tabel 2 indicate that only two correlations are significant and were based on the relationship between aptitude and preinstructional performance. From these data, and the results of the analyses of variance for total-test scores, it appears that aptitude as it is defined in this study is unrelated to both mastery and retention performance.

It was further hypothesized that the mastery learning strategy reduces the variability of test scores since sufficient time is allowed for each student to attain mastery. Consequently, mastery-status test score variance should be significantly smaller than preinstruction test score variance. In addition, retention scores should also exhibit this reduced variance when learning for mastery. The results, shown in Table 3, indicate that in unit one

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Place Table 3 about here
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small changes in variance occurred from pre to post to retention intervals. None of these differences were statistically significant (t=3.17, df=26, P>.05). However, in unit two a significant drop in test score variance was observed between preinstruction and postinstruction (P<.05). Oddly enough, retention test score variance increased dramatically, and the results were statistically significant (t=4.54, df=15, P<.05). In unit three, a statistically significant variance increase was noted between pre and post scores (t=2.05, df=18, P<.025), although the changes from post to retention were non-significant (P>.05). From these results, it would appear that a single general conclusion can not be drawn about the variability of test scores from pre to mastery to retention scores. Setting a criterion level and allowing students to study until mastery has been achieved does reduce the test score variance when these scores are obtained immediately following the time that mastery has been demonstrated. However, the dissipation of learning as indicated by decrements in the scores of retention tests does not appear to be systematically related to any factors investigated in this study. In other words, the traditional predictors of college success, namely, GPA and ACT scores, are of little value when learning for mastery.

Place Table 4 about here

The results of the analysis of variance for the high and low cognitive scales are shown in Table 4. Cell and marginal means, as well as the standard deviations for low and high cognitive scales are presented in Table 5. Although three judges familiar with Bloom's taxonomy concurred 38% of the time in the classification of test items with regard to cognitive complexity, the correlations observed between these two scales across different time intervals

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Place Table 5 about here

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ranged from -.18 to .62. Part of the typically low relationship can be attributed to the narrow range of student performance within the levels examined, (pre, post, retention), particularly under the mastery level. However, the uniformly low and largely non-significan correlations reported above must lead to the conclusion that the two sub-scales represent relatively independent cognitive dimensions.

From the ANOVA results reported in Table 4, only main effects differences over time were statistically significant ($P<.001$). As in the instance of the full scale tests, the strength of association, the correlations, were uniformly large. In no instance were the main effects tests for aptitude significant ($P>.05$) and only one of three interactions was significant. The significant interaction in unit three ($P<.05$) accounted for only nine per cent of the criterion variance and, as a consequence, was not interpreted as having practical significance. To more aptly describe the relation between aptitutde and the low and high cognitive scales, correlations were computed and are reported in the first two columns of Table 2. Only three of the 18 correlations were significant beyond the .05 level, and all three significant coefficients occurred under preinstructional conditions. Therefore, it appears that aptitude does operate in determining preinstructional status but has little influence on initial learning and retention status for either the low or high cognitive tasks.

Generally, the results of the present investigation are construed to support some of the basic assumptions of both Carroll and Bloom regarding mastery learning. Namely, that given enough time students will learn to a uniformly high level of proficiency regardless of aptitutde for learning, and that aptitude plays a relatively minor role in determining the degree to which one learns and retains instructional material. Furthermore, regardless of the cognitive complexity of the task students perform uniformly when learning for mastery as is suggested in previous research (Airasian, 1969). The authors express reservation with regard to the applicability of these conclusions to the general school population, other than a college population. There are major differences between college upperclassmen and either elementary or high school students, not the least of which is the wider range of abilities and motivation, plus developmental phenomenon, which may be emerging in younger persons and interacting with scholastic achievement. Yet, the results appear to be quite definitive with regard to the performance of university students under the mastery learning strategy, and further systematic analyses of student performance in other suject domains would be of interest. In this study, the content of units one and three were quite different from unit two (statistical concepts), and the results differed slightly with respect to the aptitude-achievement relationship for unit two. The higher correlations between aptitude and achievement for unit three, as well as the relatively high mean test score for unit three under preinstruction conditions, suggest that aptitude may facilitate transfer of general academic skills such as adapting to new material and specific instructional sequences. This is to say, students with higher aptitude scores are more efficient in benefiting from an instructional experience and transferring new skills to new learning tasks. When unit three exams are administered at the beginning of the course however, scores were observed near the chance level indicating little or no entering knowledge in the content area.

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FIGURE A

Examples of test items from the Low and High Cognitive Subscales

I Low-level Cognitive test items:

1. The most important single question which should be raised regarding any psychological test concerns its:

** A. Validity
B. Reliability
C. Content
D. Objectivity
E. Standardization

2. In Bloom's Taxanomy "synthesis" is defined as the:

** A. Combining of elements into a new product
B. Applications of standards of acceptability
C. Translation of verbal message into some other appropriate symbolic form
D. Sorting of the whole into its component parts

II High-level Cognitive test items:

1. Which of the following teachers'statements indicates the best understanding of the teachers' responsibility?

A. "Test results showed that my test was too easy."
** B. "I am pleased that my students did well on the test."
C. "Scores on my test averaged at the 50 percent level of difficulty, so it was a good test."
D. "My students could not anticipate the general nature of the test questions, so it was a good test."
E. "Test results showed that my test was too hard."

2. Measurement is related to evaluation as

A. specific to general
B. concrete to abstract
C. Sufficient to necessary
*** D. means to end

TABLE 1

F-ratios, appropriate probability statements, and correlation ratios for two-way analysis of variance for Units One, Two, and Three

Unit 1	df	F	n^2
A (Treatment)	2,50	125.1 *	.70
B (Aptitude)	2,25	.8	-
A x B	4.50	1.7	-
Unit 2			
A. (Treatment)	2.28	75.0 *	.67
B. (Aptitude)	2,16	0.0	--
A.x B	4,28	1.3	-
Unit 3			
A (Treatment)	2,34	47.4 *	.59
B (Aptitude)	2,17	1.56	--
A x B	4,34	1.2	--

* P∠.001

TABLE 2

Correlations between Aptitude and Achievement at Pre-Instruction, Post Instruction and Retention Levels

Unit One N=28	High Cognitive Achievement	Low Cognitive Achievement	Full Scale Achievement
Pre-Instruction	.15	.50**	45*
Post-Instruction	-.25	-.16	-.09
Retention	-.03	-.03	-.10
Unit Two N=17			
Pre-Instruction	-.03	-.34	-.22
Post-Instruction	.16	.25	.09
Retention	.26	.01	.15
Unit Three N=20			
Pre-Instruction	.53**	.49**	59**
Post-Instruction	.28	.04	.11
Retention	.17	.04	.11

* $P < .05$
** $P < .01$

TABLE 3

Cell and Marginal Means and Standard Deviations for the Two Way Analysis of Variance with Repeated Measures on One Way for Units One, Two, and Three.

Aptitude	Pre-Instruction		Post-Instruction		Retention		Total
Unit One	mean	s.d.	mean	s.d.	mean	s.d.	mean
High	47	7.6	71	9.1	63	4.7	60
Average	39	8.4	72	5.8	60	10.4	57
Low	41	6.0	72	7.8	65	6.1	59
Total	43		72		63		58.7
Unit Two							
High	34	10.3	74	2.7	64	17.5	57
Middle	41	8.0	73	3.3	59	9.9	58
Low	41	10.4	70	7.7	59	6.3	57
Total	38		72		61		57.3
Unit Three							
High	58	6.6	76	8.2	77	11.0	70
Middle	55	8.5	71	4.3	74	5.7	67
Low	48	10.6	76	4.8	76	7.5	67
Total	54		74		76		68

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TABLE 4

F-ratios, appropriate probability statements, and correlation ratios for two-way analysis of variance with repeated measure on one factor for the high and low cognitive scales Unit one, Two, and Three

Unit One	High Cognitive df	F	n^2	Low Cognitive df	F	n^2
A (Treatment)	2,50	68.5**	.71		62.3**	.61
B (Aptitude)	2,25	0.9	-		1.2	-
A x B	4.50	1.0	-		1.9	-
Unit Two						
A (Treatment)	2,28	92.3**	.76		20.5**	.34
B (Aptitude)	2,14	0.3	-		0.0	-
A x B	4,28	0.8	-		1.1	-
Unit Three						
A (Treatment)	2,34	25.4**	.39		38.3**	.55
B (Aptitude)	2,17	2.63	-		0.2	-
A x B	4,34	2.79*	.09		1.2	-

* $P < .05$
** $P < .01$

TABLE 5

Cell and Marginal Means and Standard Deviations for the Two Way Analysis of Variance with Repeated Measures on One Way for the High and Low Cognitive Scales for Units One, Two, and Three

	HIGH							LOW						
	Pre Instruction		Post Instruction		Retention		Marginal	Pre Instruction		Post Instruction		Retention		Marginal
Unit One N=28	mean	s.d.	mean	s.d.	mean	s.d.	means	mean	s.d.	mean	s.d.	mean	s.d.	means
Aptitude:														
High	42	13.9	68	12.9	61	6.4	57	50	8.7	70	9.6	63	6.4	61
Middle	37	8.5	67	9.6	61	12.2	55	39	10.2	75	7.0	58	11.0	58
Low	39	6.1	77	11.6	62	11.6	60	41	7.8	71	7.2	64	9.7	59
Marginal Means	39		71		61		57.3	44		72		62		59.3
Unit Two N=17														
Aptitude:														
High	30	11.9	74	2.6	69	15.6	58	39	10.3	74	11.1	58	24.1	57
Middle	34	11.1	75	4.3	63	8.8	57	51	7.4	69	9.1	54	13.9	58
Low	34	6.7	70	5.2	59	8.2	55	44	13.8	68	10.0	30	9.8	64
Marginal Means	33		73		64		57	46		71		54		58
Unit Three N=20														
Aptitude:														
High	64	6.2	73	6.1	79	8.1	72	53	7.8	76	9.8	76	12.6	68
Middle	57	13.4	74	7.9	72	9.6	68	55	7.9	69	5.9	76	7.0	67
Low	44	13.8	68	10.0	80	9.8	64	47	11.5	78	6.7	74	10.1	66
Marginal Means	56		72		77		68	52		74		75		67