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ABSTRACT

The purpose of this study was to evaluate the effects of Continuous Progress (mastery) instruction on acquisition, retention, and transfer in an introductory college physics course. Freshmen, stratified according to major, were randomly assigned to Continuous Progress and Traditional Instruction groups. The Continuous Progress group showed greater acquisition, greater transfer to a related course, and greater retention a year later. The results are discussed in terms of both support for Gagne's theory of hierarchically related knowledge and for their practical significance. (Author/CP)

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Abstract

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The need for the development and evaluation of more effective instructional systems on the university level has been noted by more than one authority (Lee, 1967; Wessell, 1967). One type of system being tried in increasing numbers of institutions is individualized instruction. Such systems require each student to demonstrate a satisfactory level of performance before advancing in a learning sequence.

The rationale on which many individualized systems have been developed is that the learning of complex materials depends upon the prior mastery of simpler materials (Gagné, 1962, 1965) and that all students, even at the college level, do not learn at the same rate (Bloom, 1968). Traditional college instruction is inefficient because it does not ensure the acquisition of simpler concepts and skills before the learning of more complex rules and strategies is attempted. Furthermore, traditional testing, in which all students take the same test at the same time, assumes that all students learn at a constant rate. In contrast, individualized systems are designed to ensure adequate knowledge of prerequisites. Also, properly designed individualized programs increase the probability that learning takes place by making it contingent on desirable rewards (Keller, 1968). Finally, individualization allows the <u>learner</u> to determine (within certain limits) when he will be evaluated thus giving a less able student the opportunity to acquire as much as his abler colleague.

A number of studies (Keller, 1968; Moore, Mahan, & Ritts, 1969) have been conducted to determine the effectiveness of individualized instruction in increasing college students' acquisition. Keller (1968) reports that the performance of introductory psychology students was improved as a result of participation in an individualized instruction program. Moore, Mahan, & Ritts (1969), in describing an experiment involving the Moore Plan for instructional improvement (A Continuous Progress Plan 1968), showed that higher achievement and improved attitude resulted from participation in individualized instruction in three college disciplines.

While these investigations provide some support for the general concept of individualized instruction, certain questions remain unanswered. For example, because the control group used by Keller was a class from a previous year there is the problem of confounding due to yearly fluctuations in student characteristics. The study involving the Moore Plan, while satisfying controlled experimental conditions, like the Keller study, failed to provide information regarding the important learning outcomes of retention and transfer. Further, only in a limited way did Moore et.al. address themselves to the generalizability of the concept across university disciplines.

Because of the need to obtain answers to questions of this type, it was the purpose of this study to complete a replication of the previous study on the Moore Plan to determine: (a) its generalizability to introductory college physics; (b) its effects on long term retention; and, (c) its effects on transfer as measured by success in later courses in physics.

Method

Subjects

Thirty-four Bucknell freshmen, designated as math, physics, or electrical engineering majors according to their high school backgrounds, participated in the experiment. Subjects, stratified according to major, were randomly assigned to the Continuous Progress (CP) or Control (C) group. Mean quantitative and verbal SAT scores and mean Math Achievement Test scores were not significantly different for the two groups. Subjects were unaware that they were part of an experiment.

Teaching Method

Both CP and C groups used the same textbook and were expected to cover the same material during the course. A different instructor taught each group. Each week the C group attended two lectures and also two quiz sections in which assigned problems were discussed. Tnree in-class tests consisting of problem type questions and a free response mode were taken by this group at predetermined points in the semester.

The CP group had no lectures but were informed as to what parts of the text should be read and what problems completed in order to attain the unit objectives. Subjects in this group used taped discussions of the assigned problems for feedback. These tapes and cassette recorders were available to Ss in the library.

There were seven unit tests which CP Ss took on an individual basis. The only restriction on time of taking tests was that each S was required to complete the seven units (comprising one semester of credit) by the end of the academic year. Thus Ss could take a full year to complete a one semester course, although only one S did take the full year.

The tests were composed of problem type questions and a multiple choice response mode. When Ss did not reach the 70% criterion on the first test they went over missed problems with their professor to identify and resolve difficulties. After further study, these Ss took a parallel form of the test. The diagnosis-retest sequence was repeated, when necessary, a number of times. When a test was passed at 70% or better, Ss went on to the next unit of material. In this way, proceeding to a new unit was contingent upon mastery of the preceding unit. Review items from the preceding units were included in each successive unit test.

A grade of B was guaranteed for Ss in the CP group who completed the seven units within two consecutive semesters. Subjects receiving averages at a specified level above the minimum 70% received an A for the course.

Evaluation

Both groups took the same final examination. Twelve of the items on the final were of the multiple choice response type familiar to the CP group and 4 were of the free response type familiar to the C group. The exam was written by both the C and the CP instructors and they agreed that the content was equally fair to both groups.

The C group took the final exam during the regular final exam period in December, 1969, while the CP Ss took the final exam when they had completed the required unit tests: seven took the final in December, five in January, two in April, and one in May.

In the second semester, Ss in both groups shared the same instructor for a traditionally taught continuation of their first semester physics course. One S in the C group didn't continue with second semester physics; all other Ss in both groups took the second semester course. Grades in this course were used to evaluate transfer effects.

Twelve to 15 months after the completion of their first semester of introductory physics a retention exam was administered to both groups. Content validity was established for the retention exam by selecting 13 problems from the common textbook which both instructors judged to contain: (a) the type of material which they would want students to retain for a year; and, (b) a fair representation of what had been covered in both forms of the course. A comparison of the contents of the retention exam and the first semester final exam showed that the item content of the retention exam was essentially a subset of the content of the final exam. The retention exam employed the free response mode only.

Subjects were asked not to study for the retention exam. To ensure high attention, since the exam did not count for a grade, Ss were told (after arriving at the examination hall) that they would receive money commensurate with the number of points scored on the exam.

Two Ss from the CP group failed to take the retention test, one because he had left Buckn[illegible] and the other because of a prior commitment. Four Ss from the C group failed to take the test--two had left Bucknell and two had other commitments. The mean SAT and Math Achievement Test scores, as well as the mean GPA for the two groups, remained equivalent.

Results and Discussion

Analysis of variance of the first semester final exam scores showed that the performance of the CP group was significantly different ($F = 7.41$, $df = 1, 27$, $p < .05$) from that of the C group (see Table 1). In terms of mean percentage scores there was a difference of 10% with the CP group scoring higher.

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Insert Table 1 about here.

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When the exam was divided into subtests according to response mode analyses revealed a significant F ($F = 3.827$, $df = 2, 27$, $p < .05$) for Major for the four free response questions. A Neuman-Keuls test of the Major means failed to detect significant differences; however, inspection showed that, not unexpectedly, the mean for physics majors (36.23) was higher than the means for math and electrical engineering majors (25.10 and 22.00 respectively). While scores on the 4 free response items did not differ significantly as a function of instructional method, scores on the 12 multiple choice items did differ ($F = 13.88$, $df = 1, 27$, $p < .01$) as a function of Method.

Although CP Ss were more adapted to using the multiple choice response mode, if familiarity with the response mode was the critical variable, a significant difference in favor of the C group would have been expected for the four free response items. Since this was not found, it appears that CP Ss did indeed learn more. In addition, since CP Ss expected to be able to retake the final exam, their scores are probably an underestimate of what they would have attained had they used maximum effort.

This finding supports the original hypotheses that attainment of prerequisite skills and concepts, provision for differences in learning rate, and making progress contingent upon mastery facilitate learning. Review items in the CP tests may have also contributed to higher performance by shaping review study behavior, but previous studies (Moore et. al., 1969) in which unit tests did not include review items show the same pattern of higher performance for CP groups. Also, teacher differences probably don't account for performance differences obtained here since the previous studies were conducted using the same teacher for both groups. These results extend the validity of the notion of Continuous Progress from indtroductory biology, philosophy, and psychology courses to still another discipline, physics.

Insert Table 2 about here.

Analysis of variance of grades in the traditional second semester physics course showed that the CP group obtained grades which were significantly different ($F = 12.30$, $df = 1, 26$, $p < .01$) from the C group (see Table 2). The average grade for CP Ss was 3.1 (on a 4.0 scale) and 2.3 for C subjects.

The main effect of Continuous Progress on grades in the second semester course gives strong support to Gagné's theory of transfer in hierarchically-related disciplines. Contingencies were the same for both groups during second semester and both groups had hourly exams given to the entire class at the same time. The only residual of the Continuous Progress treatment was that learning of the first semester material was greater for this group, and, predictably, this provided for greater transfer.

The argument could also be made that CP subjects learned useful study skills during their first semester course which facillitated their learning in second semester.

While this may be partially correct, on balance, the C group should have been more "test-wise" for the type of hourly exam given during second semester since they had experienced this type of evaluation during their first semester course.

One could also argue that the more positive attitude displayed by CP Ss (Moore, et. al., 1969) made them more motivated in second semester physics and that therefore they learned more. A study of transfer in a less hierarchically-related discipline, such as religion, might shed some light on this question of the extent to which attitude influences transfer independent of prior learning.

The analysis of grades in second semester traditional physics also revealed a significant Method x Major interaction ($F = 13.91$, $df = 1, 26$, $p < .01$). A Neuman-Keuls test of the Method x Major means showed that the C math and physics majors' average grades were significantly different ($p < .01$) from the CP math and physics majors' average grades, respectively (see Table 3), while there was no significant difference between the mean grade for C and CP electrical engineering majors.

Insert Table 3 about here.

The content of the second semester physics course emphasized the concepts of magnetism and electricity. Too, electrical engineering majors take a course in electrical circuitry concurrent with second semester physics. A very plausible interpretation of the interaction, then, is that C electrical engineering majors, though less well prepared from their first semester course, do as well as CP electrical engineering majors due to concurrent learning and perhaps to increased motivation because of the relevancy physics applied to electricity holds for them.

The retention measure also gives validation to the assumptions underlying Continuous Progress. Analysis of variance of retention exam scores showed that the CP group scores were significantly different ($F = 12.75$, $df = 1, 21$, $p < .01$) from the C group scores (see Table 4). The mean percentage score was 61% for the Continuous Progress group while the Control group mean was only 42%.

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Insert Table 4 about here.

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The retention results are particularly striking because evaluation of long term learning outcomes is rarely carried through. Wessel (1967, p. 209) made the plea that psychologists be concerned not only with immediate acquisition but with "modifying the behavior of the eighteen to twenty-three-year-old in ways that will serve him at age thirty . . . ". Measuring the retention of useful physical principles a year after acquisition is a step in this direction.

It is interesting to note that of the 18 Control group students 9 changed from their physics, math, or electrical engineering majors to a less quantitative science (psychology, biology) or a social science or arts major. Of the 14 Continuous Progress students, only 3 made such a change. While these observations are too few to analyse meaningfully, if they are replicable they would give a very practical meaning to the notion that success at a task is a necessary condition for long-term involvement with that task when choices are available.

Recently, eight "high risk" students were enrolled in the Continuous Progress physics course. High risk students had one or more of the following attributes: (a) a relatively weak high school preparation; (b) relatively low achievement test scores in math and/or physics; (c) relatively low verbal and/or quantitative aptitude test scores. Such students would not have been expected to complete a semester of traditional physics, yet all eight completed the first semester under Continuous Progress -- seven with Bs and one with an A. Six continued with the second semester Continuous Progress course, completing it with Bs (5) or an A (1).

In summary, this study adds to the finding that the concept of Continuous Progress can be generalized over a variety of disciplines, teachers, and students. It gives further validity to the theory of hierarchically related knowledge structures by finding that retention and transfer, as well as acquisition, are promoted by ensuring mastery of prerequisite skills and concepts. Finally, it adds to our practical knowledge by measuring long-term outcomes of instructional innovations.

Footnotes

[1] The research reported herein was performed pursuant to a grant with the Carnegie Corporation.

[2] The authors are grateful to Susan Hearold and John Furman for assistance in data analysis, and to Susan Hearold for helpful comment on an earlier draft of this paper.

Table 1

Analysis of Variance: Final Exam

Source	df	MS	F
Course Method	1	6749.17	7.41*
Major	2	1066.12	1.17
Method X Major	2	157.66	.17
Error	27	910.63	
Four Free Response Items			
Course Method	1	11.09	.039
Major	2	1081.74	3.827*
Method X Major	2	23.49	.083
Error	27	282.67	
Twelve Multiple Choice Items			
Course Method	1	6213.10	13.88**
Major	2	98.71	.22
Method X Major	2	70.88	.16
Error	27	447.65	

$^{*}p < .05$
$^{**}p < .01$

Table 2

Analysis of Variance: Second Semester Grades

Source	df	MS	F
Course Method	1	5.29	12.30**
Major	2	1.22	2.84
Method X Major	2	5.98	13.91**
Error	26	.43	

Table 3

Mean Grade in Second Semester Traditional Physics

	Math	Engi-neering	Physics
Control	1.75	2.33	2.57
Continuous Progress	3.50	2.25	3.40

Table 4

Analysis of Variance: Retention Exam

Source	df	MS	F
Course Method	1	6408.285	12.751**
Major	2	1506.248	2.997
Method X Major	2	614.390	1.222
Error	21	502.547	

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