Group vs. Individual Pacing in Programed Instruction

CHARLES H. FRYE

At the time the author was doing research on this article, he was research assistant at TEACHING RESEARCH, an agency of the Oregon State System of Higher Education. At present, he is working toward a doctorate at Michigan State University. *Research for this article was supported by a grant from the U.S. Department of Health, Education, and Welfare, Office of Education, under Title VII of the National Defense Education Act.*

SELF-INSTRUCTIONAL PROGRAMS (teaching machines) have demonstrated their efficiency. The literature is replete with evidence that learners using teaching machines perform as well as those using more traditional methods and often cover the material in less time (4, 5, 7, 10). Typically, the use of the teaching machine has been limited to individual instruction, as well it may be. Attempts to visualize an entire school system in which the major instructional effort is of an individual nature have been limited, although some effort along these lines has been made (2). The limited scope of such attempts may be the result of the difficult administrative and technological problems involved.

Problems of an administrative sort are apparent. Provided that students may proceed at their own rate in the use of self-instructional devices, after the first period of instruction it would be purely accidental for any two students to be working at the same place in a given program. It might be further contended that the longer they work in that program or in other programs in the same content area, the wider the span would become. Empirical evidence is not available to support or reject such a hypothesis. Such differences in placement might or might not obtain in all content areas. Individual differences in specific abilities may or may not allow groups of students to remain somewhat close together in terms of their total progress. For example, the rates with which an individual student progresses through programs in language arts, social studies, mathematics, and science might differ from those of another student, but the two might complete all programs at the same time. This would make it feasible to organize the school on the basis of a single student characteristic, chronological age, for example. On the other hand, if some general ability determined the rate with which students progress through all types of programs, wide discrepancies might soon result, and it would be difficult, if not impossible, to administer a graded school system.

If it were found that wide discrepancies in student placement did not result from completely individualizing instruction, then the currently used administrative organization would appear appropriate. Were such discrepancies evident, however, some new administrative schema would be necessary. Technologically, we are not ready for the latter possibility.

The demonstrated efficiency of programed materials has not been accidental. The procedures of programming are based in sound learning theory. It seems appropriate to assume that some of the principles that are used in programed instruction might well be used to improve our traditional instructional techniques. Under certain conditions self-instructional materials might be adaptable to group instruction in the traditional classroom. If the latter alternative proved feasible, the use of programed materials in group situations might prove to be an acceptable interim procedure prior to widescale use of self-instructional devices in the classroom.

Proponents of group instruction argue that use of the self-instructional devices precludes the operation of certain group behaviors which further enhance learning. Of primary importance among these group behaviors are those which are motivational in nature. Obviously, the use of self-instructional materials in a group limits the full contribution of some group dynamics, e.g., verbal interaction, cooperative problem solving, and constructive criticism; however, competition may still operate. The motivational attributes of competition within the group have been demonstrated (9).

This study was designed to investigate some of the conditions under which the adaptation of self-instructional techniques to a group setting are most feasible. Previous studies (1, 3) have revealed no significant differences in achievement when individuals are self-paced and automatically paced. In both studies, however, achievement was determined by scores on a posttest. Such studies suggest that group-pacing techniques will not seriously impede the learning process, but they do not reveal whether or not group pacing seriously affects the rate of learning. It was to the latter problem that this study was directed.

HYPOTHESES

Theoretically, if a group of learners were composed in such a way that all learners had the same ability patterns, motivational levels, and previous experiences, it would be expected that they would reach the same learning objectives in the same time. If such a group were then exposed to a set of programed materials in such a manner that progression through the materials were to be made as a group, it could be expected that the group members would complete the program as quickly as a group as they would if working individually. Further, if given a set to work as quickly as possible, the competition among the members might even improve the learning rate. Practically speaking, such ideal grouping procedures are impossible; however, some degree of homogeneity may be obtained. Logically, the greater the degree of homogeneity exhibited by a group, the greater will be the similarity between the group-paced and individually paced learning rates.

Four groups of 11 subjects each comprised the sample (N=44). Two groups were homogeneously determined on the basis of IQ and predicted algebra ability. One of the homogeneous groups was group paced (HomGP) and the other was individually paced (HomIP). The two heterogeneous groups were also different in that one was group paced (HetGP) and the other, individually paced (HetIP).

The following hypotheses were tested:

1. The time required to complete the program by the HetGP group is significantly greater ($p < .05$) than that of the HetIP group.
2. The time required to complete the program by the HomGP group does not differ significantly ($p < .05$) from that required by the HomIP group.
3. The time required to complete the program by the HetGP group is significantly greater ($p. < .05$) than that required by the HomGP group.

PROCEDURE

The sample was chosen from high school freshmen students enrolled in a beginning algebra course during the 1961-62 school year. Each subject completed a pretest designed to measure basic algebraic concepts. Only those subjects who demonstrated that they could solve quadratic equations by factoring and by completing the square and who, at the same time, were not familiar with the quadratic formula, were selected for the study.

Two sections of a linear Skinnerian-type program were used.[1] The "Completing the Square" section and "Quadratic Formula" section contained 47 and 88 frames, respectively. Each frame was typed on a separate sheet with a primer typewriter and then microfilmed. Eleven copies were duplicated for filmstrip use and one for slide projection. The subjects were asked to construct their answers on notebook paper. Eleven 150-watt filmstrip projectors were used to project the materials. The criterion performance for the experiment was perfect completion of a posttest which required each subject to recall the quadratic formula, substitute two given equations into the formula, and make minor simplifications. Four parallel forms of the posttest were prepared in order to eliminate practice-effect errors from those who were required to review the program and repeat the test.

Individually paced subjects worked in carrels constructed of 4-foot-square sheets of pegboard hinged together. A filmstrip projector was placed on the desk top of each subject's chair. The program frames were projected about 3 feet to a screen attached to the carrel. The subjects controlled their own projectors.

The group-pacing equipment consisted of an automatic slide projector with the remote control modified in such a way that it would advance the projector only after all subjects had responded. Depressing the button engaged a relay which relieved the subject of the necessity of holding the button down. When the projector advanced, all relays were simultaneously released. A portable 3′ x 4′ screen was used to display the projected program.

The experiment was conducted in a large, dual purpose (cafeteria-auditorium) room in a nearby high school.

[1] Prepublication material from the Center for Programed Instruction, which has been published in revised form in *Modern Mathematics: A Programed Textbook*. Chicago: Science Research Associates, 1962. Ch. 68-69.

The two installations (group-paced and carrels) were situated about 50 feet apart. The experimental groups did not interfere with one another.

Selection of Experimental Subjects

The subjects who participated in the experiment were matched on the basis of their performances on the Primary Mental Abilities (PMA) test and the Orleans Algebra Prognosis (OAP) test scores. Both tests had been administered during the previous year. The subjects were assigned to the treatment groups in such a way that each subject in one of the two group-paced groups was matched with a subject in the corresponding individually paced group. Within practical limitation, those subjects assigned to the homogeneous groups were within the second and third quarters of the distributed abilities of the total sample. Likewise, those subjects assigned to the heterogeneous groups were within the first and fourth quarters of the distribution. The pairing was done in such a way as to minimize the discrepancies between paired subjects and at the same time retain nearly equal mean ability levels in the four groups. Five subjects were shifted after the original assignments were made because their class schedule was in conflict.

By the following procedures an approximate duplication of the experimental groupings could be accomplished: (a) transform each individual's PMA score to a percentile rank and combine it with his OAP score; (b) construct an array of the resulting composite scores; (c) assign those individuals whose scores fall in the first and fourth quarters of the array to the heterogeneous groups and assign those whose scores fall in the second and third quarters of the array to the homogeneous groups; (d) arrange matched pairs within the heterogeneous and homogeneous groups; (e) randomly assign one member of each pair to the individually paced and one to the group-paced treatments; (f) make adjustments to retain comparability of PMA group means.

Statistical Analysis

The use of the more powerful parametric statistical treatments was precluded by the nature of the assignment of the subjects to the experimental groups. Consequently, nonparametric statistical procedures were used in this study. The Wilcoxon Signed-Rank Test (8:75-83) was used to test Hypotheses 1 and 2. The Wilcoxon Composite-Rank Test (6:251) was used to test Hypothesis 3.

Data Collection

During the time that the subjects were working on the program, their time and place of meeting was rearranged in accordance with the requirements of the experiment. The HomGP subjects met together during the first period, and the HetGP subjects met together during the second. The individually paced subjects met during their regularly scheduled class period. In order to have a uniform number in each experimental session, vacant stations were filled arbitrarily with other students.

The subjects were instructed to keep an accurate account of the actual time (in minutes) spent working on the filmed material and to turn this in, together with their item responses, at the end of each work session. The experimental program was completed by the first subject (HetIP) in three work sessions and by all subjects in eight. The HomGP group finished during the sixth session; the HetGP, during the seventh.

Review was necessary for those subjects who failed the posttest. For the individually paced subjects, the procedure was simply to repeat that part of the program with which they were having difficulty, log the extra time which was later added to the total learning time, and take a different form of the posttest. For the group-paced subjects, those passing the posttests were dismissed and those requiring review continued to use the group-paced device, beginning at the point where all understood the program. The group-paced subjects then proceeded rapidly as a group through the remainder of the program. The spaces vacated by those who had passed were deactivated by taping down the buttons.

In all, 13 of the 44 subjects required at least one review session and two required a second. Review sessions varied from about 10 to 30 minutes.

RESULTS

The data from this study are summarized in Table 1. The reported values are the median number of minutes required by the experimental groups to complete the program. The following results were obtained:

Hypothesis 1

The time required by the HetGP group is significantly greater than that of the HetIP group. The results of the Wilcoxon Test substantiated the hypothesis.

Hypothesis 2

The time required to complete the program by the HomGP group does not differ significantly from that required by the HomIP group. The results of the Wilcoxon Test substantiated the hypothesis.

Hypothesis 3

The time required to complete the program by the HetGP group is significantly greater than that required by the HomGP group. The results of the binomial test substantiated the hypothesis.

DISCUSSION

Verification of the experimental hypotheses indicate that a number of possible conclusions are appropriate. Considering the data in terms of the degrees of homogeneity exhibited by the groups, the experiment provided evidence that there is some merit in grouping students

TABLE 1—Median Time in Minutes Required for Each Experimental Group To Complete the Program

Pacing Technique	*Homogeneous*	*Heterogeneous*	*Difference*
Group	255	325	70*
Individual	221	240	19
Difference	34	85*	

* Statistically significant ($p < .01$)

homogeneously according to ability if programed materials are to be presented in group-paced manner in a classroom.

Consider the entries in Table 1. Apparently, only when there is a wide discrepancy in abilities within a group is there any likelihood that learning rate will be retarded by forcing the learners to progress at the rate of the group. The extremely slow learning rate of the HetGP group cannot be explained in terms of the lower abilities of some of the members of that group. The ability levels of the slower students in each experimental group were remarkably similar. The degree of homogeneity in each of the experimental groups was primarily a function of the abilities of the more able members of each group. Thus, it appears that some condition or combination of conditions other than ability operated in this experiment to bring about the obtained results. One explanation is that when a student is working in a group of students with like abilities, he recognizes the similarities and as a result feels more able to play a competitive role; however, when a student of lower ability is placed in a group which has other students who are much more capable, he tends to withdraw from any competition and becomes more cautious. The dynamics of group behavior under these circumstances merits further study.

Another factor, cost, which has not been considered previously, deserves mention. The HomGP subjects used a single program and a single teaching device to serve the entire group, whereas the individually paced subjects each required a program and a device. Monetarily, therefore, much can be said for the use of group-paced equipment. In this limited experiment, the individual student stations cost $9.27 per subject and a like amount would have been necessary for each additional subject. The group equipment, on the other hand, averaged $4.68 per subject, and only $2.50 (approximately) would have been necessary for each additional subject. The savings would soon become substantial in larger installations.[2]

As a pilot effort, this study suggests the efficiency potential that group-pacing techniques with programed materials have in the context of a graded school system, but many questions still remain unanswered. Research is needed to test whether goal-attainment time does, in fact, decrease as a function of the degree of group homogeneity. The hypotheses of this study need to be tested at other age levels, with different disciplines using various group-pacing procedures. The present study strongly favors such further investigation.

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