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ACHIEVEMENT OF STUDENTS FROM GROUPS INSTRUCTED BY PROGRAMED MATERIALS, CLASSROOM TEACHER, OR BOTH. COMPARATIVE STUDIES OF PRINCIPLES FOR PROGRAMMING MATHEMATICS IN AUTOMATED INSTRUCTION, TECHNICAL REPORT NO. 12.

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DESCRIPTORS- *PROGRAMED INSTRUCTION, ALGEBRA, SECONDARY SCHOOL MATHEMATICS, *MATHEMATICS INSTRUCTION, *PROGRAMED TEXTS, PROGRAMED UNITS, GRADE 9, ABILITY GROUPING, *PROGRAM EVALUATION, ACADEMIC ACHIEVEMENT, INSTRUCTIONAL MATERIALS, *EQUATED SCORES, TEST OF GENERAL ABILITY, SEQUENTIAL TESTS OF EDUCATIONAL PROGRESS

THE EXPERIMENTAL DESIGN IN THIS STUDY OF THE USE OF PROGRAMED MATERIALS TO TEACH HIGH SCHOOL MATHEMATICS DESIGNATED FOUR GROUPS--A CONTROL GROUP TAUGHT CONVENTIONALLY BY TEACHERS TRAINED TO USE PROGRAMED MATERIALS, A "PURE" GROUP USING PROGRAMED MATERIALS ONLY, AND "ANTICIPATING" AND "FOLLOWING" GROUPS THAT USED PROGRAMED MATERIALS BEFORE AND AFTER CONVENTIONAL CLASSROOM TEACHING OF THE SAME MATERIAL. DUE TO INADEQUATE DATA, THE "FOLLOWING" GROUP WAS NOT INCLUDED IN THE ANALYSIS. MATCHED PAIRS OF SUBJECTS, NINTH GRADERS FROM 20 CLASSES IN 16 SCHOOLS, WERE BASED ON APTITUDE AND ABILITY PRE-TESTS, BUT THE CLASSES REMAINED INTACT FOR THE DIFFERENT EXPERIMENTAL GROUPS, AND ONLY THE SCORES OF STUDENTS WHO HAD COMPLETED BOTH PRE-TESTS AND THE ACHIEVEMENT TEST WERE USED FOR ANALYSIS. COMPARISON OF SCORES BETWEEN "PURE" AND CONTROL TREATMENTS INVOLVED 90 PAIRS OF STUDENTS, BETWEEN "ANTICIPATING" AND CONTROL 53 PAIRS, AND BETWEEN "ANTICIPATING" AND "PURE" 52 PAIRS. A STUDENT'S SCORES COULD APPEAR IN MORE THAN ONE COMPARISON. RESULTS SHOWED SIGNIFICANT DIFFERENCES IN ACHIEVEMENT IN FAVOR OF THE CONTROL COMPARED TO THE "PURE" GROUP, NO DIFFERENCES BETWEEN "ANTICIPATING" AND CONTROL GROUPS, AND DIFFERENCES FAVORING THE "ANTICIPATING" OVER THE "PURE" GROUP. (OH)

UNIVERSITY OF ILLINOIS
Urbana, Illinois

Achievement of Students from Groups Instructed
by Programed Materials, Classroom Teacher, or Both

O. Robert Brown, Jr.

COMPARATIVE STUDIES OF PRINCIPLES FOR PROGRAMMING MATHEMATICS IN AUTOMATED INSTRUCTION

Technical Report No. 12
July, 1964

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Table of Contents

List of Tables and Figures

Achievement of Students from Groups Instructed by Programed Materials, Classroom Teacher, or Both

O. Robert Brown, Jr.

The purpose of the study is to investigate effects of different strategies for extended classroom use of some UICSM programed texts; students spent from eight to ten weeks studying our materials. This report summarizes some of the data gathered during the first semester of the 1962-63 school year.[1]

The data consist of results on achievement tests based on the content of both the sequence of programed texts prepared by the UICSM Programed Instruction Project and also UICSM Unit 1, a textbook on introductory algebra. The experimental samples were chosen from ninth graders in twelve classes in eight schools, the control samples from ninth graders in eight classes in eight schools. [See Appendix A.]

In one experimental treatment ["pure" condition] the programed materials were the sole agents of instruction, used in place of the classroom teachers. The other experimental treatment ["anticipating" condition] involved a UICSM-trained teacher using the programed materials to precede the usual classroom development of topics.[2] The control group students were instructed by a

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[1]See Semi-annual Report (Quarterly Reports 7 and 8) for December 6, 1962 - June 6, 1963.

[2]A third experimental treatment ["following" condition] was devised such that the programed materials were used after the classroom teacher's development of topics, but inadequate data are available for valid conclusions. Appendix C shows the bimodal nature of the ability [and achievement] distributions for the students involved.

UICSM-trained teacher using the regular UICSM Unit 1; no programed materials were used in the control classes.

METHOD

Pedagogy

The UICSM has been in the forefront of the movement toward a modern secondary school mathematics curriculum.[3] Since all the materials — experimental programed text and regular text — and all the teachers — "programed" classes and regular classes — referred to in this study were UICSM-produced or UICSM-trained, we must consider characteristics of the UICSM in order to interpret the findings. UICSM materials are carefully designed to promote, and often require, extensive use of discovery techniques in teaching. UICSM teachers are trained in leading students to develop their own problem-solving procedures and short cuts.

In addition to using discovery techniques, UICSM strives for internal consistency and cohesiveness, and for careful use of terminology. It considers the teaching process as a continuing dialogue with a minimum of "tell-and-do"; the

[3]For a brief description of the philosophical orientation of the UICSM, see Max Beberman. An Emerging Program of Secondary School Mathematics. Inglis Lecture Series. [Cambridge: Harvard University Press, 1958.]

student is led to want to do something and then to try to figure out for himself how to do it. We have made the same emphases in writing the programed texts.

Bear in mind that our programed texts are designed to approximate what a student encounters in a carefully conducted UICSM class. The programs, insofar as possible, do the same things that we have encouraged teachers attending our training institutes or watching our demonstration classes to do.[4] All mathematical concepts treated are foreshadowed, explored, introduced, and developed within the programed texts themselves (UICSM Staff, 1963).

We can characterize our study as an investigation of three ways of implementing instruction within one specific framework for teaching. The implementations are:

(i) use only programed instruction
(ii) use only teacher instruction
(iii) use complementary programed and teacher instruction,

and the framework is:

> have each student himself "discover" almost all the operational and organizational "rules" for the mathematics he is in the process of learning.

[4] An interesting by-product of our approach to programing is that the programed texts we produce can be used for training teachers in the presentation of UICSM curriculum materials. The basic pedagogical principles we follow can be pointed out very explicitly as the development of topics in the programed texts unfolds.

We have already used a revised edition of our programed materials to assist two teachers who had to teach UICSM Unit 1 without having had the training we

Materials

Programed Instructional Parts. The programed instructional parts [plastic-bound booklets], were prepared by UICSM staff members. The programers were competent UICSM classroom teachers who had gained experience in programing during our 1961-62 study. They used both linear and branching techniques and a variety of formats and styles. The books contain numerous illustrations and occasional discussions of previous problems or new ideas. The treatment of each new topic is aimed at an audience naive to that topic, giving the books a developmental emphasis. The regular text, which served as the basis for the sequence of parts, is Unit 1 of HIGH SCHOOL MATHEMATICS.[5] Appendix B lists the topics covered in each of the programed parts.

Ability and Aptitude Tests. Each student took as pretests the Test of General Ability (SRA) and a mathematics form of the Sequential Tests of Educational Progress (ETS), referred to as TOGA and STEP, respectively.

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have found is usually necessary. Each had two classes, let the programed texts be sole agents of instruction in one class, and used them with Unit 1 as desired in the other class. The students did acceptable work on the final examination and the teachers reported that they had "learned a lot".

[5] Max Beberman and H. E. Vaughan. HIGH SCHOOL MATHEMATICS, Unit 1. [Urbana: University of Illinois Press, 1960].

Table 1

Achievement tests for use with 1962-63 programed edition of UICSM Unit 1.

Test	Programed Parts Covered[a]	Text Pages Covered
1	101	[1-A] through [1-O]
2	102-103	[1-1] through [1-15]
3	104	[1-16] through [1-23]
4	105	[1-24] through [1-33]
5	106-107	[1-33] through [1-42]
6	108, 109, 110, 110.5	[1-43] through [1-62]
7	111, 112, 113, 114, 114.5	[1-63] through [1-95]
8	115	[1-95] through [1-102]
9	116	[1-103] through [1-110]
Unit 1 Exam	101 through 116	all of Unit 1

[a] Appendix B gives the number of pages in each part and the topics covered.

Scores on these two tests were used in identifying the students who made up the matched pairs used in our analyses.

Achievement tests. Each achievement test was constructed to cover explicitly the material treated in the related programed parts. Table 1 summarizes the tests and related part(s).

Tests were administered as soon as possible after a student in an experimental group had completed the necessary part(s) or as soon as a control class had covered, to its teacher's satisfaction, the requisite content. A standard summary examination, the UICSM Unit 1 Examination,[6] was also used.

Conditions

Experimental Treatments, (P) and (A). Here are descriptions of the two experimental treatments reported on in this paper:

"Pure" (P)

> The only instruction students receive, except for unusual circumstances, is by means of the programed texts. Students work in the materials throughout each class meeting, except when taking appropriate achievement tests. Homework assignments, when given, consist of additional work in the programed text.

[6] UICSM HIGH SCHOOL MATHEMATICS, Unit 1. Examination [Urbana: University of Illinois Press, 1960].

"Anticipating" (A)

> The students receive instruction both from the programed texts and from their regular classroom teacher. Assignments either for homework or for in-class work are given in such a way that every topic the teacher discusses has been anticipated by its treatment in a programed text. As these texts give the introduction of topics, the teacher's discussion includes elaboration and clarification of new topics. In addition, the teacher is encouraged to give a different perspective on the topic and help clear up general or individual difficulties of the students.

The names of the treatments were chosen to show the order and extent of interaction between the programed texts and the teacher.

Control Condition (C). The eight control class teachers were aware of the fact that students from their classes were being used as controls in a study evaluating uses of programed materials. It may be because of this that these teachers took more time [and care?] to complete their teaching of Unit 1 than comparable teachers in earlier years. The control teachers were requested to use only the usual UICSM teaching techniques and materials.

Treatment Pairs. The three implementations mentioned earlier give rise to these three questions:

(1) Do the programed texts as sole agents of instruction [condition P] teach as effectively as a UICSM-trained control teacher?

(2) Do UICSM-trained teachers using the programed texts [condition A] teach more effectively than UICSM-trained control teachers?

(3) Do UICSM-trained teachers using the programed texts teach more effectively than the programed texts as sole agents of instruction [condition P]?

Results under the "pure" mode relate to the first and third questions; those from the "anticipating" mode relate to the second and third questions. The control classes are used for questions 1 and 2.

Of course, these three questions deal only with the implementation of the finished programed texts. Basic to the actual preparation of the materials were questions dealing with such matters as step size and sequence, implementation of a discovery method of teaching, effective use of branching, etc.

Students

Pure vs. Control (Question 1). There were five P classes and five C classes from schools whose students came from very similar socioeconomic environments and which had very similar classroom conditions. We selected all students from these ten classes who had a reasonably complete record [at least scores on the two pretests and achievement tests 1-3, 5-9] and constructed matched pairs of students (P, C) such that members of each pair had identical STEP (scaled) scores and TOGA IQ estimates within 5 IQ points of one another.

Table 2

Means, SD's and t ratios for Control(C) and Pure(P) Matched Pairs

		Means		SD's		
	N[a]	C	P	C	P	t
STEP	90	282.21	282.21	8.35	8.35	---
TOGA	90	129.56	129.56	10.59	10.30	---
1	90	18.70	18.56	3.00	3.74	.680
2	90	22.97	21.39	4.02	5.54	2.236✓
3	90	19.23	19.04	4.15	4.37	.813
4	72	12.40	9.86	1.87	2.66	6.69 ✓
5	90	9.52	6.50	3.79	3.23	7.907✓
6	90	23.60	21.34	5.08	4.64	3.748✓
7	90	19.40	17.66	3.63	4.66	4.091✓
8	90	17.22	16.74	2.78	3.21	1.333
9	90	8.64	7.36	1.92	2.79	4.079✓
Total	72	156.00	141.04	19.72	25.81	4.908✓

[a] number of matched pairs

✓significant for $\alpha = .05$

Table 3

Means, SD's and t ratios for Anticipating(A) and Control(C) Matched Pairs

		Means		SD's		
	N[a]	A	C	A	C	t
STEP	53	231.02	281.02	6.63	6.63	---
TOGA	53	125.55	125.77	12.28	12.24	---
1	53	19.83	18.40	3.39	2.85	2.455 ✓
2	53	22.51	22.79	4.79	3.95	-.402
3	53	18.38	18.60	4.00	4.45	-.370
4	40	10.60	12.10	3.23	2.58	-2.732✓
5	53	9.53	8.87	3.92	3.81	.918
6	53	22.91	24.15	4.69	4.69	-1.592
7	53	18.94	19.06	4.62	3.63	.107
8	41	17.80	16.60	1.98	2.46	1.377
9	41	8.92	8.80	2.01	2.53	.314
Total	33	153.91	157.39	23.14	21.77	-.629

[a] number of matched pairs

✓significant at $\alpha = .05$

Table 4

Means, SD's and t ratios for Anticipating(A) and Pure(P) Matched Pairs

		Means		SD's		
	N[a]	P	A	P	A	t
STEP	52	283.22	283.33	7.38	7.38	---
TOGA	52	130.25	130.21	10.16	10.28	---
1	52	19.19	20.37	3.51	3.35	1.992
2	48	22.08	22.54	5.27	5.41	.644
3	52	19.92	19.37	3.62	4.33	-.799
4	52	10.52	10.81	2.66	3.26	3.789✓
5	52	7.15	10.00	4.04	4.24	4.031✓
6	52	22.67	22.98	4.71	5.04	.037
7	52	19.17	19.75	4.57	4.54	.729
8	43	17.70	18.28	2.21	1.67	1.704
9	43	8.40	8.91	2.37	2.04	1.512
Total	40	149.40	157.33	23.70	20.04	1.616

[a] number of matched pairs

✓significant at α = .05

Table 5

Means, SD's and Percentile Range on UICSM Unit 1 Examination for the Norming and the Sample Populations

Group	N	Mean	SD	%-ile range
Norming Population	2000	16.2	4.9	40-47
Sample Populations				
C_1	62	18.6	3.7	54-62
P_1	62	16.7	4.4	40-47
A_2	34	18.3	3.7	54-62
C_2	35	18.7	4.0	54-62
A_3	47	18.7	3.7	54-62
P_3	46	17.4	4.0	47-54

A total of 90 pairs was obtained in this way. Table 2 lists the means and SD's on the pretests and on our specially constructed achievement tests for the P and C groups finally determined.

Anticipating vs. Control (Question 2). There were three classes which participated under condition A. We selected all students who had a reasonably complete record [defined above] and used as our C students exactly those found in the selection from the five C classes used above. Matched pairs of students (A, C) were formed just as in the P vs. C situation. A total of 53 pairs resulted, and Table 3 lists the related means and SD's.

Anticipating vs. Pure (Question 3). All A students eligible for pairing in A vs. C and all P students eligible for pairing in P vs. C were considered in the construction of 52 matched pairs of students (A, P) with reasonably complete data. Table 4 lists the means and SD's of the A and P groups so determined.

Note that we have used what amounts to a sampling-with-replacement scheme in the construction of our matched pairs. It is possible but not necessarily the case that a P student could be in both the P vs. C and A vs. P samples.

A similar remark holds for the A students and for the C students. Whenever we need to differentiate between the two P samples used for questions 1 and 3, we write 'P_1' and 'P_3'. Similarly, we write 'C_1' and 'C_2' to differentiate between the two C samples for questions 1 and 2, 'A_2' and 'A_3' to differentiate between the two A samples for questions 2 and 3.

Table 5 lists the means and SD's on the Unit 1 summary examination of the various groups described above.

RESULTS

The Tests Individually

Pure vs. Control. The data presented in Table 2 lead us to conclude that our programed version of Unit 1 used as the sole agent of instruction failed to teach as effectively as control teachers. Six of the differences on achievement tests were significant; in each case the direction of the difference favored the control group. Consequently, the question:

> (1) Do the programed texts as sole agents of instruction [condition P] teach as effectively as UICSM-trained control teachers?

must be answered 'No'.

It is interesting to note, however, that on the standardized Unit 1 Examination [see Table 5] the mean of the C group clearly exceeded that reported for the norming population[7] and even the mean of the P group was slightly greater, but not significantly so. This result leads to the conjecture that the greater length of time spent on the Unit 1 materials by the C group tended to make their performance better than would have been predicted. Students in the P group probably did not spent as much time as the C students since no homework assignments were given during the first six weeks of instruction.

Anticipating vs. Control. The data presented in Table 3 lead us to conclude that teachers using our programed texts to treat topics before giving the topics any classroom discussion were just as effective as control teachers. Two of the reported differences are significant but the direction of the difference favored the A group once and the C group once. Looking at the Unit 1 Examination scores we see that the A and C groups had comparable means which were above that of the norming population.

On the basis of the Table 3 comparisons, the question:

> (2) Do UICSM-trained teachers using the programed texts [condition A] teach more effectively than the UICSM-trained control teachers?

must be answered 'No'. We can say, however, that our teacher-program

[7] The populations used in this study are comparable to the norming population for the Unit 1 Examination in that our students come from the upper 2/3 of the STEP distribution and the students in the norming population came from the upper 2/3 of the DAT Numerical Ability test distribution.

combination was certainly no less effective than control teachers. In addition, comments from teachers revealed that working under condition A had extra benefits, such as increased knowledge of individual student's problems.

Anticipating vs. Pure. The data presented in Table 4 show two significant differences between the A and P groups, both in favor of condition A. Since it is also the case that eight of the nine A means were numerically greater than the corresponding P means, we can answer the question:

> (3) Do skilled UICSM teachers using the programed texts [condition A] teach more effectively than the programed texts as sole agents of instruction [condition P]?

with a 'Yes'.

Finally, we note as a purely descriptive result that the P_1 and P_3 means and SD's from Tables 2 and 4 gives us an estimated minimum achievement level for students using the programs without any teacher assistance. For example, a student who studied Part 101 independently could be expected to get a score of 18 or 19 on the related achievement test. Such predictions must be evaluated in the light of the circumstances for the individual students, but the ability to predict a certain level of achievement for a given student on a given topic is useful to classroom teachers.

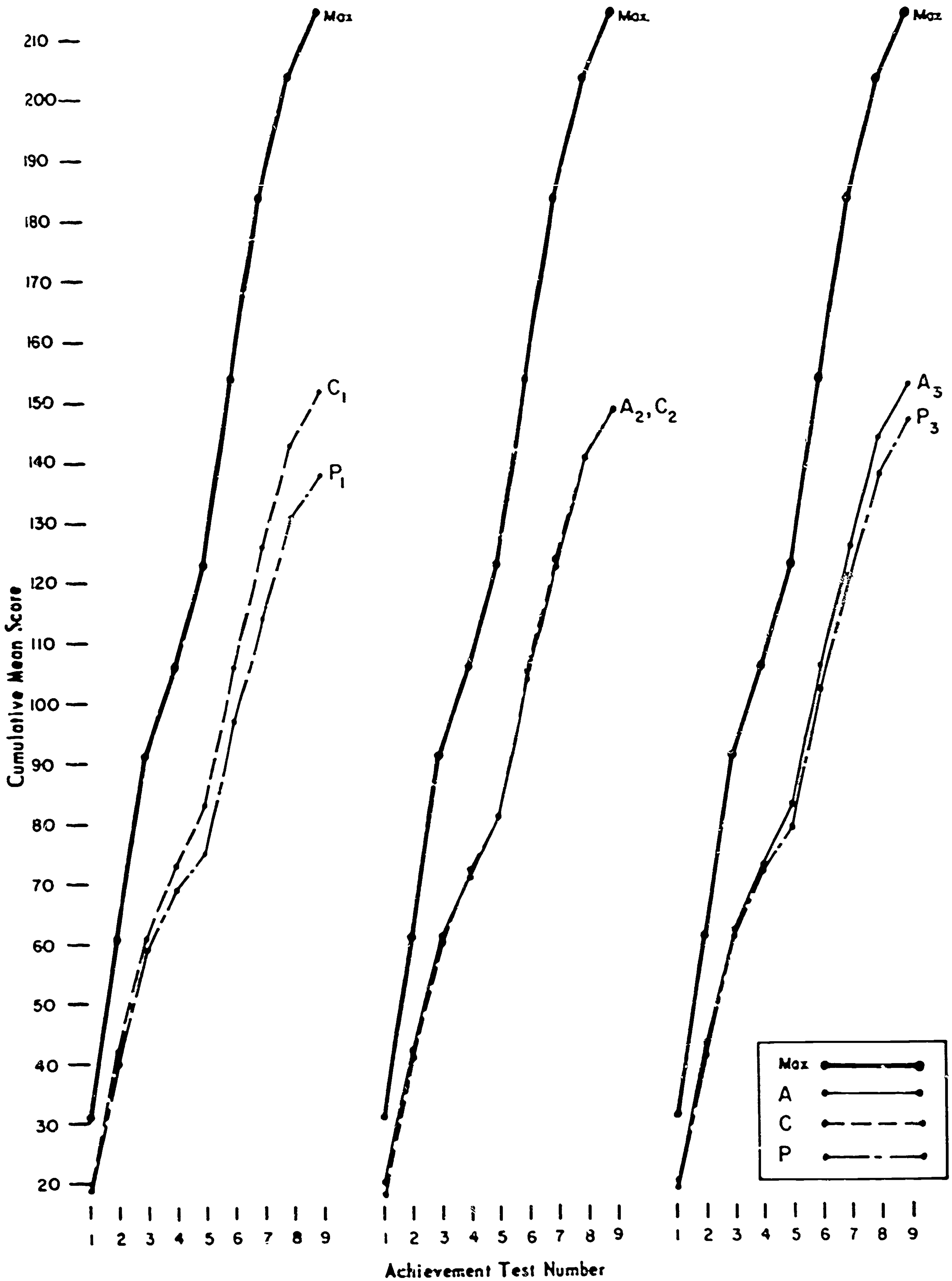

Figure 1. Cumulative mean scores on achievement tests.

Table 6

Sign-test summary by achievement test and paired groups

Test	Number of items	Groups: C - P Nb '+'	C - P Nb '-'	A - C Nb '+'	A - C Nb '-'	A - P Nb '+'	A - P Nb '-'
1	31	14	16	18	8	20	8
2	30	21	7 ✓	13	16	15	10
3	30	17	12	15	12	10	16
4	15	15	0 ✓	1	13 ✓	9	5
5	17	15	2 ✓	11	6	13	2 ✓
6	37	30	6 ✓	10	19	24	12
7	30	23	7 ✓	9	15	16	10
8	20	11	8	12	7	11	4
9	11	9	2 ✓	4	5	7	3

✓Significant at $\alpha = 0.05$

The Tests Cumulatively

Another way to look at performance on the achievement tests both within groups of pairs and between groups of pairs is to consider cumulative mean scores. Figure 1 gives a graphical presentation of continuing progress through the material for each condition in each group of pairs. Also given is the maximum possible cumulative score. In a sense, each treatment group is treated as an individual whose nine achievement test scores are the respective group means for the tests. Each "individual" is identified by a letter corresponding to the treatment he received subscripted by a numeral corresponding to the question for which his data were used.

Looking at the first pair of curves we see that the "individuals" C_1 and P_1 become slowly but surely dissimilar, C_1 gaining over P_1. The graph gives us an indication of the nearly constant rate of gain. Considering A_2 and C_2 we see that the overall effects are almost identical. The cumulative effect on A_3 and P_3 is more like that on C_1 and P_1, but clearly not as pronounced.

Looking across the graphs we see that the final positions of individuals with the same treatment but in different pairs do not agree. [See also Appendix D.]

It would be useful to have results in which three students matched for ability, one from each condition, could be related. A supplementary report to this effect will soon be issued.

Item Analyses

Another way to assess the effectiveness of the various treatments is to consider the results from an item analysis of each test. Table 6 presents sign-test data for each of the achievement tests for each of the pairs of groups: C - P, A - C, A - P. Item difficulty levels [(% correct) × 100] were computed by item for each group and direction of difference noted.

As before, the significant results come in the comparison between the C and P groups. The table shows that the C group outperformed the P group by answering correctly a significantly larger number of items on 6 of the 9 achievement tests.

These results seem to indicate that the significant differences indicated by the t tests were not functions of a few specific items. Rather, we strengthen our conclusion that treatment effects are being manifested.

In addition, we can look at item types [true-false, multiple choice, "supply"] and functions [recall, transfer, application]. In contrast to the results noted in an earlier report (Brown, 1962), this year's experimental group did not have superior performance on any particular class of items; the C group did better than the P group in all but the "true-false" class. The only other significant difference was that the A group did better than the C group on "true-false" items; this result seems to be due more to chance than to treatment effects.

Another result noted in the earlier report was that the use of our programed materials led to homogeneous performance levels on the program-related achievement tests among students of varying abilities. Looking at the distributions of achievement test scores by means of Tables 2-4 certainly does not lead to such a conclusion this year. In fact, total variance in each of the A - C and C - P comparisons is more often larger for the experimental group than it is for the control group. We must reject a "homogeneous performance levels" assertion in the context of results reported in this study. Notice, however, that our "unit" here is not classes, as it was in the previous study.

An additional result which must be mentioned came more from the preparation of our materials than from their trial. This "pedagogical" result is a collection of new devices and examples and presentation schemes. We wished to provide the "pure" students with a rich variety of experiences within the programed texts themselves and had to come up with enough approaches to a topic to approximate a trained teacher's presentation. A booklet (UICSM staff, 1963) is available which describes some of our techniques. It is interesting to note that some of the things we came up with have already been adopted for classroom use or for use in new "regular" textbooks.

DISCUSSION

The data reported in this paper refer to ways of using programed materials in the classroom. As noted earlier, we can use our "pure" mode to help establish a minimum expectation level for achievement of a student working through the materials entirely on his own. It is a minimum level in that we found that having a classroom teacher in the instructional process results in improved performance. The two comparisons we have reported which deal with the "pure" mode show that having a teacher produces significantly better results than the program alone.

The establishment of a minimum expectation level for achievement increases the values of using programed materials (a) as the main agent of instruction for homebound students or (b) as a source of controlled homework assignments, or

(c) with students who should study material, remedial or otherwise, different from that of the majority of the class. In each of these cases, the ability to predict a minimum level of achievement from independent study of the program would help a teacher make best use of the programs in an instructional sequence.

Prolonged use of the "pure" mode is most suited to research and we had hoped that prolonged use of the "anticipating" mode would be most suited to the classroom, giving a very efficient procedure for use of our programed materials. Although results from the "anticipating" mode are acceptable, we had hoped they would be even better. It may be that we were caught by a "sameness" factor; in this case it is the apparent sameness of teaching strategy. The word 'apparent' ise used because the perceived difference between programed and teacher instruction is probably far greater than any real differences we could build into the programed texts themselves. And, it is the case that, for every new topic, the order of these two kinds of instruction was the same, first the program and then the teacher.

We suspect that the programed texts could be used more flexibly than was possible under the prescriptions of the "anticipating" mode. A teacher would have to bear in mind the introductional emphasis of the program, but could well plan to start a new topic with classroom discussion late in a class period and let the program take over for homework. The teacher could expect a certain proficiency from students who had completed a given segment of a program and could build the next classroom discussion from that point. Occasional use of this order of teacher and program would clearly curtail the sameness effect noted above. In addition, it seems that it would be very efficient.

In the light of these considerations, it may be the case that programed materials might be most useful when packaged as topic-units rather than as a semester's or a year's worth of work. Topic-units would be very manageable and might generate very positive attitudes due to their short length. Using short topic-units might also enable a teacher to control better each student's progress than is possible with the usual programs, thus keeping the class together for maximum benefit from classroom discussions.

The fact that our approach to programing led us to "invent" new examples and presentation schemes warrants the suggestion that in preparing conventional texts materials one could in tandem prepare programed materials. The insights which are almost forced upon one in creative programing of a topic about how a student learns the topic piece-by-piece should be very valuable in writing new texts, or even in making revisions of an established text.

A by-product of our approach to programing, as was mentioned earlier, is that we can use the programed texts we have prepared as teacher-training instruments. A commentary, perhaps programed, to the student program could serve to point out the various pedagogical techniques used in the program. The commentary could also make suggestions for classroom implementation of the new devices which appear in the program. Even a teacher without mastery of the subject matter could profit from such training; after all, the obvious function of the programed texts is to teach the subject matter.

SUMMARY

The data from a matched-pair analysis of achievement test results representing a control group and groups using the UICSM-prepared programed materials under two experimental conditions lead to the following conclusions:

(1) Programed materials prepared by experienced UICSM writers and teachers when used as sole agents of instruction are not as effective as a UICSM teacher trained in the presentation of the same content material and using a regular text.

(2) A UICSM teacher using the programed materials to introduce topics to a class, thus anticipating their classroom development, is not more effective than a comparable teacher independent of the programed materials. In fact, the two procedures lead to roughly equivalent achievement test results.

(3) A UICSM teacher using the programed materials to introduce topics to a class is more effective than the programed materials used as sole agents of instruction.

(4) The finding from other studies that use of programed materials results in more homogeneous achievement over varying ability levels is not supported by our data which use students, not classes, as "units" of observation.

We note that the data reported for this study are only one facet of the total data analysis done. On the basis of the total analysis, a revised set of materials was prepared and is currently undergoing a comprehensive evaluation which will include careful analysis of time data as well as and in conjunction with treatment results.

In the actual creative programing effort needed to write our materials, we found important gains in our insights into how a student learns each topic; these insights resulted in new pedagogical devices, examples, and presentation schemes. The production of ideas which have uses apart from the programed texts is a dividend that enhances the worth of programing.

Finally, we note that this report does not refer to specific content in any of the comparisons, the emphasis has been on overall effects of various treatments. It would be useful to consider effects across specific content areas which recur through the Unit 1 sequence.

Appendix A

Summary of participating classes, UICSM-PIP, 1962-63

School	Number of classes	Number of students	Condition	Grade
Talawanda High School Oxford, Ohio	1	28	"anticipating"	9
Pekin Community High School Pekin, Illinois	2	62	"pure"	9
St. Louis Preparatory Seminary St. Louis, Missouri	1	34	"following"	9
The Principia, Upper School St. Louis, Missouri	1	18	"anticipating"	9
Matignon High School Cambridge, Massachusetts	2	69	"pure"	9
St. Rosalia High School Pittsburgh, Pennsylvania	1	37	"following"	9
Sacred Heart High School Pittsburgh, Pennsylvania	1	44	"anticipating"	9
Marian High School Framingham, Massachusetts	3	119	"pure"	9
Sacred Heart High School Newton Centre, Massachusetts	1	42	control	9
Sacred Heart High School Weymouth, Massachusetts	1	50	control	9
St. Mary High School Brookline, Massachusetts	1	43	control	9
Immaculate Conception High School Revere, Massachusetts	1	54	control	9
Cardinal Spellman High School Brocton, Massachusetts	1	40	control	9
Mt. St. Joseph Academy Brighton, Massachusetts	1	39	control	9
St. James High School Haverhill, Massachusetts	1	47	control	9
Fontbonne Academy Milton, Massachusetts	1	37	control	9

APPENDIX B

TABLE OF CONTENTS

UICSM Unit 1

[CONTENTS]

[CONTENTS]

Part 116 80 pp.

Appendix C

Means of "Following" Classes

	Class	
Test	E_3[a]	E_6[b]
STEP	289.38	259.41
TOGA	130.24	95.14
1	20.14	21.33
2	27.44	17.19
3	23.82	9.64
4	11.11	6.70
5	12.24	3.53
6	28.28	14.24
7	22.21	13.23
8	18.65	13.23
9	8.92	5.23
Unit 1	21.21	7.83

[a] N = 37

[b] N = 34

Appendix D

Values of t for differences of test means between each two samples representing a given treatment

	Groups		
Test	$P_3 - P_1$ [a]	$A_2 - A_3$ [b]	$C_1 - C_2$ [c]
STEP	0.800	-1.686	0.887
TOGA	0.389	-2.105✓	1.948
1	-0.332	-0.828	0.586
2	-0.152	-0.661	0.252
3	0.123	-1.203	0.858
4	1.712	-0.828	0.840
5	0.829	-0.592	0.996
6	1.635	-0.079	-0.644
7	1.883	-0.902	0.546
8	1.004	-0.934	0.614
9	1.625	-0.871	0.539

[a] The "pure" members of the A - P matched pairs are P_3 and the "pure" members of the C - P matched pairs are P_1, df = 140.

[b] The "anticipating" members of the A - C matched pairs are A_2 and the "anticipating" members of the A - P matched pairs are A_3; df = 103.

[c] The "control" members of the C - P matched pairs are C_1 and the "control" members of the A - C matched pairs are C_2, df = 141.

✓ Significant at $\alpha = 0.05$.

References

Beberman, M. and Stolurow, L. M. Comparative studies of principles for programing mathematics in automated instruction. Semi-Annual Report (Quarterly Reports 7 and 8), USOE, Project No. 71151.01, December 6, 1962–June 6, 1963.

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Table 3

Means, SD's and *t* ratios for Anticipating(A) and Control(C) Matched Pairs

		Means		SD's		
	N[a]	A	C	A	C	t
STEP	53	231.02	281.02	6.63	6.63	---
TOGA	53	125.55	125.77	12.28	12.24	---
1	53	19.83	18.40	3.39	2.85	2.455 ✓
2	53	22.51	22.79	4.79	3.95	-.402
3	53	18.38	18.60	4.00	4.45	-.370
4	40	10.60	12.10	3.23	2.58	-2.732✓
5	53	9.53	8.87	3.92	3.81	.918
6	53	22.91	24.15	4.69	4.69	-1.592
7	53	18.94	19.06	4.62	3.63	.107
8	41	17.80	16.60	1.98	2.46	1.377
9	41	8.92	8.80	2.01	2.53	.314
Total	33	153.91	157.39	23.14	21.77	-.629

[a] number of matched pairs

✓significant at $\alpha = .05$