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Studies which have utilized low-error-rate linear type programs have not been able to compare the effectiveness of various modes of feedback in correcting error in programed learning. In the present study using 75 university students, it was possible to correct errors without teaching erroneous material by using materials designed to teach 30 commonly misunderstood concepts in general science by means of computer-assisted instruction (CAI). The five treatment groups differed only with respect to feedback modes which were no feedback; feedback of "correct" or "wrong"; feedback of the correct response; feedback appropriate to the student's response; and a combination of modes two, three, and four. Items missed were presented repeatedly until a criterion of correct response to each item had been attained. There are indications that the subjects who received feedback guiding them to the correct response were learning more effectively and performed better than those who were forced to "discover" the correct response. Data indicate that for correcting error, providing a student with a statement of which response was correct or why the correct response was correct may be the most valuable. The analysis of variance on posttest scores indicates that a combination of modes is slightly superior to some of the individual feedback modes in affecting immediate retention. (MT)

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Foreword

The School of Education of Indiana State University is proud to present under this cover the scholarly work of its professors. The search for truth and educational wisdom is truly one that involves all of us, and efforts such as these are testimonials to the strength and vigor of this search.

One of the marks of a true professional is a willingness to share the results of his work with others who are involved in this quest. The distribution of papers such as this is a confirmation of this professional ideal.

It is most important that the men and women engaged in the task of expanding the boundaries of scholarship in education understand that their efforts are understood and appreciated. This statement is a way of telling them that all of us are honored by their accomplishments.

David Turney, Dean

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A COMPARISON OF SEVERAL FEEDBACK METHODS FOR CORRECTING ERRORS BY COMPUTER-ASSISTED INSTRUCTION

by

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A COMPARISON OF SEVERAL FEEDBACK METHODS FOR CORRECTING ERRORS BY COMPUTER-ASSISTED INSTRUCTION

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Computer-assisted instruction (CAI) differs from programmed texts in that the student's responses are evaluated against anticipated answers stored in the memory of the computer and feedback appropriate to the student's response can be provided. Feedback and prompting the student to respond correctly can identify and correct specific student errors. This may be an important advantage for CAI over other types of instruction.

Prior studies in programmed learning have not been able to compare the effectiveness of the several modes of feedback in correcting errors because these studies utilized low error rate linear type programs. Since few incorrect responses are made by a student learning by means of a typical linear program, little has been learned concerning how feedback can be used to correct errors.

The correction of errors by providing the student with knowledge of results is also one of the goals of the adjunct auto-instruction techniques developed by Pressey. These techniques do not necessitate a low error rate program and thus provide a better format for investigating the use of feedback to correct learner errors.

Another reason for the paucity of studies in error correction is an ethical consideration. Programmed learning researchers are very reluctant to teach learners incorrect or even inaccurate information so that they can systematically study how to correct errors.

This study used materials designed to teach commonly misunderstood concepts in general science. Errors made by the Ss occurred as a result of misconceptions they had acquired as a result of conventional instruction. It was thus possible to correct Ss' errors without teaching erroneous material and without intentionally tricking them into committing errors.

Rationale

The use of knowledge of results as a mode of feedback has its basis in the principle that reinforcement of correct responses enhances learning. Many programmers using the knowledge of results technique believe that its sale value is in its reinforcement qualities and that reinforcement occurs only when the student's response is correct.

Other programmers use feedback as a means of providing information to correct the student's misunderstanding. If there were no purpose to feedback other than to provide the student with reinforcement, statements such as "you are correct" should prove equally effective as a confirmation of the correct answer.

However, there is some evidence (Glaser, 1966) that providing the correct answer following an incorrect response is a reinforcing event in the same way as confirmation of a correct response.

Bryan and Rigney (1956) demonstrated the benefit of providing feedback contingent on the student's response. Two groups learned ship aperations by means of a tab test. When tested one week after training, an explanation of choice group was significantly superior to a knowledge of results group.

It is possible that there is some advantage in providing Ss with a combination of feedback modes in order to take advantage of reinforcement and at the same time provide the student with information. However, Swets and his co-workers (1962) found that "fairly extensive feedback may be detrimental to learning." Extensive feedback may also be inefficient in terms of time, since lengthy feedback messages require greater amounts of time.

Procedure

Seventy-five university upperclassmen were taught 30 general science concepts by means of a computer-assisted adjunct auto-instruction program. The frames of the program were multiple-choice items dealing with 30 general science concepts. One response to each item was a correct response, one response to each item was a common misunderstanding of the concept, and the other two responses were reasonable and plausible distractors.

Equipment was an IBM 1410 computer and four IBM 1050 teletypewriter terminals equipped with random access slide projectors. Instruction was teleprocessed one-half mile between the terminals and the computer. The treatment groups differed only with respect to feedback modes. The five modes of feedback compared were (Group A) no feedback, (Group B) feedback of "correct" or "wrong," (Group C) feedback of the correct response choice, (Group D) feedback appropriate to the student's response, and (Group E) a combination of the feedback modes of Groups, B, C, and D.

_Ss_ were assigned to 15 strata on the basis of scholastic aptitude test scores. The five _Ss_ in each strata were randomly assigned to one of the five treatment groups. The first iteration of the 30 item program served as the pretest and also provided instruction by means of feedback according to treatment group. The program caused all of the items to be presented on the first iteration, those missed on the first iteration to be presented on the second iteration, those on the second iteration to be repeated on the third iteration, etc., until a criterion of a correct response to each of the thirty items had been attained. A paper and pencil posttest of 30 items similar to those of the program was administered following the instruction.

A treatment x levels analysis of variance was performed to determine whether differences existed between any of the treatment groups with respect to the number of responses required to attain criterion, the number of iterations of the program, time required to attain criterion, and posttest score. When significant differences were found, Tukey's W-Procedure was used to ascertain whether differences existed between specific pairs of means.

Results

Independent variables. Analysis of variance showed no difference ($p > .05$) for between means of treatment groups with respect to either the independent variable, scholastic aptitude or the number of correct responses on the first iteration of the program which served as a pretest as well as an instructional program.

Number of responses to criterion. The analysis of variance for the number of responses required for Ss to reach criterion (Table 1) shows an F-ratio for treatment effects clearly statistically significant ($F = 65.83$) at the .01 level. The results of the Tukey W-Procedure indicated that the means of Groups C, D, and E were each significantly better than those of Groups A and B.

Number of iterations of program to criterion. The range of iterations of the program required by an S to attain criterion were from two iterations for several Ss in Groups D and E to seven iterations for one S in Group A.

The data from the number of iterations to criterion (Table 2) show an F-ratio ($F = 37.44$) a clearly significant at the .01 level.

The results from the Tukey W-Procedure found in Part C of Table 2 again show statistically significant differences between each of the means of Groups C, D, and E and those of Groups A and B.

Time required to complete instruction. Due to the relatively slow (abore 100 words per minute) typing rate of the 1050 terminal, those groups which received longer feedback messages (Groups D and E) naturally required longer to complete the instruction.

The data from time required for Ss to complete the first iteration of the 30 item program found in Table 3 shows a high F-ratio for treatment effects ($F = 32.70$) which was statistically significant at the .01 level.

Tukey's W-Procedure showed the anticipated result that those treatment groups which received long typed feedback messages (Groups D and E) required significantly longer to complete the thirty items than those groups which received short feedback messages (Groups B and C) and Group A which received no typed feedback messages. In each case, the significance was at the .01 level. Differences between means of other groups were not significant at the .05 level.

Time to criterion. The amount of time required for Ss to attain criterion, analyzed in Table 4, was significantly lower ($p < .01$) for Group C than for the other treatment groups and significantly higher ($p < .01$) for Group D than for any group except Group E. Differences between pairs of means of all other treatment groups were not significant at the .05 level.

Correct responses on posttest. The analysis of the number of correct responses on the posttest is found in Table 5. Analysis of variance results show an F-ratio for treatment effects ($F = 3.97$) statistically significant at the .01 level. The Tukey W-Procedure showed significant differences between the means scores of Group E and those of Groups A, B, and C. Although the mean of Group D was higher than the means of Groups A, B, and C, there was no significant difference between any two of these means.

Level effects. The F-ratio for level effects was not significant at the .05 level for any of the four dependent variables.

Discussion, Conclusions and Recommendations

Rate of learning. In terms of the results obtained in the analysis of number of responses and iterations of the program required by Ss to reach criterion, there are strong indications that Ss who received feedback guiding them to the correct response were learning more effectively and performed better than did those who were forced to "discover" the correct response. The results and their level of significance clearly indicate the value of providing information to students during a programmed instruction feedback. The findings are in agreement with those of Hollend (1966) who concluded that there were no advantages for prompting a student to give the correct answer after an error had been committed. Holland concludes that if a student does not know the correct answer, he might as well be told it.

These findings differ with the point of view of those programmers who prefer the simple knowledge of results technique and who find no advantage in showing the correct answer to learners who provide incorrect responses. This study indicates that simple statements such as "you are correct" do not prove equally effective as revealing the correct answer. Also, this study indicates that the appearance of a correct answer is not wasted when the student's response was incorrect. Data from the present study, however, indicate that providing a student with a statement of which response was correct, or providing him with a statement of why the correct response is correct may be of much more value than merely telling him "correct" or "wrong." The poor results demonstrated by the knowledge of results feedback group (Group B) raise questions as to whether this mode of feedback is of much value for the correction of errors.

In the comparisons of feedback mode and learning rate, it is interesting to note that there were no significant differences between Groups C, D, and E. Apparently the factor which accelerated the learning of Ss was being informed as to which response was the correct one. In both comparisons, however, the mean of Group E, the combination of feedback modes group, was only slightly, but not significantly better than the means of Groups C and D, and in both cases, significantly better than the means of Groups A and B. This finding is contrary to those of Swets and his co-workers (1962) who found that fairly extensive feedback may be detrimental to learning.

Time required for instruction. The time required for a student to receive instruction by CAI is a function of the number of instructional frames he completes and also is a function of the amount of time the student terminal spends transmitting messages.

Several studies (Gilman, 1967b; Wodtke and Gilman, 1966) have demonstrated that the operating speed of a teletypewriter terminal is slower than would be ideal for an interface between student and computer.

Immediate retention. The analysis of variance conducted on posttest scores indicated that the combination of feedback modes (Group E) was superior to some of the feedback groups in terms of number of correct responses. Apparently the amount of information the S derives from the feedback is important in affecting retention. The results of the present study indicate the advantages for learning attained by providing the correct response when a learner makes an error and also show the advantages for retention in providing the S with extensive information in feedback messages.

Recommendations for Further Research

Further research is necessary to determine the effects of using the various modes of feedback to correct errors. Many forms of programmed learning required the learner to reveal, by making some form of error, the kind of instruction he should receive next. However, most studies have been conducted with relatively error free programs and little is presently known concerning how to correct errors in instruction.

The present study should be repeated using an interface capable of faster communication and response time than the 1050 terminal. Also, the present study should be repeated using a delayed retention measure in addition to the immediate retention measure.

At Indiana State, we are continuing efforts in computer-assisted instruction research and hope to develop computer-controlled multi-media learning centers to be used in future computer-assisted instruction.

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TABLE 1

ANALYSIS OF DATA FOR SOURCES OF VARIATION FROM NUMBER OF RESPONSES TO CRITERION

A. Group Means

Means	Group A (n = 15)	Group B (n = 15)	Group C (n = 15)	Group D (n = 15)	Group E (n = 15)	Grand Mean (N = 75)
	74.53	71.93	54.20	54.00	50.47	61.03

B. Analysis of Variance

Source of Variation	df	Sums of Squares	Mean Square	F Ratio	Significance
Treatments	4	7,633.15	1,908.29	65.83	($p < .01$)
Levels	14	689.55	49.25	1.90	n.s.
Treatments X Levels	56	1,623.25	28.99		
Total	74	9.945.95			

C. Tukey's W-Procedure for Differences Between Pairs of Means

	Group B	Group C	Group D	Group E	
Group A	2.60	20.33**	20.53**	24.06**	$.05^{W}5,56 = 5.50$
Group B		17.73**	17.93**	21.46**	
Group C			0.20	3.73	$.01^{W}5,56 = 6.67$
Group D					

**Significant ($p < .01$)

TABLE 2

ANALYSIS OF DATA FOR SOURCES OF VARIATION FROM NUMBER OF ITERATIONS OF PROGRAM TO CRITERION

A. Group Means

Means	Group A (n = 15)	Group B (n = 15)	Group C (n = 15)	Group D (n = 15)	Group E (n = 15)	Grand Mean (N = 75)
	4.67	4.60	2.73	2.87	2.53	3.48

B. Analysis of Variance

Source of Variation	df	Sums of Squares	Mean Square	F Ratio	Significance
Treatments	4	67.38	16.85	37.44	($p < .01$)
Levels	14	5.92	0.42	1.00	n.s.
Treatemnts X Levels	56	25.41	0.45		
Total	74	98.72			

C. Tukey's W-Procedure for Differences Between Pairs of Means

	Group B	Group C	Group D	Group E
Group A	0.07	1.94**	1.80**	2.14**
Group B		1.87**	1.73**	2.07**
Group C			0.14	0.20
Group D				0.34

$_{.05}W_{5,56} = 0.69$

$_{.01}W_{5,56} = 0.84$

**Significant ($p < .01$)

TABLE 3

ANALYSIS OF DATA FOR SOURCES OF VARIATION FROM
CORRECT RESPONSES ON POST-TEST

A. Group Means

Means	Group A (n = 15)	Group B (n = 15)	Group C (n = 15)	Group D (n = 15)	Group E (n = 15)	Grand Mean (N = 75)
	25.87	25.73	25.80	27.60	28.67	26.73

B. Analysis of Variance

Source of Variation	df	Sums of Squares	Mean Square	F Ratio	Significance
Treatments	4	106.67	26.67	3.97	($p < .01$)
Levels	14	80.27	5.73	1.00	n.s.
Treatments X Levels	56	375.73	6.71		
Total	74	562.67			

C. Tukey's W-Procedure for Differences
Between Pairs of Means

	Group B	Group C	Group D	Group E	
Group A	0.14	0.07	1.73	2.80*	$_{.05}W_{5,56} = 2.67$
Group B		0.07	1.87	2.95*	
Group C			1.80	2.87*	$_{.01}W_{5.56} = 3.21$
Group D				1.07	

*Significant ($p < .05$)

TABLE 4

ANALYSIS OF DATA FOR SOURCES OF VARIATION FROM
TIME FOR FIRST ITERATION OF PROGRAM

A. Group Means

Mean (in minutes)	Group A (n = 15)	Group B (n = 15)	Group C (n = 15)	Group D (n = 15)	Group E (n = 15)	Grand Mean (N = 75)
	26.36	27.80	29.58	47.10	44.44	35.00

B. Analysis of Variance

Source of Variation	df	Sums of Squares	Mean Square	F Ratio	Significance
Treatments	4	5,862.40	1,465.60	32.70	($p < .01$)
Levels	14	594.30	42.75	1.00	n.s.
Treatments X Levels	56	2,509.92	44.82		
Total	74	8,966.62			

C. Tukey's W-Procedure for Differences
Between Pairs of Means

	Group B	Group C	Group D	Group E	
Group A	1.44	3.22	20.74**	18.08**	$.05^{W}5,56 = 6.91$
Group B		1.78	19.30**	16.64**	
Group C			17.52**	14.86**	$.01^{W}5,56 = 8.38$
Group D				2.66	

**Significance ($p < .01$)

TABLE 5

ANALYSIS OF DATA FOR SOURCES OF VARIATION FROM TIME TO CRITERION

A. Group Means

Mean (in minutes)	Group A (n = 15)	Group B (n = 15)	Group C (n = 15)	Group D (n = 15)	Group E (n = 15)	Grand Mean (N = 75)
	57.21	56.12	44.70	69.00	64.02	58.21

B. Analysis of Variance

Source of Variation	df	Sums of Squares	Mean Square	F Ratio	Significance
Treatments	4	5,070.00	1,267.50	19.03	($p < .01$)
Levels	14	1,842.40	131.60	1.95	n.s.
Treatments X Levels	56	3,730.72	66.62		
Total	74	10,643.12			

C. Tukey's W-Procedure for Differences Between Pairs of Means

	Group B	Group C	Group D	Group E	
Group A	1.09	12.51**	11.79**	6.81	$.05^{W}5,56 = 8.41$
Group B		11.42**	12.88**	7.90	
Group C			24.30**	19.32**	$.01^{W}5,56 = 10.20$
Group D				5.81	

**Significant ($p < .01$)

TABLE 6

COMPUTER-STUDENT INTERACTION

SAMPLE PROGRAM ITEMS

QUESTION (on slide)

01. Which of the following statements describes the relationship between insects and insecticides?

a) species of insects develop immunity to insecticides through natural selection
b) individual insects can build up a resistance to an insecticide through repeated contact
c) insecticides no longer have any effect on insects
d) insecticides have little effect on insects

COMPUTER-STUDENT INTERACTION (on teletypewriter)

Group A: No Feedback

Correct Response		Incorrect Response	
Computer:	01. ______	Computer:	01. ______
Student:	a	Student:	b
Computer:	02. ______	Computer:	02. ______

Group B: Knowledge of Results Feedback

Correct Response		Incorrect Response	
Computer:	01. ______	Computer:	01. ______
Student:	a	Student:	b
Computer:	Correct	Computer:	Wrong
	02. ______		02. ______

Group C: Knowledge of Correct Response Feedback

Correct Response		Incorrect Response	
Computer:	01. ______	Computer:	01. ______
Student:	a	Student:	b
Computer:	a is correct	Computer:	a is correct
	02. ______		02. ______

Group D: Response Contingent Feedback

Correct Response

Computer:	01. ______
Student:	a
Computer:	Certain species of insects are sometimes capable of developing, through natural selection, an immunity to insecticides. 02. ______

Incorrect Response

Computer:	01. ______
Student:	b
Computer:	The individual insects themselves are not able to build up resistance to insecticides. Certain species of insects are sometimes capable of developing, through natural selection, an immunity to insecticides. 02. ______

Group E: Combination of Feedback Modes

Correct Response

Computer:	01. ______
Student:	a
Computer:	Correct. a is correct. Certain species of insects are sometimes capable of developing, through natural selection, an immunity to insecticides. 02. ______

Incorrect Response

Computer:	01. ______
Student:	b
Computer:	Wrong. The individual insects are not able to build up resistance to insecticides. a is correct. Certain species of insects are sometimes capable of developing, through natural selection, an immunity to insecticides. 02. ______