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ABSTRACT

A comparison was made between computer-managed instruction (CMI) and conventional instruction (CI) on measures of performance, time and attitude. The sample consisted of 167 undergraduates in a health education course at Florida State University. Of these students, 41 served as a control group and the rest were randomly assigned to one of three CMI treatments, "remedial prescription - forced mastery," "remedial prescription - forced progression," or "forced progression." All students took a pretest, a posttest, and attitude measures before and after the course. For the remainder of the quarter, the CMI students proceeded with their study of appropriate self-instructional materials. When a student felt prepared, he scheduled time on a CMI terminal and was administered the posttest on the module he had completed. Final results showed a general superiority of CMI groups on performance. Of CMI treatments, "forced mastery" students did better than the others. There was no significant difference in attitude among the three modes. Among the CMI groups no significant difference in study time was found. CI students spent 30 hours in the classroom, while CMI students averaged 3.5 hours on the computer. (Author/JK)

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ABSTRACT

SELECTED INSTRUCTIONAL STRATEGIES
in
COMPUTER-MANAGED INSTRUCTION

R. MICHAEL LAWLER, WALTER DICK, and MARION RISER

This study investigated the differential effects of selected instructional strategies in a computer-managed instruction (CMI) learning environment. The investigatory questions were primarily concerned with treatment group comparisons on measures of performance, attitude, and time. The sample consisted of 167 undergraduates in a health education course at Florida State University. Forty-one of these students received traditional classroom instruction (CI) and served as a control group. The remaining students were randomly assigned to one of three CMI treatments. For these latter students, the course was divided into 14 modules with a total of 32 objectives. Throughout the course, module posttests were administered which consisted of 5 items per objective. The criterion for passing a module test was set at 80%. During the first week of classes the pretest and attitude measures were administered to all students. For the remainder of the quarter, the CMI students proceeded with their study of appropriate self-instructional materials. When a student felt prepared, he scheduled time on a CAI terminal and was administered the posttest on the module he had completed. Upon course completion, the attitude measures and final examination were administered to all students. One of the CMI treatment groups, Remedial Prescription-Forced Mastery, represented the most typical CMI strategy. If students in this group failed to reach criterion on an objective, they were presented remedial prescriptions and were required

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to take another randomly chosen set of items until they reached criterion. Students in the Remedial Prescription-Forced Progression group who failed to reach criterion on an objective were presented only the remedial prescriptions and were not permitted to repeat the failed posttest. In the Forced Progression group, students who failed to reach criterion on an objective were given neither remedial prescriptions nor were they permitted to repeat the failed posttest. The results demonstrated a general superiority of the CMI groups over the CI groups on final examination performance. This superiority was attributed to (a) a greater degree of familiarity with the objectives and criteria, and (b) possible differences in levels of achievement motivation on the final examination. The results from performance measures demonstrated that the group who was required to reach mastery and was given remedial prescriptions, had significantly greater mean final examination scores than the group which was not required to reach mastery nor given prescriptions. Comparisons of time indices among the CMI groups indicated no significant differences in study time or in the number of days required to complete half or all of the module posttests. Limited evidence suggested that the Remedial Prescription-Forced Progression group required significantly less computer time. Average time on the computer for all CMI students was approximately 3.5 hours, while CI students spent 30 hours in the classroom.

SELECTED INSTRUCTIONAL STRATEGIES
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COMPUTER-MANAGED INSTRUCTION¹

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For over a decade, researchers have been investigating various strategies for utilizing computers in the instructional process (Bushnell and Allen, 1967). Initial studies focused on tutorial and drill-and-practice instructional formats. The use of computers for controlling learning simulations has also been studied. The most recent studies have been in the area of computer-managed instruction (CMI). This latter application stresses the use of the computer for scoring tests, carrying out diagnostic procedures, and formulating the results for the instructor or student. With CMI, instructional activities usually are off-line, i.e., the student typically studies self-paced, individualized learning packages or modules. (See Baker, 1971, for a review of first-generation CMI systems.)

A series of CMI feasibility studies have been conducted at the CAI Center at Florida State University (Hagerty, 1970; Gallagher, 1970; Dick and Gallagher, 1971). In these studies, the students interacted

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directly with the computer via CRT terminals in order to receive their module criterion tests and remedial prescriptions. The purpose of the present study was to investigate three different CMI strategies which can be easily implemented on an interactive computer system.

In the typical CMI paradigm, students are required to demonstrate proficiency on each unit or module of instruction before they are permitted to continue with subsequent modules. In such instances proficiency is usually operationally defined as correctly responding to a predetermined percentage of criterion-referenced test items, e.g., eighty percent. If a student fails to reach criterion, he is given some type of feedback in the form of remedial prescriptions keyed to those items missed on the criterion test. The student is then given the opportunity to complete the remedial exercises recommended by the prescription, and is required to return to the testing situation to demonstrate proficiency on the previously failed module.

There are several reasons why the aforementioned procedures may not be optimal from an instructional viewpoint. First, if a hierarchial dependency between modules does not exist, one would not expect required mastery on one module to facilitate mastery on any other. Further, it has yet to be demonstrated that mastery on a particular module in a CMI paradigm facilitates performance on that module at some later time, for example, on a final examination. Secondly, the question arises as to whether the extensive time and resources required for the development of remedial exercises is warranted. Knowledge of incorrect responses may in itself provide sufficient information and motivation for the student to remediate his deficiencies. Finally, requiring repeated attempts to

demonstrate mastery may not be truly optimal if it promotes undesirable attitudes towards CMI in general and the subject matter in particular, or if it results in an inefficient increment in the time required to reach criterion.

The present investigation focused on several questions regarding the comparative effectiveness of required mastery and the use of remedial prescriptions in terms of student performance, attitudes, and learning time. Specifically, three selected CMI strategies were evaluated by means of four treatment groups within an undergraduate course in Health Education. This evaluation considered: a) performance on module and final examinations; b) attitudes toward CMI and toward Health Education; c) time spent on course related activities; and, d) time to midterm and course completion under self-pacing conditions.

METHOD

For the Fall Quarter of 1970, the content of a Health Education course for elementary education majors at Florida State University was converted for presentation by CMI through the development of 14 modules which included a total of 32 objectives. Each module consisted of the following components: a) One, two, or three performance objectives; b) A sample test question for each objective; c) A list of study references for each objective; d) Resource materials appropriate to the objectives; e) A five item posttest for each objective; and f) Remedial prescriptions keyed to each objective.

Components a, b, and c were given to the students in a printed "Student Guide." Component d, the resource materials, consisted of a

"Student Digest" of recent articles, as well as readings from the course textbooks. Components e and f, the module posttests and remedial prescriptions, were presented via an IBM 1500 CAI system (IBM, 1967).

The sample consisted of 167 students enrolled in Health Education in the Fall, 1970. Forty-one of these students were randomly assigned to a class taught by the instructor in the traditional manner. The remaining students were randomly assigned to one of three CMI treatment groups.

Procedures

The treatment period for this study was approximately ten weeks, the length of the Fall Academic Quarter at Florida State University. During the first week of classes students were assigned to the four treatment groups. In addition, the pretest and Attitude Toward Health Education Questionnaire were administered and an explanation of the course was given.

For the remainder of the quarter, the CMI students proceeded with their off-line study of objectives and appropriate resource materials. When a student felt prepared to be tested, he scheduled terminal time at the CAI Center and was administered the posttest on the module, or modules, of his choice. After the student's module selection, he responded to a question which required him to indicate approximately how much time he spent studying the module.

Following the student's seventh module test, the Attitude Toward CMI Questionnaire was administered. The classroom instruction students

attended class during their regularly scheduled times. Upon course completion (after 14 module tests for CMI groups; last class day for CI group) students were again administered the attitude questionnaires. The final examination was group-administered to all students during the examination period scheduled for the course. The pretest and final examination were the same instruments and students were given the same test form on the final examination as they had received on the pretest.

Apparatus

The study time assessment, the module posttests, and the remedial prescriptions were presented by an IBM 1500 CAI System (IBM, 1967). Terminals for this system consist of a cathode ray tube (CRT), a light pen, and a keyboard. The terminals were located in an air-conditioned, sound-deadened room in Florida State University's CAI Center. Student responses to these items, as well as the student's total on-line latency, were recorded automatically by the CAI system.

Treatment Groups

1. Remedial Prescription - Forced Mastery (N=42).

This group represented the common CMI strategy. Students failing to reach criterion (80%) on one or more objectives in a module were presented a remedial prescription keyed to the failed objectives and directed to reschedule terminal time to repeat the failed module test. This group was required to reach criterion on each objective within a module before making another module selection.

2. Remedial Prescription - Forced Progression (N=46).

Students in this group failing to reach criterion on an objective were presented with remedial prescriptions and were given the choice of signing off or selecting another module on which to be tested.

3. Forced Progression (N=38).

Students failing to meet criterion on an objective were given the choice of signing off or selecting another module on which to be tested.

4. Classroom Instruction (N=41).

This group was taught via the traditional classroom instruction method characterized primarily by lectures and discussion.

Summarized in tabular form the four treatment groups could be contrasted as shown in Table 1.

 Insert Table 1. here

For all of the CMI treatment groups, the decision strategy was identical if the student met criterion on the module posttest on his first attempt; i.e., he proceeded to the next module of his choice. Thus, the CMI treatments were designed to focus on the differential management of students who failed to meet criterion. It should also be noted that the entire course sequence for the CMI groups was student selected. That is, these students were free to study resource material for any module and could choose their next module test from the list of those remaining. The exception to this was, of course, the Remedial Prescription-Forced Mastery group, who could only select their next module test after reaching criterion on their prior selection. ~~Table 1~~

depicts the computer strategy used for the various CMI treatment groups.

Insert Figure 1. about here

Evaluation Instruments

Five forms of a pretest-final examination were developed. Each of the forms contained 128 items (4 per objective) with 64 items unique to each test form and 64 items common to all forms. In addition, half of each test form contained items taken from the pool stored in the computer for within-course testing (computer portion), and the remaining half (common item portion) consisted of items not stored in the computer. The use of these alternate forms generated item statistics on all items and permitted comparisons between the common item and computer item portions to assess the generalizability of that content which was specifically tested during the course.

The principal instruments used to assess student attitudes were:

- a) the 40-item Attitude Toward CMI Questionnaire (Hagerty, 1970); and
- b) the 17-item Attitude Toward Health Education Questionnaire, designed by the authors and based on scales developed by Shaw and Wright (1967).

Hagerty (1970) reported an internal consistency reliability coefficient (KR20) of .88 for the Attitude Toward CMI Questionnaire; Shaw and Wright (1967) indicate that measures constructed with their items have had obtained reliabilities ranging from .68 to .93.

Three sources of data regarding time were assessed. The first of these was the students' self-report of the amount of time spent studying each module. This data was collected at the CMI

terminal prior to each module test. The second time measure included the number of days to completion of one-half of the course (defined as completion of seven module posttests) and to course completion (defined as completion of 14 module posttests). The third measure was the total time spent on the terminal responding to test items and receiving prescriptions.

RESULTS

The results of this investigation are organized as follows: First, descriptive data on the common and computer item portions of the pretest-final examination are presented. This is followed by treatment group comparisons of performance, attitudes, and time measures, respectively.

Table 2 presents the pretest and final examination means and standard deviations for the common and computer item segments for the four treatment groups.

Insert Table 2. about here

It should be noted that: first, substantial mean gains were made by all treatment groups on both segments of the test; and second, the CMI treatment groups made relatively greater gains on the computer item portion than on the common item portion.

Treatment Comparisons of Performance Data

Two principal sources of data were employed to ascertain differences in performance among the treatment groups. These sources were the final examination performance and the within-course performance. The principal analysis from the first source of data consisted of scores on the 128-item final examination (KR-20 reliability = .84). Pretest scores served as the covariate in a one-way analysis of covariance. Included in this analysis were all students with scores on both the pretest and final examination. The obtained correlation between these two variables was $r = .38$.

The means and standard deviations for the four treatment groups on both the pretest and final examination are presented in Table 3. It may be noted that the mean performance of the Classroom Instruction group

 Insert Table 3. about here

is considerably below that of the CMI groups. The ANCOVA for these data ($F_{3,154} = 14.98$) was sufficient to reject the null hypothesis of no difference among the treatment means ($p < .01$). Further, an a posteriori test (Newman-Keuls) on the adjusted criterion means indicated that all three CMI groups differed significantly from the CI group and the Remedial Prescription Forced Mastery group differed significantly from the Forced Progression group ($p < .05$). Schematically, the summary of the a posteriori tests may be represented as follows:

Rem. Pres. Forced Mast.	Rem. Pres. Forced Prog.	Forced Prog.	Class Inst.
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(Treatments underlined by a common line did not differ; treatments not underlined by a common line did differ.)

The principle analysis of within-course performance was based on the first-pass computer test performance for the three CMI groups. The dependent variable in this one-way analysis of variance was the sum of the 5-item, first-pass test scores for the 32 objectives in the course. Thus, the maximum score possible for a particular student on this variable was 160 (i.e., 5 items x 32 objectives). Table 4 presents the means and standard deviations for the CMI groups for the within-course, first-pass total scores. These treatment group mean differences were not statistically

 Insert Table 4. about here

significant ($F_{2,123} < 1$; $p > .05$).

Treatment Comparisons of Attitudinal Data

The Attitude Toward Health Education scores (final administration) for all four treatment groups were analyzed through the use of analysis of covariance with the pre-assessment scores as the covariate. The obtained correlation between the two score distributions was .46. The means and standard deviations for both the pre and final assessment on this instrument are presented in Table 5. It may be noted that there

 Insert Table 5. about here

is very little difference in mean scores between the four treatment groups on either administration. The ANCOVA for these data yielded a non-significant F ratio ($F_{3,160} = 1.20; p < .05$). The absence of any statistically significant mean differences suggests that the students' attitudes toward health education, as herein assessed, was not differentially influenced by treatment group assignment.

A second attitudinal measure was administered which assessed the students' attitudes toward CMI. This scale was administered to the students in the CMI treatment groups upon completion of the 7th and 14th module tests. An analysis of variance on the mid-course and end of course means indicated no significant differences among the three CMI groups.

Treatment Comparisons of Time Data

All the data reported in this section are based only on learning time of the CMI students. The first index of learning time that was investigated was reported time spent studying per module (as expressed in hours). The 14 correlations between module scores and all the CMI students' self-reports of time spent studying on the respective modules are presented in Table 6. Ten of the 14 correlations were relatively small but significant ($p < .05$). These 14 separate time ratings (in

 Insert Table 6. about here

approximate hours) were summed for each student and the treatment group means and standard deviations are given in Table 7. These mean differences were

not statistically significant ($F_{2,123} < 1$; $p < .05$).

 Insert Table 7. about here

The second index of time consisted of two related components:

a) the number of days under self-paced conditions required to complete 7 of the 14 module tests, defined as "midterm"; and b) the number of days required to complete all 14 module tests, defined as "course completion." In each case, the number of days was based upon the total number of days (50) upon which the CMI system was available during the fall academic quarter. Table 8 presents the means and standard deviations for these two indices for the CMI treatment groups. Considering each of the indices in separate ANOVA's, the F ratios were not statistically significant (p 's $< .05$).

 Insert Table 8. about here

The third time index was the total terminal time for each student. This cumulative latency represents the total amount of time that each student was actively engaged in student-terminal interaction. Table 9 presents the means and standard deviations of total latency (in minutes) for the three CMI treatment groups. It should be noted that the

 Insert Table 9. about here

Remedial Prescription-Forced Progression group has the least mean time, while the Remedial Prescription-Forced Mastery group had the greatest.

A high degree of variability in system latency both within and across treatment groups is indicated by the rather large and disparate standard deviations.

DISCUSSION

Performance comparisons among the four treatment groups indicated the superiority of the CMI groups over the CI groups on final examination performance. This difference can be attributed to at least two factors. The first of these factors is related to the positive effects associated with frequent testing enhanced by immediate knowledge of results. It could be argued that the significant difference in performance was simply due to the increased practice in responding to the test items afforded the CMI groups. However, the mean final examination performance of the Remedial Prescription-Forced Mastery group was not significantly greater than that of the Remedial Prescription-Forced Progression group. Thus, while the effects of practice could partially explain differences in performance between the CMI and CI groups, an alternative interpretation is warranted. This alternative interpretation to explain the effects of frequent testing is that it provided the CMI students with a greater familiarity with the content objectives, a better understanding of the criteria used in evaluating the attainment of the objectives, and immediate feedback on their responses to test items. This knowledge would have aided the CMI students in focusing their attention on the relevant portions of the resource material as well as providing a relative index of the study time required to reach expected performance levels.

The second factor is related to possible differences in levels of motivation to do well on the final examination. Specifically, an uncontrolled source of error was introduced by the instructor of the CI students on the last week of classes. The instructor administered his own version of a final examination, informing the students that they were required to take the group-administered final examination during final examination week, but that their scores on his version, rather than their scores on the group-administered version, would be considered in determining course grades. While the CI students did take the group-administered test, and appeared to take as much time in responding as did the CMI students, this methodological error makes the assumption of equal motivation levels between the two groups questionable.

Final examination comparisons among the three CMI groups means failed to substantiate the efficacy of requiring forced mastery only or of providing remedial prescriptions only. This is evidenced by the fact that the Remedial Prescription-Forced Mastery group did significantly better than the Forced Progression group, but the mean differences between: (a) Remedial Prescription-Forced Mastery vs. Remedial Prescription-Forced Progression; and (b) Remedial Prescription-Forced Progression vs. Forced Progression were not statistically significant. This lack of clear superiority effected by requiring mastery or by providing remedial prescriptions is consistent with the lack of differences on within-course performance among the CMI groups. Collectively, these performance data support the interpretation that the differences among the CMI treatment must be attributed to the combined effect of forced mastery and remedial prescriptions.

When time-on-terminal is considered, the Remedial Prescription-Forced Progression treatment appears to be the most efficient in terms of cost. On the average, these students used an hour less terminal time than the Forced Progression group and 1.5 hours less than the Remedial Prescription-Forced Mastery group.

Treatment mean differences on the Attitude Toward Health Education and Attitude Toward Computer-Managed Instruction questionnaires were not significantly different. The data provided by both of these instruments failed to indicate any differential effects associated with the treatment groups employed. With respect to the former instrument, it should be noted that the mean Attitude Toward Health Education scores were practically the same for the CMI and CI groups. These data suggest that the method of instruction which characterized the CMI presentation was as effective in conveying positive attitudes and values as was the traditional method of instruction characterized by a greater degree of student-professor contact. Concern by professional health educators, as well as many other teachers, is as much for the development of positive attitudes toward a body of content as for acquisition of specific knowledge. Technology is often viewed as a means of conveying information but as potentially detrimental to the development of positive attitudes. However, the results of this study do not support this contention.

In conclusion, the methodology and results of the present investigation suggest the need for further exploration of instructional strategies which can be implemented via on-line CMI. For example, CAI remediation and reviews could be imbedded within the Remedial Prescription-Forced Mastery paradigm. This suggested area deals with the efficacy of

providing on-line, CAI-like instruction within the CMI framework. This instruction might take the form of on-line remedial exercises (e.g., linear or branching programs presented via CAI), simulations, or simple narrative reviews. More specifically, research is needed to determine the most effective means of designing and integrating on-line instruction for inclusion in a CMI paradigm.

It is conceivable that the addition of such on-line instruction would: (a) augment the immediate effects of frequent testing, and (b) reduce the retention loss between the time of acquisition and the time of criterion assessment.

TABLE 1

Summary Description of Four Treatment Groups

Group	Forced Mastery	Remedial Prescriptions	Module Posttests & Knowledge of Results
Remedial Prescription- Forced Mastery	Yes	Yes	Yes
Remedial Prescription- Forced Progression	No	Yes	Yes
Forced Progression	No	No	Yes
Classroom Instruction	No	No	No

TABLE 2

Pretest and Final Examination Means and
Standard Deviations for the Common and Computer
Test Item Portions for the Four Treatment Groups

	N	Pretest				Final Examination			
		Common		Computer		Common		Computer	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
Remedial Prescription- Forced Mastery	40	25.58	5.30	26.45	7.30	38.74	6.27	47.53	6.16
Remedial Prescription- Forced Progression	43	26.44	5.06	30.35	6.76	39.28	6.33	46.63	6.06
Forced Progression	35	27.11	4.64	27.74	7.34	37.57	5.57	44.51	6.20
Classroom Instruction	41	26.98	5.33	28.71	7.27	36.00	5.59	38.15	6.42

TABLE 3

Means and Standard Deviations of Four Treatment Groups for Pretest and Final Examination Scores and the Final Examination Means Adjusted for the Covariate

	Pretest			Final Exam		
	N	Mean	Standard Deviation	Mean	Standard Deviation	Adjusted Mean
Remedial Prescription- Forced Mastery	40	52.53	11.53	86.65	11.49	87.75
Remedial Prescription- Forced Progression	43	56.79	10.38	85.91	10.67	85.11
Forced Progression	35	54.86	10.98	82.09	10.92	82.15
Classroom Instruction	41	55.68	11.62	74.15	11.21	73.85

TABLE 4

Means and Standard Deviations for CMI
Groups for Within-Course, First-Pass Total Scores

Group	N	Mean	Standard Deviation	Mean as % of Total Items
Remedial Prescription- Forced Mastery	42	120.19	12.54	75
Remedial Prescription	46	120.80	10.51	76
Forced Progression	38	117.66	12.51	74

TABLE 5

Means and Standard Deviations of Four Treatment Groups for the Pre and Final Administration of the Attitude Toward Health Education Questionnaire

Group	Pre-Assessment		Final Assessment		Adjusted Final Mean
	Mean	Standard Deviation	Mean	Standard Deviation	
Remedial Prescription- Forced Mastery	69.51	6.70	73.51	7.36	72.83
Remedial Prescription- Forced Progression	68.07	6.49	70.32	8.16	70.38
Forced Progression	67.00	7.42	72.22	8.68	72.85
Classroom Instruction	68.30	6.70	71.40	7.57	71.35

TABLE 6

Correlations (r) Between Module Scores and Self-
Reports of Time Spent Studying for that Module (all CMI Ss)

Module	1	2	3	4	5	6	7
r	.21*	.18	.20*	.42**	.21*	.07	.29**

Module	8	9	10	11	12	13	14
r	.27**	.30**	.13	.25**	.30**	.11	.27**

*p < .05

**p < .01

TABLE 7

**Means and Standard Deviations of Total Reported
Study Time (in hours) for the Three CMI Groups**

Group	N	Mean	Standard Deviation
Remedial Prescription- Forced Mastery	42	35.14	12.74
Remedial Prescription- Forced Progression	46	35.78	11.72
Forced Progression	38	38.21	11.40

TABLE 8

Means and Standard Deviations for Number of Days to Completion of Midterm and Course for the Three CMI Groups

Group	N	Midterm Completion		Course Completion	
		Mean	Standard Deviation	Mean	Standard Deviation
Remedial Prescription- Forced Mastery	42	30.93	8.23	45.91	2.46
Remedial Prescription- Forced Progression	46	29.57	8.83	44.80	3.43
Forced Progression	38	28.37	9.13	45.16	3.27

TABLE 9

Means and Standard Deviations of Total Latency
(in Minutes) for the Three CMI Groups

Group	N	Mean	Standard Deviation
All CMI groups	126	214.33	166.52
Remedial Prescription- Forced Mastery	42	257.44	145.34
Remedial Prescription- Forced Progression	46	160.52	59.35
Forced Progression	38	233.87	246.00

FIGURE CAPTIONS

1. Summary of terminal procedures for CMI students

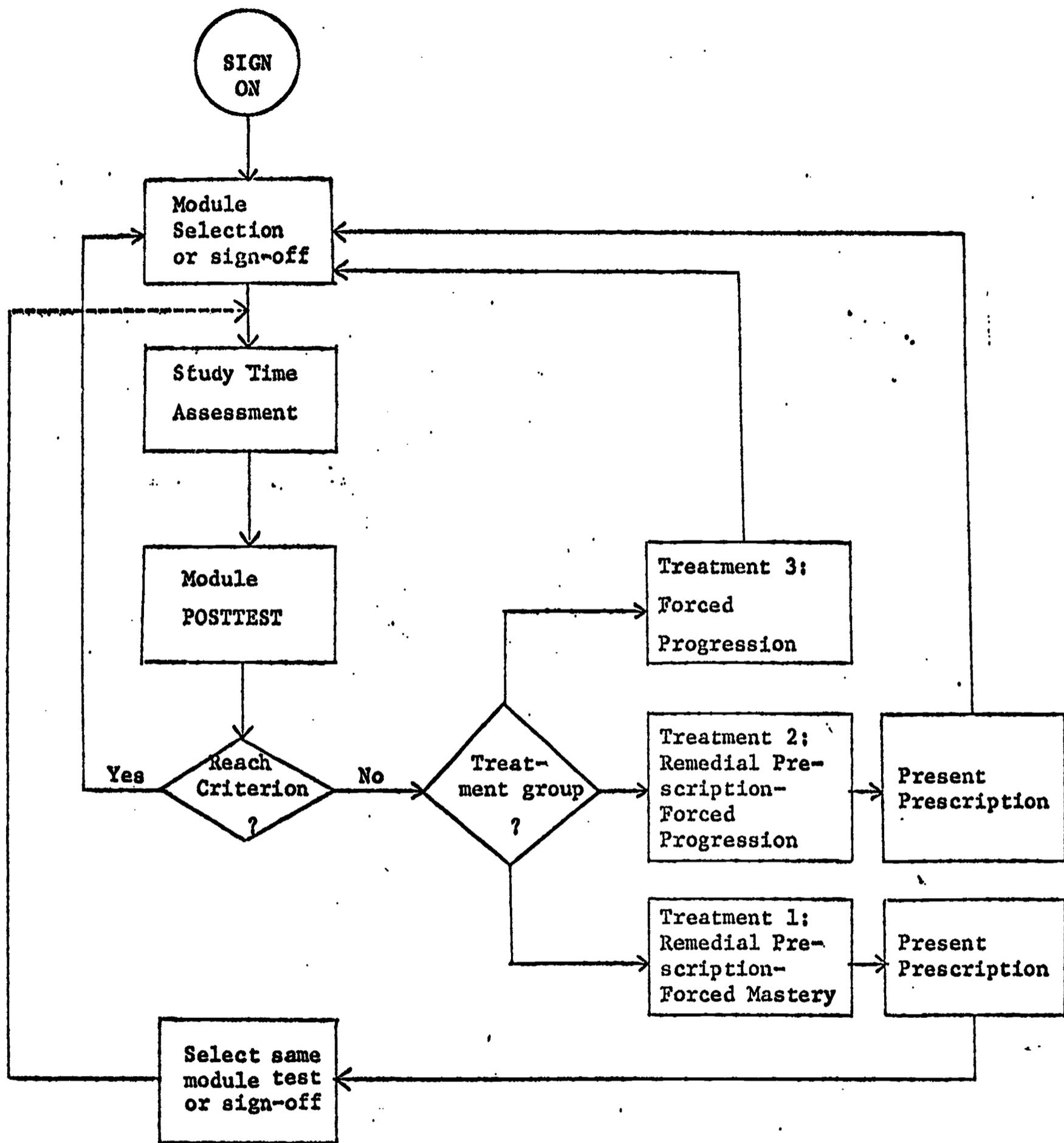


Figure 1. -- Summary of terminal procedures for CMI students.

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