SESSION V COMPUTER-AIDED INSTRUCTION

John W. Cotton, *Presider*

PROCTOR: An on-line student evaluation and monitoring system for use with PSI format courses

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PROCTOR, an on-line interactive system for student evaluation and monitoring in courses employing the PSI format, is described. This system involves a tester module that assumes many of the routine managerial duties traditionally assigned to the student proctor, such as quiz administration and scoring, performance feedback, and complete record keeping. Also, PROCTOR includes a multipurpose editor that allows an instructor to enter, examine, or modify any information in the disk files accessed by the tester. Factors related to the implementation and use of this system are considered, and its advantages for management, quality control, and staffing in PSI courses are discussed.

In recent years, there has been an increasing awareness of the need to develop an educational technology that is based upon principles of psychology derived from the study of learning (Robin, 1976). Historically, at least two major thrusts in this direction can be identified. One is the computer-assisted instruction (CAI) movement of the late 1950s that represents an outgrowth (cf. Hooper, 1978) of pioneering efforts in the areas of programmed learning and "teaching machines" (e.g., Skinner, 1968). The basic notion behind this technology was that especially effective programs of instruction could be developed by utilizing the computer as an ever-vigilant "tutor" programmed to present sequentially designed lessons, evaluate student responses, administer immediate feedback, and provide appropriate remediation, all at a pace suited to the student's own capabilities and learning style. Until recently, however, a major stumbling block to the widespread use of this pedagogical innovation has been the relatively high cost associated with the computer hardware itself. Also, the specialized knowledge of computers necessary to implement a successful CAI system has proved to be an inhibitory factor in this connection.

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In the early 1960s, an alternative approach to an educational technology was devised (Keller, 1968, 1969) that has provided the cornerstone of a movement known today as "behavioral instruction" (Johnston & Ruskin, 1977; Robin, 1976). For the most part, the methods of this system also were designed to accommodate individual differences in learning, but without the emphasis upon automated and strictly sequential lesson delivery characteristic of CAI and programmed learning. Consequently, this instructional methodology, known as the Keller Plan, or the Personalized System of Instruction (PSI), was not dependent upon costly computer hardware and has been more widely adopted and thoroughly evaluated than the CAI alternative. Numerous studies of the effectiveness of the PSI at the college level have shown that it is a better liked and more effective method of education than the traditional lecture-style format for many subjects, ranging from physics to introductory psychology (for reviews, see Johnson & Ruskin, 1977; Kulik, Jaska, & Kulik, 1978; Robin, 1976).

Unfortunately, as with CAI, the use of a behavioral instruction methodology is not without drawbacks. Ironically, however, as noted by Pennypacker (1978), perhaps the most important impediments to the adoption of a system such as the PSI can be overcome through the use of now more widely available and increasingly inexpensive computer assistance. Thus, with the wedding of two powerful instructional technologies, there is the promise together of even greater potential gain. The present paper illustrates how this technological marriage

was accomplished in an introductory psychology course at the University of Notre Dame by describing the essential features of the PSI, some major problems posed by it in unmodified form, and a resolution to these difficulties offered by computer technology.

THE PSI METHOD

General Features

Several aspects of the PSI distinguish it from more traditional methods of instruction, especially at the college level (Johnson & Ruskin, 1977; Robin, 1976). One is the emphasis placed upon mastery of the written rather than the spoken word. The material to be learned in a PSI course usually is contained exclusively in readings or textbooks. Lectures play only a secondary and chiefly motivational role in this system.

However, the written material in such a course is divided into a series of small units or lessons. For each lesson, a set of "behavioral objectives" commonly is provided. In essence, these objectives specify the concepts that are considered critical to an adequate understanding of the course content. As such, they may be viewed as a definition of what is to be learned by the student. Frequently, such objectives are contained in a study guide or workbook prepared especially for the adopted textbook.

Mastery of the information in each lesson normally is evaluated in the PSI method by means of brief unit tests. These tests consist of short-answer and/or objective items drawn from aspects of the material covered by the learning objectives. Care is usually taken to formulate each item so that attainment of the behavioral objectives for any unit will insure a high score on the lesson test.

In many, but not all, variants of the PSI method, some criterion of mastery (e.g., 90% correct) on a particular test is required before the student can go on to the next unit. No penalties are associated with failure to achieve mastery. Instead, the student retakes alternative forms of the test until the criterion is achieved. In the absence of a mastery requirement, optional retakes serve to provide an opportunity for improvement upon initial test performance.

A PSI method invariably entails a self-paced learning arrangement. Successive units can be mastered as rapidly or slowly as desired within limits imposed by course scheduling. Upon completion of each lesson test, the student normally is awarded a number of points that corresponds to the number of correct items. Final grades are determined by the total number of points accumulated in the course. Clearly, then, the student can select his/her own rate of unit completion. Moreover, because ultimate class performance is gauged primarily by the number of lessons completed, final grades also are largely self-determined.

A hallmark of the PSI method is the use of course proctors (Sherman, 1974). Typically, they are students

who have previously mastered the course material and who are thoroughly familiar with PSI procedures. A proctor has two main duties: (1) course management activities, such as test administration, scoring, and record keeping; and (2) tutorial functions involving performance feedback, question answering, concept clarification, and learning-deficit diagnosis. The latter roles commonly are viewed as an important basis for the individualization of instruction under a PSI procedure, and they are regarded as the primary means of providing a personal-social (i.e., personalized) enhancement of the learning process (Keller, 1968).

Impediments

Among the more formidable of the obstacles to the use of a PSI method are those that derive from considerations regarding course materials and staffing. Even if a suitable textbook is available for adoption, a great deal of effort must be devoted to preparation from scratch of supplementary materials for each unit, such as study guides, behavioral objectives, and alternative test forms. Fortunately, the problems posed by this potential impediment to the use of the PSI are mitigated to some extent by the existence, for many topic areas, of good, commercially available textbooks and supplementary packages designed specifically for use with this instructional format. Also, a national clearinghouse for information on the PSI method has been established (cf. Sherman & Ruskin, 1978) to assist those wishing to implement such a course.

Even with suitable materials, however, there is the problem of staffing. In order to realize the goal of personalization, the ratio of students to proctors must be kept as small as possible. This is primarily because, with limited class time, the proctors' routine course management duties can become very time-consuming when the proctors are responsible for more than 8-10 students each. Larger ratios result in relatively less time available for the personalized, and perhaps more important, tutorial functions.

Thus, a large PSI class enrollment requires a commensurately large staff in order to maintain a favorable student-proctor ratio. But this is often difficult to achieve, since, in most cases, proctors must be recruited without many tangible incentives from among the student population itself. Moreover, even if available, a large number of proctors creates added administrative difficulties stemming from the increased effort required to manage and monitor the quality of their functions. Such personnel problems can become a serious impediment to the successful implementation of a PSI-format course, however advantageous the use of such a method might be.

Our efforts to deal with this potential drawback to the use of the PSI are based upon the assumption that most, if not all, of a proctor's course management duties can be assumed by an appropriately devised interactive computer system. Such a system has the obvious advan-

tages of being ever vigilant, never bored, and relatively error free. Scheduled appropriately, 5-10 interactive stations can accommodate a very large number of students for routine tasks such as on-line quiz administration, immediate scoring and feedback, and complete record keeping. A computerized "proctor" also can provide suggestions for further study based upon the relation of incorrect test items to the learning objectives for a given unit. Using a computer in these ways means that fewer student proctors are required to staff even a large class. Furthermore, under such a system, the student proctors' duties presumably can be highly personalized and of a more tutorial nature. The result is a substantial reduction in personnel and quality-control problems associated with PSI course management. Thereby, a commensurate increase can be expected in the applicability of this powerful behavioral instruction technology in a variety of education settings. With these thoughts in mind, we developed PROCTOR, an on-line computer system suitable for use in conjunction with a PSI-format course.

PROGRAM DESCRIPTION

PROCTOR consists of two independent menu-driven programs: a student management module (Tester) and a general-purpose editor module (Editor). The former interacts with the student and assumes many of the managerial duties of a PSI proctor. The latter is reserved for the course instructor or assistants and provides for the creation, display, and modification of student records and other types of information about the class stored in the computer.

Tester

The student management module was designed to allow a student to proceed at a self-determined pace through the series of unit tests (initial and retakes) that define the course. To initiate this module, a student must enter an authorized identification number at an active station. Once started, a student may select one of several options available to perform the various functions depicted in Figure 1. In this case, in response to the "Command?:" prompt, the student's response is "Help," which results in the display of the menu supported by Tester. As the menu shows, the functions available to the student are divided into categories pertaining to: (1) general information, such as a class newsletter or a student's current class status; (2) action regarding a single unit, such as the initiation of a test or a listing of the items previously missed on a particular lesson; and (3) display of various aspects of a student's overall performance and progress in the course.

Figures 1 and 2 also illustrate the sequence of events involved in the administration and scoring of initial lesson tests and retakes. In response to entry of the "Test" command (Figure 1), Tester displays the rules of the test session and then presents a list of possible

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ENTER 9-DIGIT STUDENT ID-NUMBER: 991992993

(The current newsletter is listed upon initiation of session)

CLASS NEWSLETTER: SEPTEMBER 25

R. B. Youngblood set a new world speed record, finishing our
course in just three weeks!!! Congratulations, R. B.!! He is
expected to be up and around in a few days. The rest of the class
also is doing very well. Keep up the good work!

COMMAND?: help

*PROCTOR* IS A SYSTEM OF COMPUTERIZED COURSE MANAGEMENT UTILIZING
SCIENTIFIC PRINCIPLES DERIVED FROM THE PSYCHOLOGY OF LEARNING
DESIGNED TO MAXIMIZE STUDENT COURSE PERFORMANCE AND ENJOYMENT.
*PROCTOR* PERFORMS MANY FUNCTIONS EACH OF WHICH IS INITIATED BY A
COMMAND YOU ENTER. THE AVAILABLE COMMANDS ARE DESCRIBED BELOW.
ENTER 'END' TO EXIT *PROCTOR*.

GENERAL INFORMATION COMMANDS:
-----
INFO ..... PRESENT STUDENT IDENTIFICATION AND STATUS
NEWS ..... DISPLAY CURRENT CLASS NEWSLETTER
UNITS ..... SHOW TEST-UNIT/WORKBOOK-LESSON CORRESPONDENCE

SINGLE TEST-UNIT COMMANDS:
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MISSES ..... PROVIDE A DIAGNOSIS OF TEST ITEMS MISSED
TEST ..... INITIATE A TEST SESSION FOR TAKING A NEW TEST

OVERALL PERFORMANCE-PROGRESS COMMANDS:
-----
ALL ..... DISPLAY ALL STUDENT RECORD INFORMATION
BONUS ..... PRESENT RECORD OF BONUS POINTS RECEIVED
CHART ..... PLOT GRADE POINT CHART
CUM ..... PRESENT CUMULATIVE UNIT/BONUS/TOTAL POINTS
RETAKE ..... PRESENT RECORD OF RETAKE TESTS TAKEN
SCORES ..... DISPLAY RECORD OF TEST SCORES AND DATES

COMMAND?: test

TEST RULES (Test rules displayed here can be altered by instructor)
1. TEST SESSION CANNOT BE INTERRUPTED ONCE STARTED.
   ATTEMPTS AT INTERRUPTION MAY RESULT IN LOSS OF POINTS.
2. TERMINAL AREA MUST BE CLEAR OF BOOKS, PAPERS, AND PENS.
3. LEAVING YOUR TERMINAL DURING TEST IS NOT ALLOWED.
4. SPEAKING WITH OTHER STUDENTS DURING TEST IS NOT ALLOWED.
5. LOOKING AT OTHER TERMINAL SCREENS IS NOT ALLOWED.

STUDENT 991992993 MAY TAKE ONE OF THE FOLLOWING:
INITIAL 10
RETAKE 9 8
ENTER INITIAL, RETAKE, OR EXIT: initial

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Figure 1. Example of the sign-on procedure with Tester and sample listings following the "Help" and "Test" commands. In this and remaining figures, responses entered by the user are underlined lowercase text and commentary is lowercase text enclosed in parentheses.

test options. These options are derived in accord with the assumption that most textbooks and study guides are maximally informative only when processed in sequence from front to back. Thus, Tester requires that the student attempt initial tests for all units in an ordinal progression.

In addition to this sequence constraint, the test options provided by Tester at any point depend upon whether or not the instructor has selected a mastery requirement for the course. With such a criterion, the student is required to answer a certain number of items correctly on any unit test before being allowed to progress. Under this circumstance, the student must continue to retake alternative forms of the lesson test until the mastery criterion is achieved. Currently, a maximum of three retakes is possible with the PROCTOR system. After that, the student is required by the program to consult with the instructor before being allowed to continue. Without a mastery requirement, the student is free to proceed to the next unit regardless of present performance. Optional retakes are available in this mode, but these tests are only influential if they result in an improvement upon initial test performance. However, to prevent the student's delaying further study of a unit for too long, a restriction is placed on the availability of retakes under this condition. As many

TEST QUESTION 1

diagnosis” following the test.

initial tests can be attempted on a given day as desired, but all retakes of those units must be completed before moving on to the next initial unit test on another day. Otherwise, the first initial lesson test attempted on the next class day cancels retake options for all units taken before that day.

Both the criterion of mastery and the number of retakes allowed (up to the maximum of three) are predetermined by the instructor for each student. In part, the number of retakes is dependent upon the size of the available test item pool for any unit, as well as upon the manner in which actual test items are selected from the total pool. In the PROCTOR system, the instructor is required to decide in advance which test items will appear on initial and retake exams for a given unit. This information is included in a table used by Tester at the time of test administration. While the specific assignments in this table can be varied within the PROCTOR system, once arranged they are the same for all students.

Three levels of feedback to the student regarding course performance are provided by the PROCTOR system. One, illustrated in Figure 2, involves the immediate evaluation of the correctness of a student's answer to each question during the unit test. A second level, also depicted in Figure 2, consists of a posttest summary of lesson performance in terms of the items missed followed by an "objective mastery diagnosis" for that

unit. The latter is based upon the correspondence between test items and study guide learning objectives that is an integral part of the PSI method. Such correspondence allows each missed test item to be related to specific lesson objectives and also to sections of the text in which the subject matter relevant to the objective is discussed.

The third level of feedback is shown in Figure 3. This level is provided by the various options in the Tester menu that display different aspects of a student's overall progress in the course. This figure illustrates use of the "Scores" and "Chart" commands. The first results in the display of a student's highest score (initial or retake) for each unit that has been attempted. The "Chart" command, illustrated at the bottom of Figure 3, provides a cumulative record of a student's total course points as a function of class days in relation to an approximately linear extrapolation of the performance (i.e., target rate) required to obtain any desired grade by the end of the semester.

Editor

The second of the two modules that compose the PROCTOR system is a general-purpose on-line editor program intended for use only by the course instructor and assistants. With Editor, it is possible to create, display, or change any aspect of a student's class record stored on disk. Also, modification of information in class files used by Tester, such as test item assignments, question and/or answer texts, mastery criteria, or the number of retakes allowed, can be accomplished by this program.

After initiation of Editor, a variety of commands

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COUNTD?: scores
TEST SCORE RECORD          STUDENT 999999999
UNIT   DATE    SCORE      UNIT   DATE    SCORE
  1 0829       8         16 0910       7
  2 0901       7         17 0912       8
  3 0901       8         18 0912       8
  4 0903       8         19 0912       7
  5 0903       7         20 0912       7
  6 0905       8         21 0915       7
  7 0905       8         22 0915       8
  8 0905       8         23 0915       6
  9 0905       7         24 0915       6
 10 0905       7         25 0917       8
 11 0906       7         26 0917       7
 12 0906       8         27 0917       8
 13 0506       7         28 0917       6
 14 0910       8         29 0919       7
 15 0910       7         30 0922       70

COUNTD?: chart
ENTER YOUR TARGET COURSE GRADE (A,B,C, OR D): a

GRADE POINTS CHART FOR STUDENT 999999999: YOUNGBLOOD ROBERT B.
224 +-+
      *
      |
      |
C  U H 168 +-+
      |
      |
      |
      |
P O T
112 +-+
      |
      |
      |
E F 56 +-+
      |
      |
T I 56 +-+
      |
      |
S A  +
L  L  +
G -+12345678901234567890123456789012345678901
CLASS DAYS

CUTOFFS WITH FINAL: A >296 A- >286 C >259 B- >250 C >213 D >160
STUDENT 999999999 HAS 315 CUM PTS AND NEEDS C PTS FOR TARGET GRADE
COUNTD?:

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Figure 3. Sample listings following the "Scores" and "Chart" commands in Tester.

are available to the user. Figure 4 lists these options as they would be displayed in response to a "Help" command following the "EDIT?" prompt. As illustrated at the bottom of Figure 4, many of these commands (e.g., "Examine") initiate modes wherein one or more subcommands (e.g., "Info" and "Retakes") are available.

As the menu indicates, three broad categories of function are performed by this module. The first pertains to the class as a whole and includes options such as displaying a summary of class performance for all or a subset (e.g., those not finished) of students and producing a hard copy of student records. Also in this category are commands for alteration of the status of all students in the course. With PROCTOR, course status is indicated by the state of three flags or switches for each student. A test flag in each student's record indicates whether or not further test taking is permitted. This flag is altered manually or by the Tester program and provides the instructor ultimate control over test administration. A record-write flag exists to prevent simultaneous and potentially conflicting changes of the same student's information by Tester and Editor. When a student's record is accessed by either module for the purpose of altering its contents, the state of this flag is temporarily changed to prevent the other program's writing new information there until the first module's function is terminated. The third switch, a course flag, signifies whether or not a student has completed all units.

Generally, these status flags would be altered on an individual basis, rather than for the class as a whole. However, in the interest of security, for example, it is convenient to use a command in this category to disable the test flags of all students at the end of a daily session. Finally, in this entire-class category are commands to perform miscellaneous functions such as examination or editing of a class newsletter displayed to each student at the start of a session.

A second category of Editor functions relates to information for a single student. Options here permit creation, deletion, display, and/or change of any aspect of an individual student's record, including status flags. In the final category are commands relevant to the test item pool and the operation of Tester. For example, the "Qadd" and "Qchange" commands permit the question/answer text, book page number, correct answer, or lesson objectives relevant to a test item to be created or changed. The "Parm" function provides for alteration of mastery criterion, number of retakes, and test item assignment. Finally, miscellaneous functions in this category include listings of test items or answers and the presentation of an item analysis for selected questions.

IMPLEMENTATION DETAILS

Hardware/Software Requirements

The version of PROCTOR described above was written in the PL/I programming language (for the PL/I optimizing compiler) and is implemented on an IBM 370/168 computer in a timesharing (TSO) environment. Ten 9,600-baud IBM 3278 video terminals, hardwired to the computer, presently serve as interactive stations. Also, 300-baud phone-access terminals (e.g., Hazeltine Model 2000) have been employed. PROCTOR utilizes two 30-track keyed-access (ISAM) disk files to store test items, assignment tables, and student records. Several additional one-track physical-sequential data sets are used to store information such as the test rules, the newsletter, changeable passwords, and so on. Some of PROCTOR's functions make use of IBM system utility routines for sorting and writing hard copy to the printer. In addition, a library of command procedures (CLISTs) and assembly language routines has been developed to aid in PROCTOR's daily initiation and termination, as well as to help with magnetic tape backup of program master files.

As it stands, PROCTOR in load module form would be transportable to installations with an IBM 360 or 370 computer or compatible machine (e.g., Amdahl, ITEL) with a TSO or comparable (e.g., TONE) timesharing system. Also, a PL/I transient library appropriate for IBM's full implementation of this language would be necessary. Changes in the source would be required and could adapt PROCTOR for use with the Conversational Monitoring System (CMS). Other requirements include the interactive terminals, appropriate

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EDIT?: help

THE EDITOR PERFORMS GENERAL PURPOSE EDIT FUNCTIONS FOR THE
*PROCTOR* COMPUTERIZED COURSE MANAGEMENT SYSTEM. EACH OF THE
AVAILABLE COMMANDS ARE DESCRIBED BELOW. ENTER 'END' TO EXIT FROM
THE EDITOR.

COMMANDS FOR THE ENTIRE CLASS:
-----
CSTATUS ..... ALTER TEST-TAKING, RECORD-WRITE, OR COURSE STATUS
LIST ..... DISPLAY ENTIRE CLASS OR A SPECIFIC SUBSET
NEWS ..... ALTER OR DISPLAY CURRENT CLASS NEWSLETTER
PRINT ..... PRODUCE HARDCOPY OF STUDENT RECORDS
UNITS ..... SHOW TEST-UNIT/FORELOO LESSON CORRESPONDENCE

COMMANDS FOR A SINGLE-STUDENT:
-----
ADD ..... ADD A NEW STUDENT RECORD
CHANGE ..... ALTER STUDENT RECORD INFORMATION
DELETE ..... DELETE AN EXISTING STUDENT RECORD
EXAMINE ..... EXAMINE CURRENT STUDENT INFORMATION
STATUS ..... ALTER TEST-TAKING, RECORD-WRITE, OR COURSE STATUS

COMMANDS FOR TEST ITEM POOL:
-----
ANSWERS ..... DISPLAY ALL ANSWERS FOR A TEST
PARG ..... CHANGE MASTERY, RETAKE, OR ITEM ASSIGNMENT
QADD ..... ADD NEW ITEMS TO THE TEST ITEM POOL
QCHANGE ..... ALTER ITEM TEXT, ANSWER, OBJECTIVE, PAGE, TOPIC, ITEM
QEXAMINE ..... DISPLAY ITEMS PRESENTED ON A TEST
QSTATS ..... PRESENT TEST ITEM ANALYSIS

EDIT?: examine
STUDENT ID-NUMBER?: 000000000

+ RECORD ACCESSED FOR STUDENT 000000000: VERMILION JOHN THOMAS

EXAMINE?: INFO

CURRENT STUDENT INFORMATION
-----
YOURGLOOM JOHN THOMAS 330 PLANNING, UNIV. 00000000
STATUS: TESTS-OK WRITE-OK COURSE-OK
LAST INITIAL UNIT 30 WAS TAKEN ON 1972

EXAMINE?: RETAKES

RETAKE RECORD STUDENT 000000000
UNIT 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
RETAKE 0 1 0 1 1 0 1 1 1 1 1 1 1 1 1
UNIT 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
RETAKE 1 0 0 1 1 1 1 1 1 1 1 1 1 1 1

EXAMINE?:

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Figure 4. Examples of the displays produced by the instructor's Editor module in response to the "Help" and "Examine" commands as well as the "Info" and "Retakes" subcommands of the Examine mode.

utility programs, and the equivalent of at least two cylinders of an IBM 3330 or 3350 disk. Utilization of core is not excessive under TSO, and PROCTOR averages 7-15 sec of CPU time per terminal on the IBM 370/168 computer in a 2-h session.

Security

Since PROCTOR is used to administer tests that count toward a student's grade, we have taken special precautions to protect the privacy and security of programs and master files. For example, the initiation procedures for PROCTOR at any station are kept highly confidential by insuring that Tester is ongoing when students arrive. Also, special assembly language routines serve both to dynamically allocate (and deallocate) the master files during a daily session and to disable program termination by means of an "attention interrupt" or break signal. These measures contribute to the confidentiality of master disk file locations and names. Also, to discourage unauthorized use of PROCTOR further, all files and programs are password protected. Finally, to prevent access to the master files other than through Tester or Editor, a "scrambler" routine is used to render the information stored in the ISAM data sets unintelligible except with the use of a "decoder" program that reformats the data at the time of PROCTOR execution.

Course Management

The PROCTOR system has been used at Notre Dame in conjunction with a PSI-format course in introductory psychology. The materials for this course were derived from one of the better, currently available commercial packages, including a text titled *Psychology* by Lefton (1979), a study guide with learning objectives for this book by Valvatne (1979), and a class-tested multiple-choice question item pool in a file on magnetic tape supplied by Lefton (Allyn & Bacon, Inc.) Since the latter contained all of the information necessary to construct multiple tests and to provide an "objective mastery diagnosis" for each unit, this file was converted directly into the ISAM form that provided the basis of PROCTOR's internal test item pool. However, any computer-compatible test item file can be utilized, provided that it contains the necessary information and a routine is available for conversion to the required ISAM format.

In this course, eight-item unit tests are employed, with no mastery criterion. Only one retake of the initial test for any unit is allowed, and different questions are used on each alternate form.

Use of the PROCTOR system at the University of Notre Dame greatly aided in the resolution of the personnel and quality-control problems noted above. For example, in a class with an enrollment of 80, only 2 student proctors, rather than the usual 8-10, were required for efficient operation. This savings occurred with no apparent loss of benefit to the student in terms of either attitude toward the course or performance.

Systematic research is planned to more fully document the impact of PROCTOR in this connection.

We have experimented with the use of the PSI for more than 5 years. During that time, we have been mindful of a persistent problem with this method: namely, student procrastination (cf. Johnson & Ruskin, 1977). In an effort to circumvent this difficulty, we instituted an incentive system using "bonus points" as rewards for consistent course progress. These points are added to the student's cumulative total to reduce, in effect, the number of points needed for any desired grade. The PROCTOR system, a relatively recent addition to our PSI method, incorporates this incentive arrangement and automatically awards bonus points on each of a series of predetermined dates to all students who have advanced to a specified unit by that time. In general, this procedure has been relatively effective in keeping students "on track," and we did not expect the PROCTOR system to affect this outcome. If anything, however, there has been less procrastination and more early completions of the course under the computerized arrangement than before, perhaps because of some motivational factor intrinsic to interactions with a computer. Of course, further systematic observations will be required to verify this ancillary benefit of PROCTOR and to determine the reasons for its possible occurrence.

On the other hand, our computer system did create an unusual scheduling problem. With PROCTOR, only as many students can take unit tests simultaneously as there are interactive terminals. Also, these stations should be confined to a relatively private area such as a single room, so that monitoring is convenient and questions or problems can be attended to quickly. These factors result in the need for additional space, preferably near, where students can (and often have to) wait for a terminal to become available.

To minimize the potential difficulties in this situation, we station a student proctor in each area to answer questions and monitor activities. In the waiting/study room, the proctor maintains a waiting list on a first come, first served basis. Students are routed to an open station in the terminal area in accord with this list. Each terminal is numbered, and the student is given an index card designating the station to which he or she is assigned. Upon completion of their interaction with PROCTOR, students are instructed to return the index cards to the waiting area for reassignment. Students also are encouraged to take no more than two tests at a sitting, but they are able to recycle through the waiting area for additional sittings if they desire. With this arrangement, 10 terminals have been sufficient to accommodate 80 students in a 2-h session. Three sessions a week of this kind are scheduled.

CONCLUSIONS AND DIRECTIONS

In summary, PROCTOR has served as a useful adjunct to our PSI-format courses by assuming many of

the routine duties normally performed by student proctors. Thereby, less emphasis is likely to be placed on the proctor's role as administrator and evaluator, and more attention can be given to the function of learning facilitator. In this way, an even greater than normal degree of personalization may be possible in a PSI course.

It should be noted, however, that PROCTOR currently is a system designed primarily for evaluation and monitoring of student performance. Enhancements are therefore planned in the direction of providing PROCTOR with increased instructional capability. Features such as drill and practice tests, supplementary instructor's notes, and on-line question-and-answer facilities come to mind in this connection.

As a result of the benefits noted above, and because of its increased efficiency, PROCTOR seems ideally suited to research on behavioral instruction. That is, with this system, it should be relatively easier to maintain or to initiate PSI course offerings for various subjects. Thereby, the research vehicle may be more readily available to continue the ongoing component analysis of the effectiveness of the PSI (cf. Kulik et al., 1978), not to mention of PROCTOR itself.

Finally, in the interest of maximizing the applicability of PROCTOR to a variety of educational contexts, it is desirable to emancipate this system from dependency upon large, centralized, main-frame timesharing environments. Clearly, the rapidly developing micro-processor technology offers a relatively attractive means to this end (Bowles, 1978). A micro-PROCTOR system, among other things, would be self-contained, highly

portable, and undoubtedly cost effective. For these reasons, we are currently developing a general-purpose version of PROCTOR in BASIC for the Apple II micro-processor.

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