DESIGNING MACHINES TO WORK WITH TEACHERS

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After seven years of developing teaching machines with funds from his own pocket, Sidney L. Pressey made the following statement in 1932:

> The writer has found from bitter experience that one person alone can accomplish very little, and he is regretfully dropping further work on these problems. But he hopes that enough may have been done to stimulate other workers, that this fascinating field may be developed. (1)

It is ironic that Pressey was a professor of psychology at Ohio State University and yet was forced to give up his research on teaching machines due to a lack of funds, as Ohio State is now IBM's leading Coursewriter customer and one of the most significant contributors of computer-assisted instruction (CAI) courseware in this country. Dr. Pressey is no longer "alone" (he is still developing self-correcting teaching materials at the University of Arizona), but his early work demonstrated exceptional genius in designing machines to aid teachers and demands the attention of all educators involved in the development of automated teaching media.

PRESSEY'S MACHINES TO AID TEACHERS

In 1912, Edward L. Thorndike set the theoretical stage for Pressey's work by writing:

> If, by a miracle of mechanical ingenuity, a book could be so arranged so that only to him who had done what was directed on page one would page two become visible, and so on, much that now requires personal instruction could be accomplished by print. (2) . . . The best teacher uses books and appliances as well as his own insight, sympathy, and magnetism. (3)

Pressey realized Thorndike's miracle in 1926 (4). At that time, Pressey exhibited a machine which presented multiple choice questions one at a time from a cylindrical drum and provided four keys for student response. In test mode, no indication as to correctness of response was supplied. In drill mode, all keys except the correct one were locked. The device <u>automatically recorded all responses</u> for later teacher evaluation. Pressey noted in a much later paper (5) that an attachable mechanism existed which would give the user a candy lozenge when a specific number of correct responses had been made. These features are especially interesting, as they predate Skinner's writings in machine reinforcement by almost thirty years.

In 1927, Pressey refined the drill mode of his original machine so that it would omit presentations of questions which had been correctly answered twice in succession (6). Skinner adopted a similar contingency in 1958 (7).

Before abandoning his work in 1932, Pressey published another paper entitled "A Third and Fourth Contribution Toward the Coming 'Industrial Revolution' in Education" (8). The "third" contribution was a generalized answer unit consisting simply of a 3" by 5" card with numbered answer boxes. By placing a transparent window over the student's card, the teacher could easily distinguish correct responses.

Pressey's "fourth" contribution was an elaborate machine for grading tests. The student marked his response by punching through a circle on a cardboard answer sheet. The card was processed by a machine which contained spring loaded pins in the correct answer positions. The device was able to sense the pins which protruded through the correctly punched holes, print the number of correct responses on the answer sheet, and <u>keep a running tabulation</u> of the number of correct responses to each item at a rate of one answer sheet per second! The tabulated results could be read directly from the back of the machine to provide instant item analysis for class discussion. If produced today, this device might seriously compete for the smaller classroom market!

TEACHERS AND TECHNOLOGY

Skinner's teaching machines were the products of a much more highly developed theoretical and experimental framework than Pressey's, but the main philosophical difference between the two researchers is that Pressey was not trying to replace teachers. Pressey's philosophy (9) reflects that of Thorndike (3): Teachers have more to offer than they have time to present, and thus they should use technology wherever possible to alleviate the more mundane testing, drill, and administrative responsibilities that tend to smother creative, higher order instruction. Thelan argued in 1963 that the "program as teacher" concept must be eliminated if programmed instruction is to gain widespread acceptance in our schools (10). In discussing his teaching machines in 1927, Pressey wrote:

> Such devices should not operate to mechanize education in any unfortunate way (though educational sentimentalists may bring this charge). Rather they should free the teacher from much of the present-day drudgery of paper-grading, drill, and information-fixing -- free her for real teaching of the inspirational. (11)

The common misunderstanding of this intent of teaching machines constitutes one of the major roadblocks to the widespread adoption of tutorial computer-assisted instruction. Most teachers fail to realize the wide range of possibilities which technology can offer as a teacher aid without necessitating a complete destruction of the classroom. The following scheme depicts the role which technology can play in aiding teachers.

In Figure one, the student is represented as being surrounded by knowledge. Whether one thinks of knowledge as a set of facts or experiences, all educators must believe in the existence of knowledge and its value to the student who acquires it. Most of us would agree that knowledge is ubiquitous, and that the variety of paths which the student may follow to increase his knowledge is practically infinite.

Figure two depicts the student as a seeker of knowledge in an open environment. Applying the philosophies of A.S. Neill, all paths lead to knowledge of at least some value, experiential if not factual. The problem with this approach is that students may not be able to find specific knowledge that they seek totally on their own. Robin Mager has claimed, "If you give each learner a copy of your objectives, you may not have to do much else" (12). Perhaps this is true, but the winding paths in this figure represent the difficulties which students can experience before they achieve a specific objective. Teachers assume that their actions can reduce the amount of effort (or at least anxiety) required to gain knowledge.

Figure three illustrates the teacher's role in facilitating the student's search for knowledge. The path on the left is an obstructed, difficult one, while the one on the right is hazardous and unsafe. One shortcoming of this approach is that the student's learning may be limited by the teacher's knowledge, a situation which is compounded when class size increases.

In the basic process of teacher-centered instruction, all students follow the same path as diagrammed in Figure four. The talented teacher may well be able to individualize his instruction without teaching aids, but only within the basic path. Other paths may be more beneficial to certain students. For example, the path at the left leads to more knowldege than the teacher-centered path, while the one at the right may be perfectly suited for a specific student even though it leads to a very narrow area of knowledge.

Today's teachers are not unaware of the currently available aids for individualizing and mediating instruction. Figure five illustrates some of these possibilities and the role which the teacher usually plays when they are utilized. In order to assure effectiveness, the teacher must directly monitor instruction by all media and thus can be spread quite thin in attempting to be everywhere at once.

Figure six once again depicts the open interactions that most of us would like students to experience with our subject matter. In this scheme, the teacher and technology are _facilitators_ in the student's quest for knowledge, and each achieves its highest level of effectiveness when it _complements_ rather than replaces the functions of the other. Technology needs teachers as much as teachers need technology. The paths in this diagram reflect those in Figure two, but they are more direct, more efficient, and more clearly defined.

LINKING TEACHERS AND STUDENTS THROUGH COMPUTERS

The computer is the most sophisticated tool that technology has to offer education, but its use in the classroom is an extremely expensive proposition. Pressey's ingenious inventions demonstrate the wide range of instructional innovation which can be accomplished with much simpler machines. The Scramble-Texts of Norman Crowder (13) are probably capable of performing all the contingent branching possibilities which most of today's CAI programs purport to offer. Pressey himself warned against the bandwagon use of computers when simpler, less expensive, and more convenient materials will do the job equally well (14).

What, then, are the capabilities of the computer which justify its use in instruction? One answer to this question is data analysis. While Pressey's 1927 teaching machine and 1932 test grader were able to tabulate responses, only the computer can do complex item analysis in a short amount of time. Instruction administered by computer can be extensively analyzed to identify which aspects are effective and which are not. The progress of each student can be individually recorded, analyzed, and displayed in graphic form to allow the teacher to monitor and guide learning without being physically present while the instruction is taking place.

Automated instruction never works for every student, of course, but one of the major problems this presents is that the teacher is usually at a loss to identify which aspect of the instruction has been missed when the program fails. The teacher is thus left with no choice but to reteach from the beginning, destroying the structure and efficiency for which the system was designed. Only when the teacher gets asked the same question by many students does he get an idea of the program's specific shortcomings. By recording student responses, the computer is able to analyze difficulties and prompt both the student and teacher as to what alternative actions might be taken.

During July of 1973, the author was fortunate to gain access to the PLATO system at the University of Illinois. This dedicated CAI system utilizes an 8 1/2 inch square plasma panel as its computer terminal with high speed display capabilities. The product of those four weeks was a prototype computer-managed instruction (CMI) program for providing teachers with on-line access to data on CAI usage. The program was designed for teachers who are naive in the workings of computers, and who will be <u>users</u> rather than authors of CAI materials.

Imagine that a class has been using CAI modules for adjunct instruction during the first few weeks of a primarily lecture-oriented course. The instructor may then wish to obtain information as to which subjects have been giving his students trouble and deserve special attention in his lectures. He may also be concerned with identifying those students who need particular remediation in specific subject matter areas. This information may be derived from data stored on the usage of the CAI materials which complement his course.

When the instructor logs on to the computer, the display shown in Figure seven is presented. (The program was entitled "Together" because it was intended to provide a missing link in aiding teachers and technology to work together via the computer medium.) The program options are presented for the teacher to choose, no memorization of display commands or mnemonic codes is necessary. Options are invoked by the press of a single key, and a gentle error message is displayed if one of the available keys is not chosen.

To gain a quick overview of all student work, the teacher may press the letter "1" and generate the display shown in Figure eight. All displays are individually generated from disk files, and thus no display can be destroyed by the teacher. That is, if the user presses the wrong key, he may simply erase the current display by selecting another option and still return at another time. From the sample data shown here, a teacher might decide that Thomas Baker is in need of special assistance with the subject matter in module six and arrange to meet with him for a private discussion. The options are once again printed so that the teacher has nothing to memorize.

If the teacher wishes to study data on individual lesson modules, option "m" will cause the course log to be displayed as shown in Figure nine. In this mode, characteristics of lessons on specific subject matter topics may be analyzed and information inferred about their effectiveness. The data displayed here indicates that module five is probably in bad need of revision. Note the small difference in the options which are now available as compared to those in Figure eight. In truth, all options are active at all times, but only those which are most likely to be selected are displayed to save space on the screen. This feature is equally desirable on hard copy terminals to save time.

The instructor may generate statistics on the entire course by selecting option "s". Figure ten shows three of the many possible computations which could be performed. The important point is that all data is displayed in simple form such as hours, minutes, and seconds rather than "computerese".

By pressing the letter "o", the original six options are redisplayed. The teacher may then select to view the student roster shown in Figure eleven. This display lists the students in alphabetical order and shows their reference numbers and the date of their last entries. If the instructor had last checked the CMI data on 7/18, he can immediately distinguish that no new data will have been recorded on those students whose last entry precedes that date. From this page, an individual student record may be selected by number and displays viewed such as that shown in Figure twelve. As in the statistics display, many more computations and contingency messages could be presented on this page. The instructor might gain insight on students' perceptions of subject matter organization by studying the sequence of modules which students follow.

Photographs of other displays can not be included due to space limitations, but perhaps descriptions will make their functions clear. The administrative options in the prototype program allowed the user to manipulate the course log for simulating CAI usage and demonstrating other displays. In a real version of the program, the teacher would be able to add students to the roster, leave messages for students, change the module into which a student will be channeled when he signs on, and establish differential success criteria for different students, to name a few possibilities.

Module titles and their criteria for successful completion were displayed by another option. This feature was designed to remind the teacher about the meanings of the decimal representations of module numbers.

The description of the "Together" program logic would have no analogous display in a working version of this program. This sequence described the coding format which was used to store the student data and from which the displays were generated. In this case, all data was stored within a single block of 322 60-bit words in a random access file, allocating five words for each log entry. Extensive use was made of integer and fractional part functions to achieve "pseudo" bit string manipulation to conserve storage space.

The PLATO system does offer full bit string manipulation, and a much more sophisticated use of the storage area could have been accomplished if bit commands had been utilized. The prototype program successfully demonstrates, however, that even without this powerful capability a large amount of data manipulation can be performed.

DIRECTIONS FOR FUTURE DEVELOPMENT

Considerable refinement of the prototype program is warranted. Data can be displayed graphically rather than in tabular form, additional computational facilities can be added, and additional display formats can be programmed. Developments at both the PLATO project and the TICCIT project (at Brigham Young Universtity) will allow highly sophisticated on-line data display of CAI usage. The author is currently developing a series of BASIC language programs to provide some of these capabilities on the typewriter-based and sequential access file systems which are in use with most university and secondary school CAI systems.

The important aspects of this work are three: First, computer uses should be tailored to the special capabilities of the medium rather than merely computerizing techniques which are just as effective on less expensive media. Second, CMI programs for teachers should require only the absolute minimum user knowledge of computers to prevent the operation of the machine from interfering with the user's access to actual data. Finally, systems should be designed with the intent of <u>complementing</u> the teacher's role as a valuable educational resource rather than trying to replace those functions which the teacher so capably performs.

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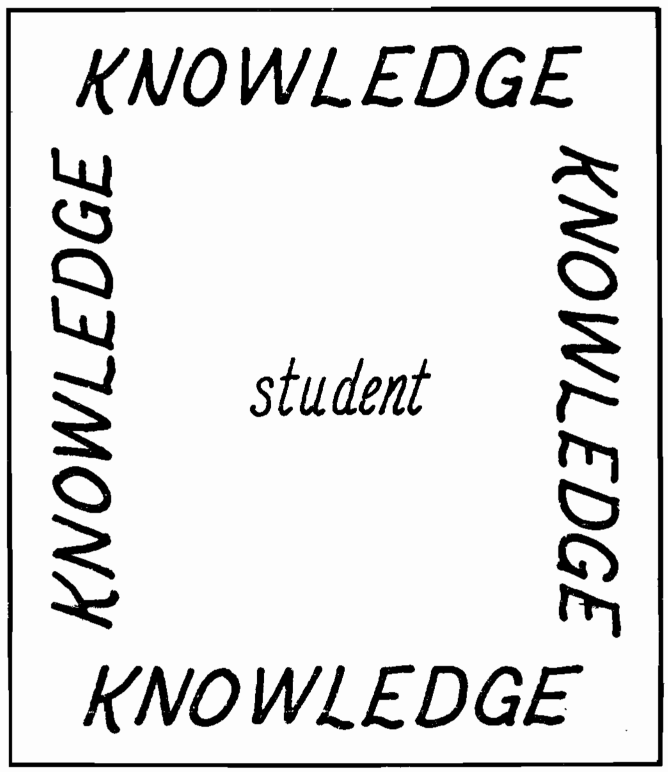

Figure 1.

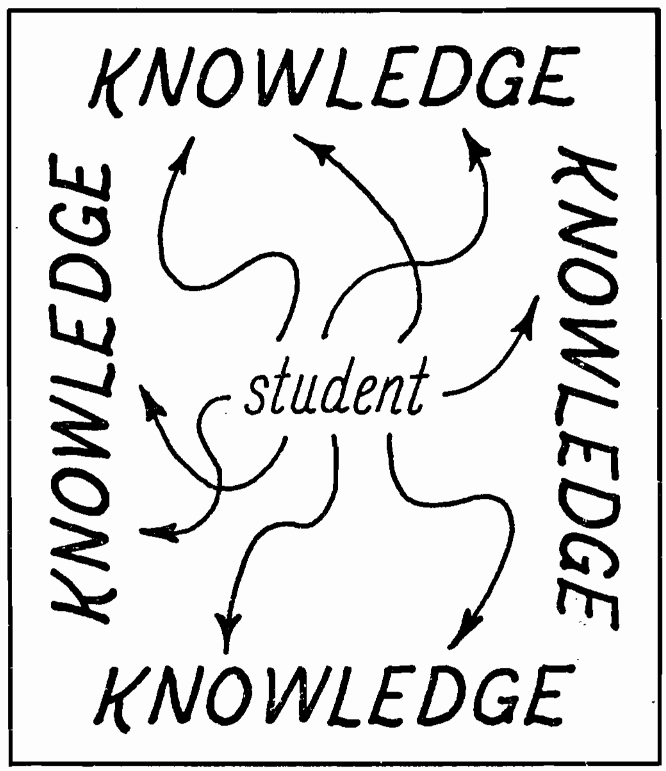

Figure 2.

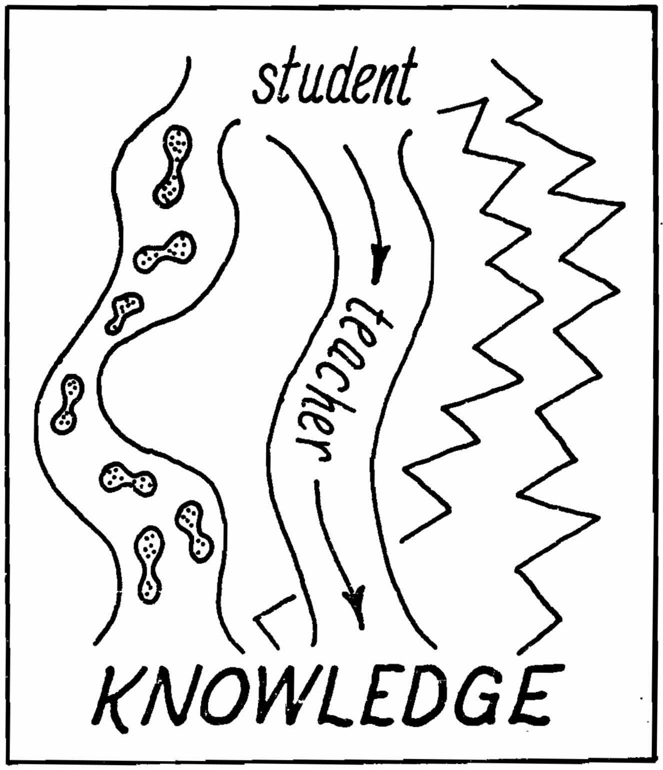

Figure 3.

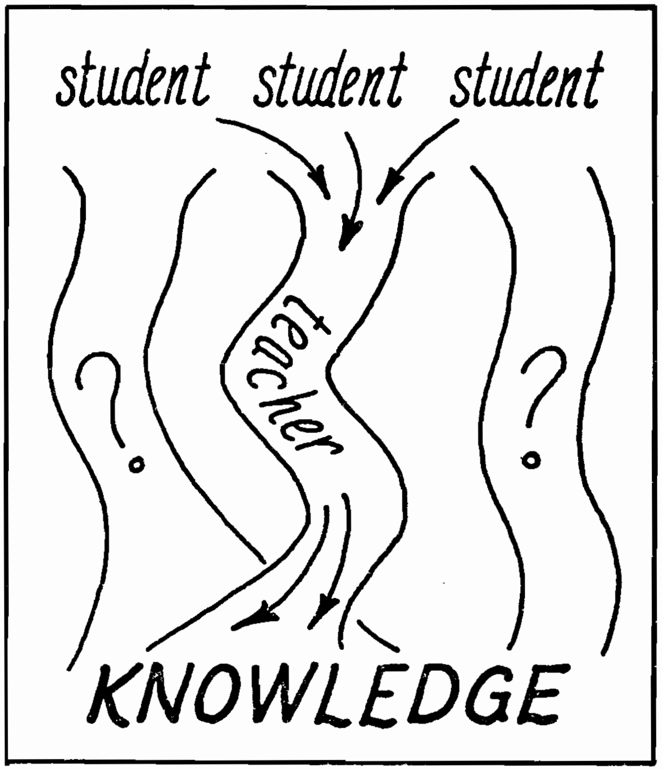

Figure 4.

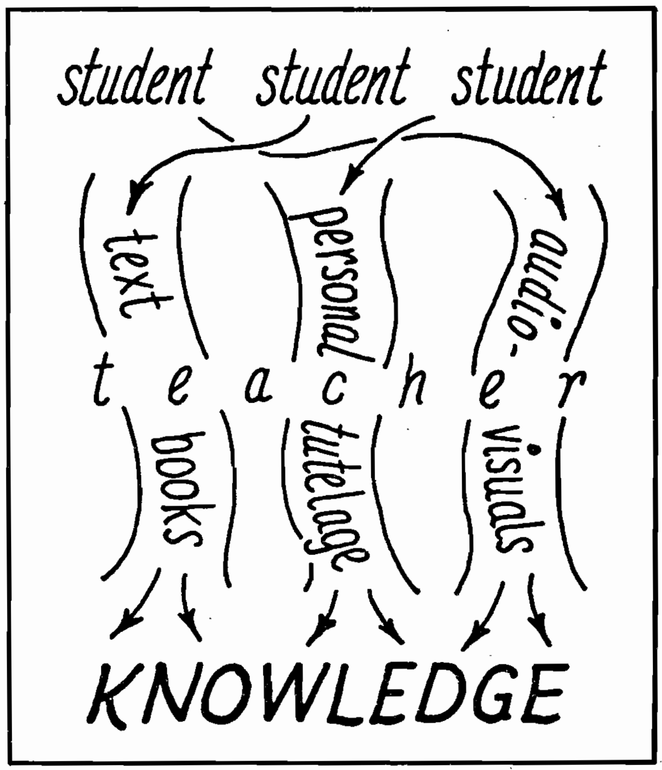
student student student
text
books
personal
tutelage
audio-
visuals
t e a c h e r
KNOWLEDGE

Figure 5.

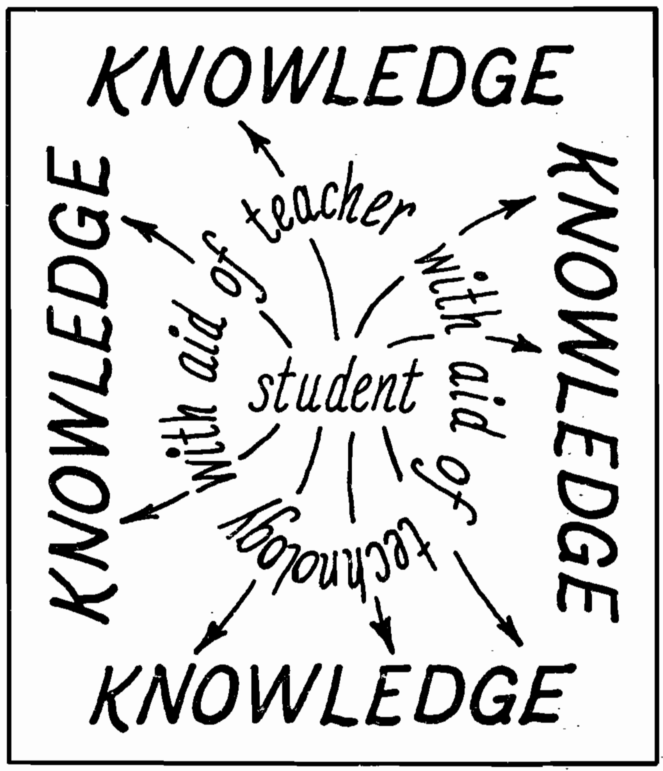
KNOWLEDGE
KNOWLEDGE
KNOWLEDGE
KNOWLEDGE
with aid of teacher
with aid of
with aid of technology
student

Figure 6.


together
... an instructional managing program for both teachers and students
jesse heines
uicc
summer, 1973
Please type the letter of the display you wish to view:
(l) Course log
(i) Records of individual students
(a) Administrative options
(r) Class roster
(m) Module titles and criteria
(t) Description of "Together" program logic
Option ≫ k no Please press NEXT, then type a letter.

Figure 7.

* * * COURSE LOG in ALPHABETICAL order * * *

Total number of entries: 40 Page 1 of 3

#	date	name	module number	time m s	completed satisfactorily	
1	7/10	Abrams, Michael	5.02	20.05		No
2	7/13	Abrams, Michael	5.01	2.19	Yes	
3	7/20	Abrams, Michael	5.05	15.54	Yes	
4	7/24	Baker, Thomas	6.02	19.34		No
5	7/24	Baker, Thomas	6.01	17.50		No
6	7/18	Coates, Joan	9.03	19.16		No
7	7/16	Folsom, Clyde	6.04	11.48	Yes	
8	7/23	Folsom, Clyde	2.02	9.27	Yes	
9	7/10	Folsom, Clyde	8.02	13.07	Yes	
10	7/19	Folsom, Clyde	3.02	10.08		No
11	7/17	Gerber, Vivien	8.03	9.10		No
12	7/13	Gerber, Vivien	1.01	10.08		No
13	7/22	Gerber, Vivien	9.05	3.24	Yes	
14	7/10	Hansom, Robert	5.05	12.40	Yes	
15	7/19	Hansom, Robert	6.05	14.10	Yes	

Options available (type one of the following letters):

(f) Roll this display forward one page.
(d) Display this log in order by date.
(m) Display this log in order by module number.
(s) Compute statistics from this log.
(o) Show more options.

Option >

Figure 8.

* * * COURSE LOG in order by LESSON NUMBER * * *

Total number of entries: 40 Page 1 of 3

•	date	name	module number	time m.s	completed satisfactorily	
1	7/13	Gerber, Vivien	1.01	10.08		No
2	7/10	McKay, Angie	1.02	10.35	Yes	
3	7/17	Uher, Johann	1.04	11.58	Yes	
4	7/19	Lambert, Alex	1.05	10.19	Yes	
5	7/23	Folsom, Clyde	2.02	9.27	Yes	
6	7/15	Oppenheim, Stuart	2.03	10.43	Yes	
7	7/18	Uher, Johann	3.01	19.49	Yes	
8	7/14	Rosenthal, Diane	3.02	19.06	Yes	
9	7/19	Folsom, Clyde	3.02	10.08		No
10	7/12	Von Lee, John	3.04	5.04	Yes	
11	7/13	Abrams, Michael	5.01	2.19	Yes	
12	7/16	Scott, Catherine	5.02	16.09		No
13	7/10	Abrams, Michael	5.02	20.05		No
14	7/11	Von Lee, John	5.04	1.07		No
15	7/17	Hansom, Robert	5.04	3.41		No

Options available (type one of the following letters):

(f) Roll this display forward one page.
(d) Display this log in order by date.
(a) Display this log in alphabetical order.
(s) Compute statistics from this log.
(o) Show more options.

Option ❯

Figure 9.


* * * STATISTICS on COURSE LOG * * *
Total number of entries 40
Total user time (hr:min sec) 7:57 23
Average time used per entry (min sec) 11 56
Options available (type one of the following letters):
(d) Display this log in order by date
(a) Display this log in alphabetical order
(m) Display this log in order by module number
(o) Show more options
Option >

Figure 10.

* * * STUDENT ROSTER * * *

Number of students: 19

ref #	name	last entry	ref #	name	last entry
1	Blumenthal, D.	07/18	16	Thomm, Hans	07/14
2	Christiansen, J.		17	Uher, Johann	07/22
3	Davidow, Joe	07/20	18	Von Lee, John	
4	Droege, Sally	07/21	19	Williams, Jim	
5	Folsom, Clyde	07/21			
6	Go, Adolfo	07/21			
7	Hansom, Robert	07/16			
8	Johnson, Karen	07/14			
9	Lambert, Alex	07/12			
10	McKay, Angie	07/21			
11	Nelson, Ted	08/01			
12	Quincy, John				
13	Remenchik, Karen	07/16			
14	Rowell, Peter				
15	Scott, Catherine	07/21			

Options available (type one of the following letters):

(i) Display an individual student record.
(l) Branch to the course log.
(a) Branch to the administrative options.
(o) Return to the main options page.

Option >

Figure 11.

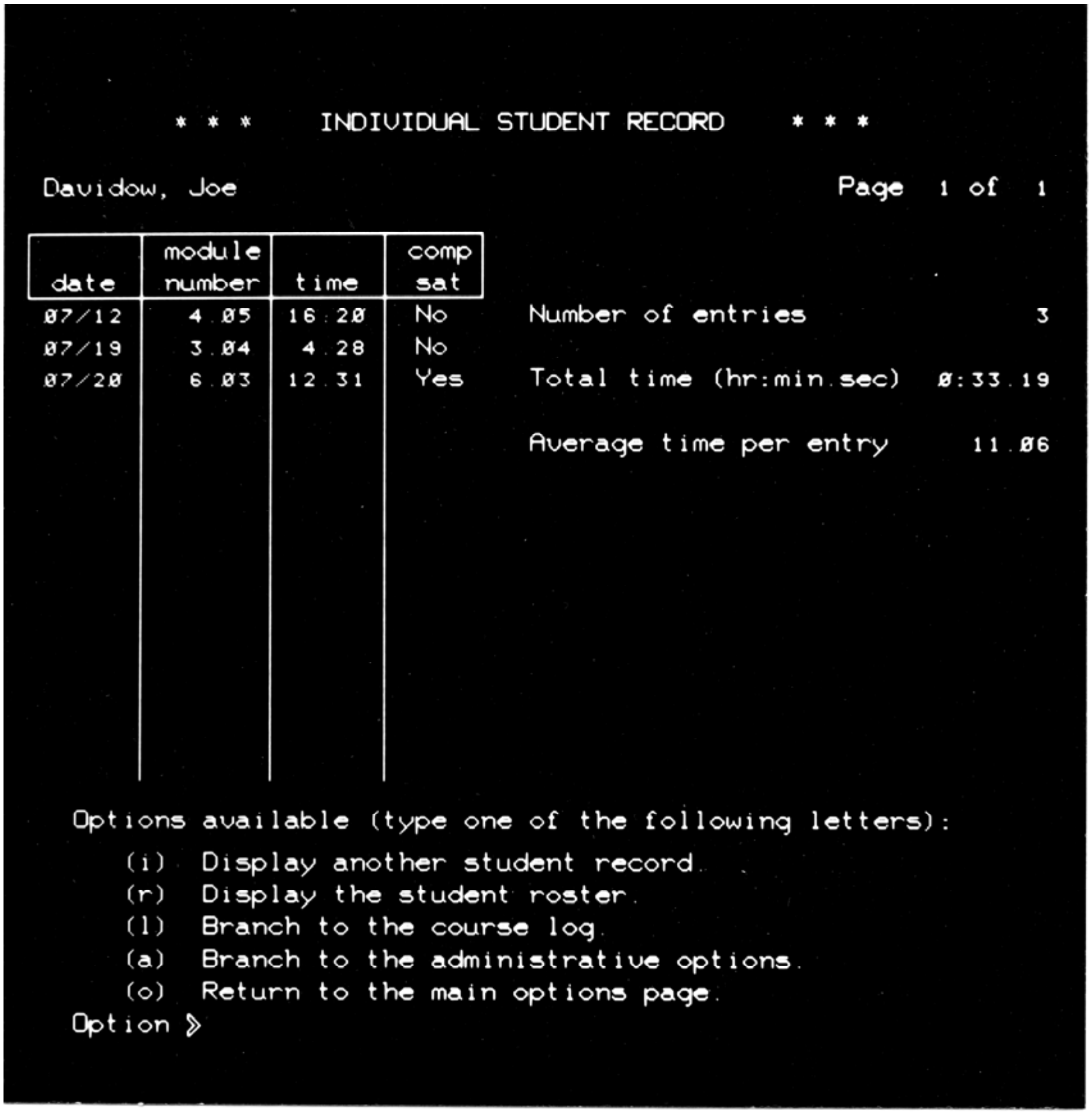
* * * INDIVIDUAL STUDENT RECORD * * *
Davidow, Joe
Page 1 of 1
date
module number
time
comp sat
07/12 4.05 16.20 No
07/19 3.04 4.28 No
07/20 6.03 12.31 Yes
Number of entries 3
Total time (hr:min.sec) 0:33.19
Average time per entry 11.06
Options available (type one of the following letters):
(i) Display another student record.
(r) Display the student roster.
(l) Branch to the course log.
(a) Branch to the administrative options.
(o) Return to the main options page.
Option »

Figure 12.

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February 1, 1974

Jesse Heines
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Dear Mr. Heines:

Your paper "Designing Machines to Work with Teachers" has been reviewed by the Board of Editors. I regret to advise you that the decision is not to publish the paper in its present form.

The paper is well written and timely. However it does seem to be on two different subjects, Pressey's contributions and your own work with CAI. Both are interesting. For the purposes of this Journal the interest could be heightened if direct application to the sciences were emphasized.

Incidentally (pp. 5, 16) is it Robin or Robert Mager?

I do wish to thank you for the privilege of reading your paper. It was very interesting and I do regret that, in its present form, it does not fit into the Journal. You may wish to consider two separate short papers on these subjects.

Sincerely,

Leo Schubert

LS/vf

cc: Rosemary Amidei