Computer-Assisted Instruction in Logic: PLATO IV

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PLATO IV, a program through which computer assistance in various fields is realized, uses a Control Data Corporation Cyber 27 computer housed on the Urbana campus of the University of Illinois.[1] The system interacts with nearly one thousand terminals across the country. Terminals for PLATO IV use recent plasma technology, making available to the programmer a number of special features, such as graphics, microfiche, animation, and touch panel. Multiterminal interaction is also possible. Lesson material is displayed on a screen twenty-two centimeters square, capable of showing a grid 512 by 512 characters. Students respond to the material on a special keyset that closely resembles a typewriter keyboard. PLATO IV programming languages are COMPASS (for systems level) and TUTOR (for user level). TUTOR has been specifically designed to facilitate the writing of interactive, instructional programs on a graphic computer system.[2]

All student programs are "re-entrant"; that is, they allow the student to sign off and later return to the same point in the program. The PLATO IV system presently includes approximately seven thousand one-hour lessons in 120 subject areas. System programs occupy approximately 150,000 words.

The program in introductory logic which I have developed contains two general sub-programs, one on the Aristotelian syllogistic logic and one on elementary first-order predicate calculus. Each sub-program involves several specific lessons. Both sub-programs are self-contained and are structured around the presentation of successively new material. Each lesson constitutes a stock of knowledge requisite for working a series of review exercises and subject-mastery quizzes. Students choose the program, the specific part of it on which they would like to work, and the amount of time to be spent on any one component of the program. The student may choose to continue with the program as developed to a particular point or repeat a segment of the program for purposes of review. (Such a review may be made from any point in the program back to any earlier point in the program but cannot be made from one program to a different program.) Other alternatives allow students to skip ahead to the review exercises and quizzes or simply terminate the program.

A PLATO IV Logic Program

The considerable flexibility of the PLATO IV program may be indicated by a brief discussion of some of the operations provided by the PLATO IV terminal. A student interacting with PLATO IV faces the terminal screen across a small keyset. After typing appropriate code-words, a student is able to select any one of a number of specific lessons. These range from basic operations performed on the Aristotelian square of opposition to more sophisticated operations and derivations performed in the predicate calculus. A student might select, for example, the initial program on the square of opposition. Assuming that the program is to be worked from the beginning, PLATO IV initially presents the student with a series of definitions and examples of the relationships among, and inferences possible from, the propositions on the square. This presentation is followed by a short quiz. The student is then presented with a square of opposition and is invited to type in any proposition of his choosing in standard form, with an indication of the truth-value thereof. Once this operation has been completed, PLATO IV will display the three corresponding propositions together with their appropriate truth-values. This lesson may be repeated indefinitely.

In the second lesson, the immediate inferences from the square of opposition are supplemented by conversion, obversion, and contraposition. Once again, initial definitions and examples are presented and followed by a quiz. The students are invited to type a proposition of their choice with what they believe to be its converse (or obverse, or contrapositive) and the two respective truth-values. When the inference is performed incorrectly, or when the truth-value of the resulting proposition is not ascertained, PLATO IV informs the student and requests that another attempt be made. If the student is incorrect a second time, PLATO IV provides the correct answer for the proposition initially selected and encourages the student to try again with a different proposition. This process may be repeated as often as the student chooses to run the program.

The lessons which have proven to be the most popular are those which deal with determinations of validity for categorical syllogisms. These lessons have been developed in two phases. In the first phase, following the presentation of new material and review, the student types any two propositions. An invitation is then made to reduce them to standard categorical form. If the reduction is correct, PLATO IV proceeds with the program. If the reduction is incorrect, the error is indicated and the student is invited to try again. Should the student not provide a correct answer on the second attempt, PLATO IV indicates an acceptable translation and invites the student to continue with the program. Once an acceptable translation has been found, the computer program constructs a Venn diagram for the propositions and requests the student to provide a proper conclusion. If the conclusion does not correctly follow, PLATO IV diagrams it, together with the correct conclusion, and invites the

student to try another syllogism. This phase of the program is indefinitely repeatable.

The second phase of the lesson allows the student to begin with a complete argument for which a translation to standard form is requested, proposition by proposition. The student also indicates the major premise, the minor premise, the conclusion, and so on. If any of these operations are performed incorrectly, a second attempt is requested. Should the second attempt be incorrect, PLATO IV supplies the correct operation, together with the incorrect student effort, and indicates the point at which the error was committed.

A request is then made for a determination of the mood and figure of the syllogism. Once obtained, PLATO IV requests a Venn diagram to test for validity. The diagram outline is provided by PLATO IV, but the student is responsible for the appropriate entries. If the student is not correct by the second answer attempted, the error is indicated. The complete program also projects a correct diagram together with the incorrect one. Once validity or invalidity has been correctly established, the student is requested to indicate which fallacies, if any, have been committed by the argument. Correct answers are provided, as necessary, and the program is indefinitely repeatable. Similar programs are available in the first-order predicate calculus.

Criteria vs. Norms

If one indication of the student's mastery of the conceptual apparatus constituting the core of a course in basic logic is facility in the manipulation of appropriate symbols, then the development of such facility ought to rank high among the goals of the introductory course. Diligent attention to working exercises in logic has long been recognized as an excellent way for the student to develop the requisite facility in symbol manipulation. It has been recognized also that the traditional lecture-recitation format provides the student with little motivation to this end. In an attempt to remedy this weakness, many teachers of logic have adopted a policy of regularly scheduled subject-mastery quizzes. If frequently offered and relatively short, such quizzes may do more than simply measure student progress and readiness to advance to new material; they may serve also as effective learning devices in their own right.

But to be as effective as they might such quizzes should be criterion-referenced rather than norm-referenced. The basic characteristic of norm-referenced measures is that scores are usually spread out widely from high to low in order that an individual's *relative position* within some defined group can be determined as reliably as possible. Norm-referenced measures are used to identify an individual's level of performance in terms of this relative position within a group (usually the class). Educational decisions based upon *differences* in performance (for example, classification, selection, promotion) can be made with confidence. A criterion-referenced measure is appropriate when interpretation of an individual's performance is to be described in behavioral or performance terms *without* reference to the kinds of perform-

ance exhibited by other members of the group. The basic characteristic of criterion-referenced measures is the setting of a specific standard which all students are expected to achieve. The specific criterion behavior to be accepted as the *minimum* level of satisfactory performance usually is predetermined and stated as part of each instructional objective or set for a class of objectives (for example, demonstrate mastery performance at the eighty percent level).

Even under the best of circumstances, there are a number of shortcomings inherent in the use of criterion-referenced instruments:

1. Individual students must be allowed as much time as is necessary to achieve the appropriate level of mastery. This involves obvious practical difficulties. For example, this might require preparing thirty different quizzes per week for a class of thirty students. Even assuming a relatively uniform rate of progress for the members of the class, the time spent in preparation and evaluation of such quizzes is not cost-effective.

2. As in any class, a variety of learning needs and abilities must be served. It is unlikely that even an extensive series of criterion-referenced quizzes or small independent learning modules developed for a given unit of material will be sufficiently diverse to accommodate even a small percentage of variations in student abilities.

3. There are likely to be a number of students in any class who, for whatever reason, cannot maintain pace with advanced members of that class as progress is made from one learning module to another. In spite of the best efforts of the instructor, some students experience such frustration that failure seems inevitable.

4. The use of norm-referenced measures, whether to identify an individual's level of performance in terms of relative position in the class, or to measure degree of achievement beyond the mastery of the minimum essentials in the course, is so frequently encountered by students (as a natural component in other grading situations) that some students expect all exercises to be norm-referenced. For these students, a background of educational competition requires that any type of "score" on an exercise be understood as a grade. This grade often becomes so important that students cannot without counseling benefit from criterion-referenced measures.

Although this list of problems is certainly not exhaustive, it may indicate some of the difficulties inherent in the criterion-referenced approach to the determination of subject-mastery. Particularly in an attempt to overcome some of these weaknesses, I have been experimenting for the past several semesters with the PLATO IV Computer Based Learning Program. As one of a number of recently developed computer-based education programs designed to provide interactive, self-paced instruction to large numbers of students, PLATO IV is an

attractive educational alternative to the traditional lecture-recitation format of class presentation. My use of the PLATO IV program is designed to increase the quality of undergraduate logic education by encouraging mastery-level learning through self-pacing for large numbers of students.

Using PLATO IV

The PLATO IV approach to subject-mastery offers four specific advantages over the more traditional criterion-referenced measures. The first advantage is a motivational one. PLATO IV is still a relatively unique program, and the opportunity to watch a computer actually perform many of the same operations which the student must perform in solving logic problems is of keen interest to may students. Even in the light of rapid advances in computer-based education over the last several years, most students have had little opportunity to work with such a program before their exposure in college courses. As a result, the mere availability of the equipment attracts a number of students to the study of logic.

A second advantage to this approach to the study of logic is that students are completely free to work at their own pace. There is no necessity for the "quick" student to wait for others to catch up, nor for slower students to feel compelled to rush into material for which there is inadequate preparation. Since students can proceed at their own rate, time spent on the lesson, unlike a lecture, automatically adjusts to the needs of the student. In fact, students proceed at greatly different rates when given the opportunity. Each student is free to work with the computer at any time, subject, of course, to the availability of a terminal.

Unfortunately, access to a terminal can be a problem. Large numbers of terminals are required to make an impact on instruction. In order to provide four hours of logic instruction per week for each of one hundred students, for example, each of the three terminals available in Fort Wayne would have to be operated for 134 hours per week on logic alone. At Indiana University-Purdue University at Fort Wayne, the three PLATO IV terminals must serve a population of over 9,300 students. Thus, it is not uncommon to find the terminals in operation from 6:30 a.m. until 2 a.m. This difficulty, we hope, will be alleviated when Control Data Corporation markets PLATO IV on a commercial basis.

A third advantage to the use of PLATO IV is that students are provided with immediate reinforcement of individual efforts. Waiting to receive corrected quizzes or evaluations on unit modules is no problem at all. Various operations in logic allow for both immediate observation and participation. In addition, students are free of pressures to perform for grades. Each student merely indicates the amount of time actually spent on the use of the equipment. Students need not indicate which programs were utilized, the number of times a program was repeated or the number or type of errors committed. If such results are desired, however, it is a simple matter to program PLATO IV to record this data. Indeed, in addition to allowing multiple entry points and

review opportunities, lessons should adjust to each student within each section. For example, help should be provided either when requested by the student (there is a HELP key in the keyset) or when it is clear that he is having difficulty. The number of problems presented can be easily adjusted to the student by, for example, requiring that two consecutive correct answers be provided before continuing with the program. Data from lessons can and should be used to check that the lesson is adjusting properly to the student's needs.

Finally, PLATO IV seems to make for high success ratings. As measured by traditional pre-test/post-test devices, student learning gains are considerably more dramatic with the use of PLATO IV than without. Students turn in more work: Nearly all students complete all instructional lessons, and they nearly all turn in all assigned homework lessons. In the three semesters in which I have been working with this program, seventy-five PLATO IV students and 150 students taught by traditional methods have taken the same two-hour final exams. Mean and median scores for the PLATO IV students were slightly higher, but statistically insignificant. Distribution of scores was similar between the groups.

Evaluations

It must be emphasized that these encouraging results have been obtained during a period when the techniques for using this new medium were still being discovered. Few systematic attempts have yet been made to evaluate the efficacy of the PLATO IV logic program, and the significant learning-gains which seem to have been achieved with the program may be as much a reflection on the instructional competence (or lack thereof) of the faculty as on the value of the program. Nonetheless, the initial results are encouraging. An evaluational program was developed which utilized the PLATO IV equipment itself. This involved a questionnaire designed to elicit information on user reactions to the content of the lessons, style of presentation, pace of programs, time required for subject-mastery, and the degree of difficulty experienced by users. As reported consistently in the questionnaire and in informal comments, students like PLATO IV-based logic instruction. Since the course involved several hours of PLATO IV use per week, it is likely that student approval of logic instruction with PLATO IV is not due simply to its novelty. Students report that they believe that PLATO IV instruction is helpful in learning the material.[3]

My use of PLATO IV has been restricted to introductory logic and only then as an adjunct to a number of other instructional techniques. But PLATO IV need not be so limited. Potential benefits to be obtained from the implementation of a more extensive computer-based project fall into two general categories: 1) improvement in the quality, quantity, and availability of individualized, self-paced instruction,[4] and 2) a significant reduction in the cost of providing such instruction.

A computer-based program in any education system requires and takes individual action. As a result, students frequently spend less time on computer-based materials to reach the same level of performance as would have been attained with more traditional methods of instruction. Computer programs can discern those areas in which a student is particularly in need of additional assistance and take almost instantaneous action, while in a traditionally-oriented classroom, the students inevitably spend time listening to presentations which are aimed at the learning needs of other class members. The computer approach spends extra time with the slower student in order to ensure that acceptable levels of performance are reached without jeopardizing the instructional time available to others. At the same time, the computer enables some students to proceed to new and ever more challenging materials at fairly brisk paces. Since a single computer can handle large numbers of remotely located terminals, computer-based education has the potential to provide individual instruction to a quite a number of students at any one time.

There are significant cost advantages to be attained through the implementation of an extensive computer-based education program. The cost of the development of curriculum material for the PLATO IV system is primarily the time required by the teacher to create the programs. An experienced PLATO IV user can create an hour of instruction in from ten to fifty hours at a terminal, with some additonal planning time away from the terminal. The cost of producing a PLATO IV lesson is thus similar to the cost of producing a chapter in a textbook.[5] If such a program allows students to complete some aspect of the curriculum faster than otherwise, the productivity of the university is increased. If the computer assumes a substantial portion of the university's instructional delivery, members of the faculty are free to spend more time designing the course or contents for the most effective instruction. The computer can provide high-quality education to a much larger audience, both in terms of the sheer numbers of students and in terms of the diversity of their educational backgrounds, than can an individual instructor. A working computer-based education lesson can be revised year after year. It also becomes less expensive to prepare with more extensive use, in sharp contrast to the traditional lesson which becomes more expensive to prepare the more extensively it is used.[6] When the lessons on computer-based education programs are developed as relatively small independent modules, it becomes easier to synchronize difficult curricula and avoid redundant effort and the associated costs. Finally, the use of large-scale computer-based education networks may allow for the development of lessons at one institution to be distributed immediately to thousands of students across the network.

Notes

1. There are additional PLATO IV systems in Minneapolis, Minnesota (operated by Control Data Corporation), and in Tallahassee, Florida (operated by Florida State University).

2. Authors should be primarily concerned with the problems of teaching and not with learning about computers. Professional consultants can be reached easily through a PLATO IV terminal.

3. A lesson review conducted by faculty colleagues with logic expertise was also performed. Such reviews are especially helpful for suggesting revisions to authors, and may include suggestions about the programming, instructional design, and content accuracy.

4. This assumes, of course, that self-paced individualized instruction is beneficial in its own right and worthy of further development.

5. The actual cost of delivering instruction on the PLATO IV system will obviously depend on the cost of the major components (the terminals, the central computing facility, maintenance, salaries for the computer center staff, telephone connections for terminals located far from the central facility and so on), the organization operating the system, and the percentage of use of the facilities devoted to non-instructional activities.

6. The initial cost of the computer required for a PLATO IV system is admittedly high, but is offset by heavy usage. The cost of establishing additional PLATO IV systems may be further reduced by advances in computer technology.

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