What classroom role should the PLATO computer system play?

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Inserting computers into the ecology of an elementary school classroom involves a combination of promise and uncertainty that parallels similar technological innovations in other areas, whether heart pacers, artificial kidneys, tranquilizers, atomic power plants, transportation, food production or virtually any other area one can think of. In each instance we lack a complete description of the original ecology, and we cannot be, a priori, fully aware of new possibilities.

This note explores a small part of this territory in the case of the PLATO computer system, as used in relation to elementary school mathematics and reading. Our purpose is to emphasize the large range of possible roles that computers might play, probably with varying degrees of effectiveness. Because of the many possibilities it should become clear that the question “Can PLATO teach?” is improperly phrased, and should be replaced by the question “What useful roles can PLATO play in the classroom?”

THE PLATO SYSTEM

From a student’s point of view, the PLATO computer system is a terminal with a screen somewhat like a television set, plus a keyboard somewhat like a typewriter. In fact, the screen is a plasma panel, consisting of a quarter of a million tiny, independently controlled points of light, in the form of minute bubbles of neon gas. Because the plasma panel uses digital data, it is absolutely free from distortion of the kind that limits the usefulness of CRT’s. The information rate into each terminal precludes showing “movies” a la TV, but a considerable amount of animation is possible—a train can run across the screen, for example, or a bird could fly across.

A touch panel allows the computer to know where a child touches the panel, if he does. A random access audio unit allows the computer to “talk” to students with good quality reproduction of the human voice, or of other sounds. Slides can be shown on the screen, via rear-view projection.

In fact, although students are ordinarily unaware of it, these terminals are connected to a time-shared computer (CDC 6000 series). The screen can be thought of as the page of a book on which the computer can write or draw, the child can write or draw, and modest animation is possible, plus pictures from the rear-view projection of slides. The use of a large time-shared computer means that many programs or “lessons” are simultaneously available (the “Library of Congress” effect), together with a considerable amount of computing power. The computer keeps records on the performance of each student during his or her previous sessions with the terminal.

THE “NATIONAL DEMONSTRATION” OF PLATO

Obviously, the PLATO computer system is a powerful and flexible tool that should be capable of playing many useful roles in the classroom. To begin to test these possibilities, an official “demonstration” is under way, costing approximately 8 million dollars. During the academic years September 1974—June 1975 and September 1975—June 1976 PLATO will be in operation with a reading program in kindergarten and grade one, and a mathematics program in grades 4, 5, and 6, with 100 terminals in elementary schools in Champaign and Urbana, Illinois. The results will be observed and described by Educational Testing Service, of Princeton, New Jersey.

The goal of this demonstration is to identify one or more useful roles that PLATO can play in elementary school classrooms.

CHILDREN’S MATHEMATICAL THOUGHT

As one part of the job of getting ready for this demonstration, the PLATO courseware group has been studying the mathematical thinking of children who are in grades 5, 6, and 7 in an individualized paper-and-pencil school mathematics program that does NOT use computers. This has given us a direct view of how these children solve and discuss various mathematical problems, from which we can infer a great deal about the way they think about mathematics. From this, and from direct observation of the school program, we can infer what transactions are taking place in the classroom, and how the cumulative experience with these transactions is effecting the child’s thinking.

One typical result is the following: the school program presents the child with a pamphlet showing an illustrative example, followed by problems of the same type for the child to work out. When completed, this pamphlet is turned in, corrected, and returned to the student with an indication of
which problems were solved correctly, and which are wrong. Among the transactions that do not occur are: students talking about their work to adults or to other students, experience in physical uses of mathematics (as in making an accurate scale drawing of the school playground), and student diagnostic analysis to decide how to attack a problem (since problem sets are homogeneous).

A fifth-grade girl in the program, asked to add
\[ .3 + .4 = \]
wrote
\[ .3 + .4 = .7 \]
Asked to add
\[ 3. + 4. = \]
she wrote
\[ 3. + 4. = 7. ; \]
but, asked to add
\[ .3 + 4. = \]
she wrote
\[ .3 + 4. = .7 . \]

How large is .7.? Is it bigger than 6, or smaller than 1? She did not know. The symbol .7. was of course meaningless to her, but this did not trouble her; many of the notations of mathematics were meaningless to her, and she had learned to accept that situation gracefully. To her, those little periods were something to be copied as one who does not speak French might copy accent marks in copying a French sentence.

This example is typical of students in this school program, and in toto such examples seem to support the assessment that math in this program was presented essentially as a matter of meaningless symbols, and learned as meaningless symbols.

THE ECOLOGY OF THE CLASSROOM

Assuming that what a child learns is influenced by the transactions in the classroom it becomes important to study these transactions. We are thus asking: “What can we learn about the ecology of the classroom BEFORE we allow computers to intrude there?”

As a suggestion of the variety of things that go on, we offer the following incomplete list.

What do teachers do?
They arrange for a child to have a new experience (by taking the child to a zoo, or by showing a film, or by handing the child a thermometer, etc.)
They encourage the child to talk about that experience. They orchestrate, if they do not compose, the curriculum (and some teachers compose it).
They explain something new by reference to things that are more familiar.

They arrange for student A to help student B.
They review things the child has done, and encourage him to reinterpret his experiences.
They demonstrate how to do something.
They suggest things to get a child started on a new line of thought.
They supervise.
They observe a student, and offer constructive criticism.
They show appreciation for student work or student discoveries.
They provide drill (as with flash cards for addition facts).
They lead a child to recognize some of the consequences of his thinking, a kind of elementary school adaptation of reductio ad absurdum.
They assign tasks.
They set goals.
They administer tests or other diagnostic procedures.
They help establish values and priorities.
They listen when a child needs an adult to talk to.
By their physical presence, they reassure.
They give a child the sense that someone cares about him, remembers who he is, recognizes him, and remembers what he did yesterday.
They set expectations.
They answer questions.

By their own behavior, they set an example (for instance, some children believe at first that in order to read you must know the story from memory beforehand, and they “read” this way, until it suddenly dawns on them that the adults are doing something different—namely, decoding the written symbols).

They guide a student performance.
They dole out helpful hints.
They influence the social reward system (but they cannot usually control it to the point of total denial of peer-group inputs).

But—a child is not alone in the room with the teacher. Other children play a major role. If, for example, a child hears other children recite, he may develop his ability to listen critically for weak spots in the other child’s argument, or to identify hints that he can use himself. He will be subject to “social facilitation,” acquiring goals from high-status children who have those goals. If he wishes to enter an argument, he may get practice in developing alternative conceptualizations, much as an attorney finds a way to construe a case. He is surely aware of how other children appraise his performance.

Perhaps the most important step a student takes is to accept a social contract to allow others to influence what he does and even how he thinks. The different extent to which two students do this may be the major difference between them.

Another important thing that students do is to work out their own rational explanation of what seems to be happening, in the form of explanatory rules or goals.

Students also, and to varying degrees, explore, discover, practice, make original creations, learn to take pride in their
work, learn to organize their time, learn different ways to deal with different people or different situations, learn to resolve internal conflicts, and so on. Students may (not often enough) study problems in order to work out their own line of attack. They develop heuristic analysis strategies. They learn to have confidence in some things, and not to have confidence in others.

Typically, in mathematics, teachers do NOT explain a task clearly, but instead carry it out, and leave students the job of inferring the goal from observing and imitating the activity. A few teachers reverse this, and make sure the children have a clear understanding of the task, after which the teacher leaves it up to the child to devise a method of carrying out the task (this is one variant of “discovery” teaching).

Other things happen: teachers teach some things badly; some important items are left out altogether; teachers themselves learn a great deal in their own classrooms, about children in general, about specific individual children, and about the curriculum subjects (for example, from textbooks, reference books, etc.). Outside of the classroom, teachers learn from in-service courses and from independent study.

WHAT PLATO IS TRYING TO DO

Which of the items on our list—or on the much longer lists that can be made—should PLATO attempt to address? Which are logical, or “natural,” tasks for PLATO? We can get some guidance from past PLATO experience: for example, it does not seem natural for PLATO to try to answer questions.

Most questions are badly stated, and often very specific to that setting. Although PLATO offers C.A.I. lessons on PLATO authoring in the TUTOR language, most novice programmers seek human question answers, and their questions are often as specific as “Why is my program doing this (with a demonstration)?” Children’s questions tend to be even more obscurely stated, and even more situation-specific. When one really has a question, usually part of the difficulty is that one is unable to state it clearly.

Can PLATO show a student the consequences of his own thinking, in a reductio ad absurdum fashion? We have one modest start in this direction, in a lesson on average velocity, authored by Bruce Sherwood, and designed for university students: if a student gives a wrong formula for average velocity—say, \( v = v_f - v_i \)—PLATO states a simple word problem (“A car accelerates uniformly from 40 mph to 60 mph. What is its average speed during this acceleration?”). Students nearly always answer this correctly (50 mph). Then PLATO responds; “But your formula \( v = v_f - v_i \) gives 20 mph.”

Can this technique be extended into elementary school? Possibly, but the misconceptions of elementary school children are considerably deeper and more elusive, and one would need a very clear presentation of the contradiction before one could convince them. (At present we are not attempting this.)

For the present 5th grade mathematics courseware, we are recognizing four aspects of mathematical knowledge, and explicitly pursuing three of them. The four are:

(i) knowing meanings (usually in concrete terms) of the various symbols, operations, concepts, etc.

(ii) skill in symbol manipulation

(iii) competence in using heuristic problem-analysis strategies

(iv) having appropriate attitudes and expectations.

We deal with the fourth, above, only implicitly; the first three we tackle explicitly.

Some of the methods used can be suggested by a few examples:

Example 1. “Darts and balloons.” A vertical number line appears on the screen, with 0 and 1 indicated. The line can be interpreted as a wall, to which (using random numbers) PLATO attaches five balloons. If a student types \( \frac{1}{2} \) (or 0.5, or \( \frac{1}{4} + \frac{1}{4} \), and so on), a dart flies across the screen and thuds into the wall one-half of the way from 0 to 1. If it hits a balloon, the balloon bursts.

The simplest goal of this learning experience is to guarantee that children have a reasonable notion of the size of any common fraction. But more is possible; children transform this into many different lessons. One girl typed \( \frac{1}{2} \), not near any balloon; but, with the distance from 0 to \( \frac{1}{2} \) available to her as a unit, she measured this off with her fingers, and found \( \frac{1}{2} \) for \( n = 2, 3, \) and 4. If she found a balloon, she burst it. If any remained, she tried \( \frac{1}{2} \), and so on.

One adult studied the tolerance—how close to the mid-line of a balloon must you hit in order to burst the balloon?

This should serve to remind us that learning experiences are complex things, not easily described, and not identifiable by brief statements of simple objectives.

Example 2. The Game “WEST.” This is, in effect, a board game. The game board, and three spinners, appear on the PLATO screen. By pressing a key, the student “spins” the spinners, thus obtaining integer values for \( N_1, N_2, \) and \( N_3 \). Under simple rules (e.g., no operation sign used more than once), the player forms an expression (such as \( N_1 \times (N_2 + N_3) \)), and—provided he states the value of this expression correctly—he moves forward by this amount.

The evident explicit goal here is to provide a large amount of painless practice in arithmetic; but notice that there are also other goals: for example, to get students started thinking about the maximum value of such expressions.

Example 3. Names for Today’s Date. In pursuing some of the possibilities for letting students create, letting them be proud of their work, letting them share and compete with one another, a lesson has been designed that says: “Today’s date is November 7 (or whatever it is). What names can you make up for today’s date?” The student now enters whatever names he chooses, such as

\[
2 \times 3\frac{1}{2}
\]

\[
\text{rnd}(\pi^2) - (9)^{4/7}
\]

After he has entered as many names as he wishes, he
preserves the “NEXT” key, and PLATO displays the complete list of all names entered thusfar, including his own, with the names of the students who entered them. He now—having looked at the work of the other students—may enter still more names if he wishes.

Example 4. Programming PLATO. This lesson sequence also deals with allowing children to create within mathematics, much as they would in art or poetry—specifically, they can create original computer programs. The programming language is pictorial, and is developed by touching pictures on the PLATO screen. Sub-routines can be created, named, and used by name as instructions in future programs. A typical procedure might put trees in various locations, outline a street, then have a boy cross the street just in front of a car that drives down the street.

This is an experimental venture, the value of which may not be known for some time.

Example 5. The definition of fractions. What is interesting in this sequence is the underlying teaching strategy: the sequence begins with something children know very well indeed—whether a chocolate bar has been shared fairly, or not, among two, three, or four children. So the action is familiar; but while this familiar action is being carried on, it is being discussed in the language of fractions—thus, the first introduction of this language is by use, not definition. After some use, a new level is reached: operating on a “meta” level, PLATO and the student cycle back over what they have just done, but this time, instead of doing it, they analyze it.

Example 6. Interterminal Games. Two or more terminals can be interconnected (by the courseware) so that children can play games against live opponents, in real time.

Summary

Obviously, PLATO can attempt to address a fairly sizable range of typical classroom activities. Courseware is now being created to pursue a scattering of these. Presumably other classroom transactions would not be natural (or feasible) on PLATO. For the National Demonstration, we hope to show that there are some classroom tasks which we have correctly identified as appropriate and feasible via PLATO. On a few of our nominees we may fail to achieve success, either because the task is unsuitable, or else because we have not created appropriate courseware or appropriate conditions of use.

THE SESSION SELECTOR

On PLATO, one has great freedom in deciding whether choices are to be made by the children, or by the teacher, or by PLATO itself. When the choice is made by PLATO, the Session Selector program does it.

Good lessons, like good concerts and good chess games, have a beginning, a middle, and an end. The Session Selector plans PLATO lessons this way, choosing first the main course, which will appear to the student in the middle slot. This choice is the most carefully made, and utilizes the records of the individual student, plus the curriculum tree. After the choice for Slot II has been made, appropriate review or introductory material is chosen for Slot I; some appropriate games or other favorites of the children are then made available for Slot III. Although PLATO plans in the order II, I, III, the student of course encounters the slots in their usual order: the lesson begins with the Slot I selection, then goes on to Slot II, and ends with the Slot III games.

INTERACTIONS BETWEEN USE AND HARDWARE/SOFTWARE

It is probably obvious that the way PLATO is used in schools shapes the demands on the hardware and system software, and is in turn shaped by the capabilities of the hardware and the software. We cite one example: the allocations of extended core storage (ecs) on PLATO originally assumed that, on the average, twenty students were using the same lesson at the same time. A few years ago this might have been feasible—schools commonly had “a math period,” “a reading period,” and so on. It was not unusual for the teacher to say: “All right, children, now let’s everyone turn to page 45 in our readers.” Today, in the schools we are working with, this would be unusual. They have moved toward the “integrated day” approach; time is no longer subdivided, but space is—there is no “reading period,” but there is a “reading corner,” and there’s always somebody over there reading. To accommodate to such schools, it has been necessary to rearrange memory allocation on PLATO, so that, on the average, it is necessary for four students to be using the same lesson. Since, when fully developed, PLATO may be serving 2,000 students at the same time, the 4-to-1 average may not impose too severe a restriction.

THE SHORT TERM VALUE OF PLATO

There are long-term hopes that PLATO may be an effective economy option, highly cost-effective because it makes the classroom more capital intensive and less labor intensive, and that the use of PLATO may significantly improve the quality of education. Both of these hopes may be realized, but probably not immediately. For the short term, PLATO is at a developmental stage, where the task confronting us is to see which classroom transactions we can handle well via PLATO, and to acquire the means of doing so.

But even in the short run, PLATO has considerable value as a research tool: as more classroom jobs are assigned to PLATO, we gain a far greater degree of control over what is going on in the classroom, which allows us to get far better
data on the importance of different kinds of transactions. The will-o’-the-wisp elusiveness, subtlety, and complexity of traditional classrooms never allowed us, for example, to study the effect of omitting much or all of the usual arithmetic drill, inserting instead games such as WEST that provide less-controlled experience with arithmetical operations. In the traditional open classroom, as Featherstone points out, one often found that every child had learned to read, but you could not identify when, where, or how this had taken place. PLATO should give us a far greater ability to pinpoint the contributions made by the various kinds of activities and transactions, which in turn allows one to plan the future role of PLATO on the basis of a more secure rational theory.

BIBLIOGRAPHY