An academic meets industry—
Rethinking computer-based education
and personalized systems of instruction

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PROLOGUE

Education is a versatile animal. After belonging exclusively
in the domain of the home for millennia, public education in
the United States became institutionalized about 1800.
Today, the school system in many cultures is often equated
to "the" educational system. However, industrial institu­
tions are also becoming acutely aware that education is a
vital component of their structure, and in some cases, of
their market.

I believe that education is vital in all three of the above
institutions: home, school, and industry. If a role of edu­
cation is to help us learn new ways, as well as to understand
current and past concepts and events, then we are in for a
great deal of education in the future.

It hardly seems possible
that Tomor's
Future Shock is already eight years old, as we
observe and share in rapidly changing lifestyles and insti­
tutions constantly today.

THE ACADEMIC

It is my deep conviction that a large part of education can
occur in a framework other than in a formal classroom
setting. In such a formal lecture/testing situation, students
are most often evaluated on a basis of comparison with other
people who happen to be in the class. The resulting attitudes
are ones we've all seen or experienced: the confident, bright,
fast-learning top 10 percent, the slower-learning bottom 10-
20 percent who consider themselves "dumb" or "stupid,"
and the large majority in between—not really understanding
much, but content to receive a "C" and get out.

It was attitudes such as these which prompted me several
years ago to investigate alternative modes of education.
The alternatives involved evaluating students on the basis of
mastery of definable objectives, and not on how well or
poorly or rapidly their classmates performed. I first inves­
tigated computer-based education (CBE) over ten years ago,
became disillusioned with the quality, and left. When
PLATO became viable in the early 1970s, my interest and
activity were rekindled. Shortly thereafter, a friend intro­
duced me to Keller's Personalized System of Instruction
(PSI). Combining CBE and PSI in a university framework
proved very useful in eliminating many of the attitudes men­
tioned earlier. Then, a few years ago, I introduced explicit
cooperation into these courses, lest students become
too isolated. The primary cooperative efforts were: study
partners for PSI units, design of a computerized personal
data base by a small group, mutual design and use of inter­
active programs, use of cooperative exercises and parties.

THE ATTRACTION OF INDUSTRY

Texas Instruments (TI) is a very natural professional home
at this time. It has a long-standing interest in the individual
consumer: it can deliver high-technology personal products
at affordable prices; mini- and microcomputers are current
offerings of the company; it has made a commitment to
using an extremely well structured programming language
(Pascal); a large educational effort is underway to deliver
this tool; and most importantly, it actively encourages cre­
ative solutions to challenging problems. Consequently, my
active interests in personal computing and CBE/PSI edu­
cational systems could be naturally joined to help deliver a
useful, fun and challenging tool to homes everywhere.

"Computing power to the people" became an area where
contributions were definitely possible. In fact, TI received
top billing in an excellent recent article on CBE, where the
author stated: "... it is not wise to underestimate the in­
genuity of the private sector in harnessing mass production
to perceived consumer needs, whether in the home or in the
He then goes on to describe the popular Speak & Spell (TM) product of TI. Texas Instruments has made a substantial effort to improve the scope and calibre of on-the-job education for its employees. And because of the diversity of employees in such a company, it is an ideal site for applying CBE/PSI principles developed in academia. Lessons learned in this environment can be utilized as TI also actively pursues a market beyond its own confines. This market is the general populace which can make fantastic creative contributions if given a versatile, well-designed home computer capable of educating and of becoming “educated” itself. An excellent article in a recent issue of *Computer* is a well balanced overview of some of these contributions and how they might come about in the 1980s, according to a group of experts.8

The ability of machines to become “educable” is my requirement for personal computers. They must be able to perform many useful and fun tasks. Pick up any copy of *Creative Computing, Personal Computing, Byte, People’s Computers*, etc. for a vast array of marvelous application areas. But the same computers must also be able to be told how to do new things—no amount of ROM is adequate here. Historically, we have told the machine how to do new things by creating a new program for it. I doubt very much if the general public will program in the same ways you and I have for 20 years, but we must make it possible for them to “teach new tricks” to their new helper and game-player.

Our natural language researchers in artificial intelligence should be a big help here. Smalltalk at Xerox PARC is an excellent start.9

**POTENTIAL CONTRIBUTIONS**

Both CBE and PSI, after a relatively sheltered life in academic institutions, hold great promise in other institutions, notably the home and industry. Control Data Education Company and others are deeply involved with CBE in industry.5 And it is rumored CDC is even looking at the home market.4 PSI, on the other hand, is almost exclusively used in schools. Therefore, one of the potential contributions is to formulate a strategy to maximize the effectiveness of both tools in an industrial environment. They have proven themselves to be viable in their original settings. Now we are in a position to respond to numerous calls for cooperation between the university and industry.4,17

Upper-level management at TI has decided that the widely-recognized superiority of Pascal for many programming tasks will be acknowledged within a majority of future TI products. Consequently, they have funded the effort to produce the first industrial version of Pascal, called TI Pascal. The language, in both its sequential and concurrent forms, has been formally released.

Now formulating the (few) extensions to Pascal and implementing the associated compilers, interpreters, and runtime support systems is no mean feat. However, the educational effort required for widespread use of this tool is also considerable. The universities have been a great help here as they continue to replace their introductory courses oriented to Fortran and assembly language with ones emphasizing Pascal and associated reliable design techniques. A recent issue of *Byte* contains many readable articles on Pascal.7 Textbooks are also rapidly appearing.25,18

Within TI then, we are experiencing many of the problems associated with university classes: “too many” students for only a few instructors, not enough individual attention, time conflicts, student travel time, multiple entry levels, etc. In addition, there are some unique concerns. In particular, student time is worth money! This is a revolutionary concept in school, but a vital consideration in industry. Moreover, students do not really receive a letter grade. Rather, it is *assumed* that, after they have attended a Pascal course for n hours, they know Pascal sufficiently to be able to read and write Pascal programs.

**A POSSIBLE SOLUTION**

One of the possibilities under consideration by TI for delivering some courses involves both CBE and PSI. The following is one option.

1. Develop CBE materials using off-the-shelf hardware, and pieces of courseware, if available.
2. Use the product for a few classes until the majority of the major errors are removed.
3. Concurrently, develop TI software and hardware designed for a well-engineered CBE interface, relying on experience gained in the current system by users and authors.
4. Transport currently developed courseware to the new distributed TI system permitting interterminal communication.

At this point, students will take a lesson (or course) near their site at a TI system. User consultants will be available on-line in prime time, with a notes feature used at other times.

The course will usually consist of several units as in PSI, where each unit contains an introduction, objectives, suggested procedures (involving reading, program writing, taking CBE lessons, etc.), sample exercises and a multiple version unit test. Unit mastery will be demonstrated by passing the unit test at 80-90 percent competency, where each question will relate to a unit objective and be categorized by Bloom’s educational cognitive taxonomy.1 For readers unfamiliar with PSI, the excellent paperback by Keller and Sherman is recommended,10 in addition to earlier referenced papers of the author. Briefly, PSI is characterized by five attributes:

1. Mastery-based
2. Self-pacing
3. Non-lecture
4. Written materials
5. Proctors

The argument in favor of PSI runs something like this.
Students can gain in self-respect, and justifiably so, when they demonstrate they can master the material (a). But since students grasp material at widely varying rates, such mastery will occur only if the students are primarily responsible for pacing themselves (b). However, if they pace themselves, there is no way any lecturer could possibly speak to all students at their individual points of progress (c). But if the information is not transmitted verbally, how can it be done? Written material provides a partial answer (d). With the widely varying rates of progress through a course, there is no way one instructor could manage the evaluation process for 30 students working on 20 units of material, each with its own multi-version unit test. Hence, proctors become invaluable (e). They each, including the instructor, take responsibility for about ten students. That is, they go over the unit tests, answer questions, suggest resources, etc.

The first unit test will be graded on-line at the student’s convenience by an instructor. If competency is not demonstrated, suggestions for further study will be given and another version of the test taken later. This will continue until mastery is achieved, and then the student will start the second lesson. For latter units, either the instructor or another student who had passed the unit earlier (internal proctor) will grade the test and make suggestions. This proctor can be at the same site as the student taking the test or at another TI site. In either case, the proctor can see the student’s quiz and carry on a full dialogue.

Course mastery will be demonstrated by passing all units at mastery level. Statistics regarding completion times, number of unit test retries, proctors, comments on lessons taken, ill-stated questions or objectives, etc., are easily gathered in the proposed system and can be released to authorized personnel. For example, a cost center manager might wish to see how much money should be budgeted for students to take the TI Pascal course.

A FUTURE

I would expect that, should TI decide to try the preceding alternative to current course development and delivery, the company will also market a similar product eventually. A home computer can be utilized for educational lessons with dial-up access to instructors or proctors who might become widely-scattered friends over time. Components of the lessons can use the many exciting peripherals forthcoming: touch panels, audio output and input, video disks, synthesizers, etc. as well as our best and most versatile resource: people. If a student has difficulty understanding something, cooperation is encouraged! I think we are here to help one another, not to compete continuously.

SUMMARY

I have suggested that the institutions of home, school, and industry have much to gain by cooperation with one another. My interest in providing computing power at an individual level has led me on an odyssey from industry to university life, and now back to a computer industry vitally involved with personal computing. Lessons learned in the university about how students learn better are suggested as viable options in the industrial environment. In particular, CBE (computer-based education) and PSI (Personalized System of Instruction) are conjoined to offer flexible courses internally. And from these efforts, modified ones can be made available to the public, permitting learning to occur wherever people happen to be, perhaps just finishing up with a rousing game of interterminal "Star Trek" or "Oregon Trail!"

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5. Control Data Education Company, Courseware Catalog, Fall 1978.