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ABSTRACT

Computer-assisted instruction (CAI) is not making an important, visible impact on the educational system of this country. Though its instructional value has been proven time after time, the high cost of the hardware and the lack of quality courseware is preventing CAI from becoming a market success. In order for CAI to reach its market potential it must find a new educational target market. The junior colleges represent the best market for CAI because of their increasing enrollments and their intermediate position between the generally recalcitrant school districts and the graduate oriented universities. The high cost of hardware is being solved and all that really remains is for the CAI industry to meet the high-volume instruction requirements of the courseware. The production and dissemination of courseware will require a new design and development technology with high quality standards. The author discusses the entire subject of marketing CAI in depth. (MC)

MARKETS AND MODELS FOR LARGE-SCALE COURSEWARE DEVELOPMENT

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ABSTRACT

Computer-aided instruction has not achieved widespread use, even though experimental results have been promising, because of a complex of technical, economic, and social factors. The problems these factors produce might be overcome if a major "market success" could be achieved with CAI systems. One potentially high-volume market having probably a lower resistance to profound innovation than other sectors of education is the junior college.

To achieve a "market success" which would catalyze public and private investment to sustain the growth and dissemination of CAI requires technical solutions in the areas of hardware, software, and courseware. Courseware is a term designating the applications programs fcr CAI systems and associated textual, audio-visual, and other materials of instruction. Two different approaches to the production of courseware and their underlying philosophies were discussed and contrasted. The extent to which these different models of courseware design and development might lead toward the goal of mass dissemination was highlighted.

MARKETS AND MODELS FOR LARGE-SCALE COURSEWARE DEVELOPMENT

Computer-aided instruction (CAI) has not achieved the widespread use predicted by many of its early proponents during the past ten years. Research and demonstration using CAI systems has often been of poor quality, wasteful, and disappointing. Yet enough good research and development has been conducted to accumulate a corpus of data which on the whole is impressive. It is suggestive that CAI indeed has a revolutionary quality about it. It provides an operational means to profoundly restructure the educational system and to replace inefficient methods with man-machine systems of high efficiency and effectiveness.

In general, research results have shown that well-designed CAI programs in subject-matter areas for which CAI is well justified yield performance gains of at least equal magnitude to traditional instruction. Often mean performance among CAI groups is considerably better than in traditional instruction. Moreover, CAI is usually found to be far more efficient. On the average, students will finish in considerably less time than in classroom instruction. Time-savings of from 20% to 60% for the average student are common. Lower ability students, however, may take longer. With CAI more of them eventually succeed, so another general finding of CAI research has been that failure rate is reduced.

There are many reasons, both empirical and logical, for expecting much from CAI. These are well known and, except for recent data which support earlier promise, have been well known for a number of years. Yet those companies which several years ago invested in CAI, and in some cases began serious marketing efforts, have retreated substantially. CAI is not making an important, visible impact on the educational system in this or any other country. It is impossible to trace all of the sociological, technological, and economic reasons for this lack of success, but an attempt to identify the major problems must be made.

It can be argued that what CAI needs to get out of the doldrums is a "market success" which would catalyze industry, government, and authoring talent to invest further in its development and dissemination. There are three major problems which have impeded such a market success. These are:

1. The high cost of hardware having adequate display and processing capabilities.

2. The selection of a high-volume/low-resistance market for targeted introduction of complete CAI systems and materials.

3. The development of a large enough body of high quality curricular materials (courseware) to make a substantial impact on the target market.

All three of these problems must be solved simultaneously to produce a CAI system which can be widely disseminated. This has never been achieved in any CAI efforts to date.

The first problem is technological. Computer systems and terminal devices with an adequate range of capabilities for a wide enough range of applications have not been available at a low enough cost. Stetten and Bitzer describe alternate hardware and software systems in this session, both of which have a wide range of capabilities. Both have presented cost projections which, if validated in practice, will make CAI having these capabilities very competitive economically. If the other two problems can be solved using one or both of these systems, a market success is feasible.

The second problem has not often even been recognized by those who have attempted to disseminate CAI. Systems have been offered to the entire educational public without attempting to identify critical educational needs for which the systems were appropriate. Because of different needs and different resistance factors, the same approach to different sectors of the educational public is not appropriate. Because of limited resources, a focussing is necessary.

Selecting the most strategic target market is not n obvious nor easy task. Universities have high resistance factors to the introduction of computers in a manner which would significantly change the ways things are done. Their focus on graduate education and research at the expense of the large undergraduate courses, departmentalization, and faculty autonomy have made universities a bastion of resistance against any form of CAI that seriously challenges the teacher's central role in the classroom. There are economic and political forces at work which may change this.

Within universities, medical education, special education, remedial systems for disadvantaged enrollees, and high-volume laboratory courses are promising sub-markets.

Elementary and secondary education is highly decentralized. In large part its dispersed units are controlled by a recalcitrant establishment which has not been subject to the disciplines of direct accountability and is not anxious to change. This is the largest potential market, however, and one which, at least in the elementary grades, renews itself every six years. (The Walt Disney empire provides a model for capitalizing on this fact: Mary Poppins will be re-released in 1973.) Military training provides a large potential market, especially with the advent of the volunteer army. Resistance is high to obtaining initial adoption, and it is often frustrating to work through bid procedures to obtain proper equipment, but once these hurdles are overcome, and given the appropriate courseware, resistance can be effectively brushed aside. Industrial training is also a market with great potential and low resistance once the proper executives are convinced.

The junior colleges represent a high-volume market with potentially low resistance. In addition, they are strategically located to stimulate change upward into universities, downward into secondary education, and outward into adult education, including industrial and military training. If one of the key ingredients missing in the process of disseminating CAI has been a focused effort, then junior colleges may be the most strategic target. Consider the following statistics about junior colleges: Enrollment in junior colleges is growing at a rate about 2-1/2 times faster than are the other enrollments in higher education. The junior college share of the market has grown from under 20% in 1960 to 27% in 1969-70 and is estimated to be 33% in 1981-82, and 34% in 1987-88. This would cover a total head-count enrollment of 2,186,272 in junior colleges in 1969-70 and an estimated total enrollment of 4,475,580 in 1981-82, leveling off to 4,598,130 in 1987-88. Much of this enrollment growth is a result of the open-door admissions attitude of public junior colleges. This admissions policy will lead to even wider audiences of students as nearly all the large metropolitan areas will be served by junior colleges in the next four to five years.

This large and growing population of potential users of CAI receives, on the average, 320 hours of classroom contact per capita per year at the cost of \$3.26 per contact hour. The \$3.26 figure is obtained from the national average contact hour cost of \$2.47 by an additional 32% for capital outlay. The \$2.47 is broken out as follows:

Percentages of junior college costs
in different categories

1.	Instructional costs	60%
2.	General administration	15%
3.	Operation and maintenance	16%
4.	Library or resources center	5%
5.	Extension services and research	4%
	Total	100%

The cost is less than \$3.26 for college preparatory courses (\$3.10) and more (\$3.87) for terminal (or vocational-technical) courses.

Of the 320 hours of classroom contact per junior college student, 86 or 27% were in the subject areas of English, math, and data processing. Two CAI courses (or module banks) in mathematics, precalculus mathematics and remedial mathematics, two in English, freshman composition and remedial English, and one in data processing would account for a major portion of this 27% of the junior college instructional program. Thus, the development of a relatively small amount of courseware could have a very large market impact potential.

It is very difficult to estimate the economic impact of the introduction of CAI into these courses. The raw cost of a terminal hour at the computer will be no more than $1.00, if the estimates of Stetten and Bitzer are correct. Thus, if it could be assumed that CAI was no more nor less effective than traditionally administered instruction (TAI), and that CAI could supplant all instructional costs (60% of $2.47 or $1.48 per hour), then a clear economic argument can be made. As mentioned earlier in this paper, CAI is likely to be more effective, especially for lower ability students. Moreover, it is likely to increase the throughput substantially. Increased throughput will potentially impact all other categories. Administration, operation and maintenance, library, and physical plant cost a fixed amount per year. If students move through more rapidly, or more students move through in the same period of time, the cost per student is decreased.

The impact on physical plant needs and utilization of CAI could have important cost implications. These implications arise from three factors: increased throughput, reduced space needs of individual study areas vs. classroom space, and the decentralization off campus of remote terminals. In 1968-69, a survey of 17 states revealed a mean standard of 18 square feet per student for planning standard classroom space and 12 square feet per student for planning individual carrel space. This is a 33-1/3% saving in the amount of space needed per student if CAI rather than traditional classrooms is used. In regard to the utilization of this space, the standard for good usage of carrel study space is far higher than for classroom space so the transition to this type usage is even more advantageous. If at-home use of the system is implemented over CATV, the space requirement for campus construction would be reduced by an even more substantial factor. In addition, utilization of computer time could extend into the nights and weekends to increase even further the utilization percentage.

In addition to high volume and potential cost savings, junior colleges have other advantages as a target demonstration market. They seem to offer less resistance to educational innovation than other sectors of the educational establishment. Consider the following:

1. Mores and traditions are not so set as in universities. This is the main reason why there is a higher faculty turnover rate. There is a larger percentage of schools only a very few years old. Many new ones organize each year. Projections are for 260 new ones through 1980 based on population growth alone. Replacement of physical plant by the construction of new campuses may account for an additional 40 during the same period, for a total estimate of 300 new campuses by 1980.

2. Several states have strong central offices for all junior colleges, e.g., Virginia, Wisconsin, New York. Thus, statewide adoption of CAI systems is quite feasible.

3. Michigan, Washington, and California have state-financed (or federal grants administered by the state) in-service programs to train faculty in new learner-centered educational technologies.

4. Several states have followed California's model of setting up accounting mechanisms to pay the state's funding share of any individualized instruction. including CAI. This is important, for in most states funding has traditionally been tied to the contact hour and CAI is designed to reduce contact hours.

5. Junior college decisions usually are made by administrators rather than faculty so there are fewer people to sell on the idea of CAI feasibility than there are in the senior college and university setting.

6. Many states have large groups of faculty already "tooling up" to implement learning systems approaches with individualization and measurable objectives.

Thus, it appears that the second obstacle to the wide dissemination of CAI might be overcome through the introduction of CAI into targeted high-impact courses in junior colleges.

The third obstacle is the lack of sufficient courseware and the time, expense, and uncertainty involved in producing it. If the analysis above is correct, a small number of CAI courses can have a significant impact on the instructional load and economics of junior colleges. Yet there exists great controversy among educators regarding the advisability of attempting to design and produce complete man-machine systems using CAI heavily and greatly redefining the teacher's role. Many feel that we do not know enough about learning theory or about self-paced, individualized scheduling plans to proceed boldly. They fear unforeseen negative consequences of automation. Most of all, they fear that teachers might be displaced as the central controlling figure in the classroom. There is an article of faith which one repeatedly hears intoned at professional meetings of educators where CAI is discussed: "Of course the computer can never replace the teacher." The program these people recommend is to pursue further trial and error in computer uses adjunct to and under the control of classroom teachers.

On the other hand, there are those who are convinced that we do know enough to develop CAI courses in a manner which will lead to effective, efficient and palatable instruction. It is not a question of replacing the teacher completely in these courses, but of redefining his role and creating new roles for him and for others. We are convinced that a new technology of courseware design is rapidly developing which provides quality control and management control of production time and costs, and leads to products suitable for mass dissemination. These products are complete man-machine systems for administering large blocks of instruction with greater effectiveness and at lower cost.

These two extreme philosophies of how we should approach the development of courseware lead to a useful distinction between two classes of CAI programs. These are illustrated in Figure 1. The main difference between these two classes of programs is in the role of the teacher. In the adjunct approach the teacher is the central figure, and the programs are used as supplements to traditional classroom or laboratory work or as a new kind of homework. These uses include problem solving using the computer, simulation and modeling, drill & practice supplements or remedial units, and use of programs for illustration during lectures or laboratories. It is the teacher or his students who do the programming in these instances. The products of this "cottage shop" method of development are heavily dependent upon their originator to provide the context. Thus dissemination is not enhanced.

A "mainline" CAI application on the other hand is designed from the first for mass dissemination. A complete instructional system is redesigned for a substantial block of material so that the roles of teachers may be greatly redefined and possibly reduced as the system becomes more technology-intensive and less labor-intensive. The lock-step scheduling system is replaced by a self-paced, individualized scheduling system with a new criterion referenced standard for grading to replace grading "by the curve." A design and development team having total capabilities not often possessed by individual teachers is responsible for the courseware development, documentation, and packaging for distribution.

As Figure 1 indicates, there are other differences between the two classes of programs. Adjunctive applications, having little impact on the teacher's role, represent an add-on cost to present instruction, but they may require low capital investment for both computer equipment and courseware development. Mainline applications, on the other hand, have the potential of great economic impact on education, for they supplant existing costs. They require high capital investment for hardware and for courseware development however. They are high-risk/high-yield technological innovations.

The two models for courseware represent extremes of a continuum. Many variations fall somewhere in between. For example, the well-known Stanford CAI project uses a type of systematic team approach to the

ADJUNCT → → MAINLINE

ADJUNCT

--Context provided by teacher.

--Programming by teacher and student.

--Fits with standard credit-hour scheduling.

MAINLINE

--Redesign of a complete instructional system, including the teacher's role.

--Specifications and programming by design-production teams.

--Requires self-paced scheduling and grading.

Some Consequences of Each Approach

ADJUNCT

--Represents an add-one cost.

--Requires low to moderate capital investment.

--Dependent on individual personality.

--Increased effectiveness: opportunity for restructuring objectives and subject matter.

--Modest but variable system requirements; use scientific or business oriented computer system.

TTY's or typewriters,
Batch or interactive standard languages.
(Sometimes sophisticated graphics)

MAINLINE

--Great economical potential: supplantive.

--Requires high capital investment.

--Designed and documented for mass dissemination.

--Increased effectiveness and efficiency.

--Specific engineering design for education:

CRT or plasma display,
Interactive and efficient special author and student languages.

Figure 1.--*A Useful Distinction Between Two Classes of CAI Programs.*

design and development of courseware, but the resulting "drill and practice" programs are adjunctive to the teacher who still plays the central role, supplies the context and provides most of the instruction. Nevertheless, both polar extremes have real advocates in the world of CAI today. Advocates of the adjunctive approach often disparage the efforts of those who would develop complete systems, saying that too little is known and that as a result this form of CAI comes out looking like warmed-over programmed instruction. Advocates of the mainline approach usually regard both kinds of CAI as necessary. They see the adjunctive approach as a source of creative ideas in the use of computers to restructure concepts and pedagogical approaches, but find it unsuited both in its economic consequences and its packaging for mass dissemination. They see mass dissemination of effective, efficient and palatable CAI courseware as a way to bring about greater individualization with a better cost/effectiveness ratio.

Of the three obstacles to a "market success" for CAI mentioned in this paper, the first two are temporary. Hardware and systems software acceptable both in terms of cost and performance will soon be available. Industry will have no problem in supplying the needs of our society on this score. Once the more strategic markets for early introduction of CAI are identified, they can be cultivated. But the problem of assuming a continuous flow of quality courseware is more acute. Even as software development is becoming the most important expense in the computer field, and good programmers the sine qua non of a first-rate computer organization, so courseware and courseware designers could well become the key to the future of CAI.

Programmed instruction suffered from a premature commercialization characterized by a flood of ineffective and poor quality materials. These materials were generated on low budgets, usually using teachers and students untrained in the systematic discipline of instructional psychology and instructional design, then an infant field. An early "market success" for CAI could encounter similar problems unless standards for the design, development, and validation of courseware products are established.

To prevent a recurrence of this unfortunate historical sequence, we need both to establish such standards and to provide educational opportunities for the training of adequate numbers of instructional psychologists and instructional designers, respectively the "scientists" and "engineers" of a new technology of courseware development. Let me outline a systematic model for courseware design which has evolved at The University of Texas CAI Laboratory. It is helpful in considering standards and in understanding the role of instructional psychologists and instructional designers. An earlier version is discussed in Bunderson (1970) and a case study in Abboud and Bunderson (1971). In general, this procedure for courseware design has the flavor of systems engineering, as seen by the incorporation of three important concepts. That is, the context within a larger system of the course to be developed is considered as a "black box" with definite and measurable input and output in terms of student performance; the black box is analyzed into component black boxes; a mock-up is synthesized and tested against its output specifications; and the feedback from testing is used for revision until the system performs as specified. A production team is required for the whole process. In one staffing pattern, an instructional psychologist, whose analogue in engineering is the systems engineer, lays out the overall architecture of the system, applies instructional theorems where appropriate in the design of instructional strategies, and exercises an editorial quality control. One or more authors (whose analogue in engineering is the design engineer) provides content expertise and writes materials. The instructional designer serves many functions, including the writing of objectives and the preparation and administration of test items, and data analysis for revision purposes. He may also assist in packaging the draft materials as computer code and audio-visual materials.

The systematic procedure for instructional design and development used at The University of Texas CAI Laboratory incorporates these concepts in a method that also provides for management and quality control of program development. For large-scale courseware development, cost and time management techniques similar to those used in large-scale software production efforts must be employed.

The important concepts of courseware design can be illustrated by means of a review of the products of this systematic procedure. These products may be classified as public documents, intermediate design products, and final program materials (see the column headings in Figure 2).

The need for the public documents and final program materials is easily seen by considering the effects of their absence. The lone faculty author employing the adjunct approach will usually produce only the digital code and perhaps the slides, tapes, or booklets which accompany the final program. He may provide minimal technical specifications in terms of a computer listing. This listing, however, may use type-codes which do not correspond to CRT characters, and in other ways be complex and difficult to decipher. This minimal documentation may allow him to exchange small adjunct programs with friends or colleagues, but not mainline programs.

When people ask such an author, "What does it teach?", he is at a loss without written statements of goals and objectives. If they ask, "Does it succeed?", he needs validation data showing, at least, the extent of pretest and posttest gain by different students taking the program.

Public Documentation | *I[illegible] Products* | *Program Materials*

I. Context information:
--Societal needs.
--Institutional needs.
Brochure
--Goals: "Mastery Model"; prerequisites
Prerequisite Test
--General description of approach; justification.
Proposal
--Some evaluative data.
--Production plan (see V).

II. Design architecture & rationale:
--Performance objectives.
--Analysis; objectives and learning hierarchy.
Criterion Test
--Synthesis; course structure and restrictions.
Professional Publications
.Individualizing mechanisms, (flowcharts).
Diagnostic Test (if any)
.Tests to measure objectives.
.Specification of display and response conventions, each subordinate objective.
--Technical evaluation and research reports.
.Formative (revision data).
.Summative (effectiveness and logistics data).

III. Manuscript or author's draft:
Program:
Digital
A-V
Text
--Program steps and step formats; subroutines (for production personnel).

User Manual
IV. Technical documentation; final program components:
--Program documentation for systems programmers.
--Documentation for operations: operator and proctor guides.
Proctor and Student Guides
--Student manuals.

V. Production management plans for the production of all procedures listed above.

Figure 2.--*Products of Instructional Design.*

If they ask, "For what type of students is it intended?", he needs a description of the target population and, better, a prerequisites test. If asked for a copy of the program, he cannot respond in a helpful manner without user documentation and technical specifications for the programmer who will maintain it. Clearly, these problems increase greatly in severity as we depart from small adjunct programs to consideration of complex mainline systems.

From the "intermediate design products" the structure of a systematic approach to instructional development can be inferred. These products consist of notes, prose passages, flowcharts, manuscripts, student data, and other ephemeral or rapidly changing forms of information. They result from a sequence of important design decisions. As the arrows in Figure 2 indicate, they lead to the production of final documentation and program materials.

The three overall aspects of the systems engineering approach can be seen in the list of intermediate products. Context is considered through the needs, goals, and justification which result in "brochure information" useful for potential users or as part of a development proposal. Real societal and institutional needs must be addressed if the system is to be disseminated successfully, and CAI must be a well-justified method to meet these needs. In the box in Figure 2 are listed those design products which arise in connection with the synthesis of the "black box." Performance objectives which lead to criterion tests and prerequisite tests define the input-output specifications. (Other specifications in the form of constraints, such as time, may also be determined.) The analysis of objectives and definition of the system architecture in terms of a hierarchy or other structure of intermediate objectives is the key step in this process. Synthesis of mechanisms for individualization and representational conventions for display and response for each subordinate objective depend on the analysis step. The special training of the instructional psychologists and instructional designer is most critical in the stage of design indicated within the box in Figure 2. It is here that the application of empirically derived principles of instruction is most needed. It is here that an eventual theory of instruction will be applied.

The notion of testing and iterative revision is implicit in the concept of formative (or developmental) evaluation. This is more interesting for the empirically oriented designer than an overall evaluation of the final product (called "summative evaluation"). Formative evaluation can be characterized as a continuing cycle between experiment and adjustment until the program seems to be working. Summative evaluation is most relevant to the production of brochure information and professional publications--to convince others that the program works if indeed it proves successful. It is also useful to obtain field logistics data (distributions of completion times, housekeeping details, etc.) for the user manual.

The concept of formative evaluation provides a strong answer to those critics of mainline programming efforts who have often told me, "It is inappropriate to undertake these projects until we know ---------." (The blank may be filled in by "how people learn," "what reinforcement to give different students," "what instructional strategy to use for different students," etc.) Happily, we can proceed through, at worst, a combination of rank empiricism (to identify deficiencies) and the use of intuition and common sense to revise it until it does achieve its objectives. We naturally wish to base our revisions on known instructional principles and on instructional theory as fast as it is developed. It may be the case, however, that the existence and long-term use of high quality CAI courses is a prerequisite for the development of an adequate instructional theory. Such programs would for the first time provide a situation wherein all displays, responses, and sequences are operationally defined and data from alternative presentation paradigms collected automatically.

The main concept in the first column of Figure 2 is that proper documentation for CAI programs cannot be determined until it is recognized that there are different audiences for documentation. The potential user needs brochure information, especially the institutional need, which describes a real problem in a real institutional setting that generated the program development. The justification for using CAI to meet this problem is most crucial to the potential user. He also needs an overview of how the program works, a review of its coverage (goals) and objectives, a definition of the target population, and any validation and cost data available. Much of this same information, plus a description of societal needs and a production plan for all products, is needed by a funding agency, a most important "machine" at this stage of the game.

Design architecture and rationale are of interest to sophisticated potential users, but full detail is most appropriate for professional publications. The pressure on universities in the United States from state legislatures to concentrate on teaching undergraduate students is in conflict with the "publish or perish" research ethic. A possible rapprochement is through doing research on the structure, organization, and pedagogical logic of one's discipline in the context of applied curriculum development projects. Such research may lead to important simplifications and reconceptualizations which may actually represent a theoretical contribution to that discipline. For example, Kekule's invention of the benzene ring representation simplified an array of complex phenomena for students as well as for chemists. Some analysis of subject matter undertaken in connection with CAI development has uncovered ambiguities and led to clarifying research.

Other audiences who need special forms of documentation include technical personnel who will operate, maintain, and update a complex mainline CAI program, managers, teachers, and proctors who will administer it, and students who will take it.

The preceding brief review of the products of systematic courseware design leaves much unsaid, but perhaps suggests that the process of courseware design for mass dissemination is sufficiently complex to be addressed as an emerging technology. The existence or non-existence of various design products could form the basis for the establishment of reliable standards--standards which were missing in the history of programmed instruction. The thinking and production processes implied by the sequenced list of intermediate design products serves as a framework for graduate degree programs in instructional design and instructional psychology. The establishment of such degree programs, or their equivalent, will be necessary to sustain the production of quality courseware following any initial "market success." Finally, the explicit identification of design products and their sequence forms the basis for tight management of production, with the incorporation of quality control.

In summary, it appears possible to achieve a "market success" for CAI by addressing a relatively small number of initial courses in junior college education which represent a high-volume need. Computer hardware and software to meet this market must be engineered to performance and cost specifications not heretofore achieved but now within the state-of-the-art. The production of courseware to meet the high-volume instruction requirements and lead to mass dissemination will probably require a new technology of design and development, requiring a differentiated staffing pattern and new skills. To sustain the beneficial expansion of CAI will require the establishment of quality standards for courseware, and the training of adequate numbers of courseware designers and the instructional scientists who back them up.

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