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ABSTRACT

This paper presents Project C-BE suggestions for those investigating the possibilities of using computers as an instructional resource. Topics are suggested to stimulate thought with regard to both the problems and the potential of computer-based education. (Author/CH)

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AS AN INSTRUCTIONAL RESOURCE

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IMPLEMENTING THE COMPUTER AS AN INSTRUCTIONAL RESOURCE

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Today's information explosion, the growing student population, and an emphasis on accountability and individualized education, are challenging educators to implement more effective and efficient instructional systems. Institutions are turning more and more to technology to meet their needs. Computer-based techniques have great potential not only for facilitating administrative tasks, but also for serving as unique instructional media. This paper discusses a systematic approach to system change in education with an emphasis on computer-based techniques.

Once the decision to effect a change in traditional procedures has been made, it is imperative that the change be addressed pragmatically and thoughtfully. Institutions can and have spent large sums of money on what proved to be less efficient and more expensive instructional systems than those which a more thorough investigation of the problem may have uncovered.

A systematic approach to change in education would begin with a study of the current situation. This study would include:

- (1) A statement of the goals and objectives of the program.
- (2) An analysis of current materials and technologies used at the local institution.
- (3) Identification of specified goals which the current system fails to achieve.
- (4) An estimate of the costs of instruction and the results obtained.

Most important in the above list is the statement of objectives, which generates specifications for the end product and provides a criterion for evaluation of alternative systems.

Once the state of the art extant in current systems, instruction and hardware, has been thoroughly analyzed, the next step is to review and consider the results achieved by systems at other institutions. A search through the appropriate literature, attendance at national conferences, and personal contacts, should produce a fairly comprehensive list of

possible solutions. These solutions would then be examined in terms of what is feasible for the user institution. Generally, three alternatives present themselves:

- (1) A perfectly compatible and ideally suited instructional system is located and transferred directly to the user institution without modification.
- (2) A reasonably suitable system is available which, with some modification, can be implemented at the user institution.
- (3) No suitable, externally developed system is feasible, and the user institution is faced with the task of developing its own instructional system.

This last alternative is what most institutions now find to be true, not because similar instructional tasks have not been accomplished, but because the systems in use are not readily transferable. This lack of readily transferable materials has cost a great deal of money because of the repeated development of unique systems at many institutions, none of which has made a significant impact on the national need. Computer-based education is a dramatic example of this problem.

PROJECT C-BE, a Computer-Based Education project at The University of Texas at Austin, has been funded by the National Science Foundation to study the computer as an instructional resource. One of the goals of the project is to suggest guidelines for the development of computer-based materials. The following pages discuss some of these guidelines, as well as discussion of the dissemination and cost factors which should be considered when computer-based education materials are being designed.

Computer-Applications Development

The procedure recommended by PROJECT C-BE is the use of computers to supplement, rather than to supplant existing instructional systems. To design a course in which computers may be used, one must conceive of the course material in terms of a series of individual lessons (modules), some of which may be implemented more effectively by a computer. With this scheme in mind, the following are six suggested steps to develop functional, transferable, computer-based instructional materials:

Intent and Rationale -- State the rationale for the instructional materials, including a needs assessment, consideration of past and proposed efforts to meet those needs, an outline of the proposed development of the materials, and a cost estimate.

Design: Analysis -- Assess prerequisites; conduct a task analysis and state terminal behavioral objectives. This assessment also includes an analysis of learner traits, an analysis of media and equipment, and a comparison of the cost of various media.

Design: Synthesis -- Design learning activities, including provisions for individualization, pre and post tests, suitable media, and instructional material.

Production -- Produce, pilot test, edit, and revise the instructional materials.

Evaluation -- Assess the teaching success of the instructional materials. This includes an external empirical evaluation of the validity and efficiency of the materials, an internal evaluation of construct validity, and an evaluation of criterion test reliability.

Dissemination -- Distribute only instructional materials which meet specifications enabling other universities or other departments to utilize the products.³

These basic steps compose a dynamic process including several cycles for refinement, as indicated by Figure 1.

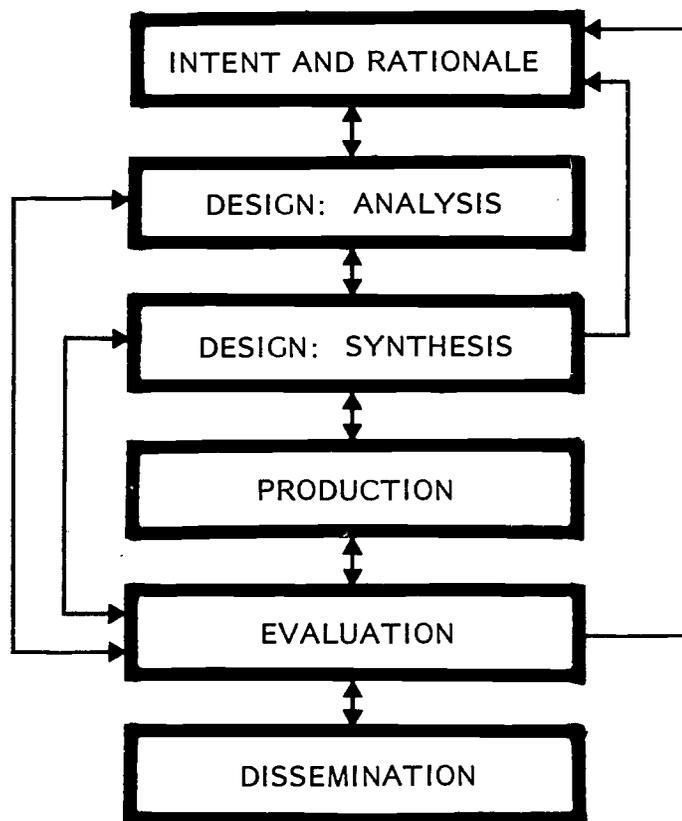


Figure 1. C-BE Design Sequence

Each of these stages, when broken down, includes analytic or fact-finding tasks, synthetic or creative tasks, and interactional tasks, as shown in Table 1. The analytic tasks are concerned with breaking down the problem, identifying solutions, and analyzing the instructional content. They are exploratory tasks which try to determine the necessary components, the practical possibilities, and the limitations of the situation. Synthetic tasks are concerned with selecting and combining components identified by the analytic tasks. They are aimed at formulating optimal solutions to the problem. The interactional tasks involve communication with other individuals involved in the project.

The processes involved in system change and computer-applications development are conceptually identical, but operate at different levels. Indeed, this same process will be repeated several times on more microscopic levels, e.g., the production of individual modules, the perfection of each display item, etc.

Dissemination

The technical and pedagogical information requirements for successful dissemination of computer-based educational systems present many complex problems. The transfer of programs between dissimilar computers is a mechanical process which is simplified by adherence to universally accepted standards for flow charting, programming language, and program documentation. The cost of transferring programs ranges from about 10% of the original cost for well written programs to a cost greater than the original cost for poorly prepared programs.

Research shows that the major obstacle to transferring educational computer programs is not the technical problem of transfer but rather faculty reluctance to accept the pedagogical elements of the instructional material. Acceptance of the instructional concepts employed is more likely to occur when program documentation includes: (1) a description of the academic environment in which the material was developed and tested: prerequisites, student academic profiles, instructional strategy, etc; (2) validation and evaluation data: pre and post test results, behavioral objectives, review by colleagues; (3) supplementary published materials: related texts, student handbooks, instructor handbooks, sample computer outputs; (4) miscellaneous information: operating cost data, student feedback, instructor feedback; (5) information regarding continued update and user feedback.

	ANALYTIC TASKS	SYNTHETIC TASKS	INTERACTIVE TASKS
INTENT AND RATIONAL E	<p>Describing the situation in general, preliminary terms. Stating the needs, defining the problem.</p> <p>Analyzing past efforts to deal with the problem.</p> <p>Determining what limits and opportunities are set by the institution, program content, media, target population, etc.</p> <p>Testing limits and advantages of alternate approaches.</p>	<p>Determining the global objectives, the goal of the instructional materials.</p> <p>Formulating possible solutions to meet the goal.</p> <p>Selecting most suitable approach, defining the project.</p> <p>Describing the project.</p>	<p>Eliciting and receiving information from those experiencing the problem.</p> <p>Reviewing the literature, consulting with others involved.</p> <p>Obtaining commitments of resources and putting them into operation.</p> <p>Promoting expression and exchange of preferences among persons involved.</p> <p>Consulting with persons involved to assist in decision making.</p>
DESIGN	<p>Analyzing program tasks, stating program prerequisites, intermediate and terminal objectives.</p> <p>Analyzing capabilities and limits of instructional media.</p>	<p>Describing program constraints.</p> <p>Selecting instructional strategies.</p> <p>Selecting instructional media.</p> <p>Designing flow charts.</p> <p>Specifying representation of intermediate objectives.</p> <p>Designing data collection systems.</p> <p>Drafting the instructional materials.</p>	<p>Consulting with persons involved to assist in decision making.</p>
PRODUCTION	<p>Evaluating data from pilot tests.</p>	<p>Developing program manuals, guidebooks, etc.</p> <p>Developing media.</p> <p>Editing and revising product.</p> <p>Assembling product.</p>	<p>Interpreting designs and drafts for production staff.</p> <p>Obtaining feedback, pilot testing sample of target population.</p> <p>Retesting product.</p>
EVALUATION	<p>Analyzing data.</p>	<p>Revising instructional materials as indicated by data analysis.</p> <p>Reporting results of program evaluation, covering effectiveness, efficiency, cost, etc.</p>	<p>Implementing program and obtaining data on instructional materials from designated sources.</p>
DISSEMINATION	<p>Identifying new problems for planning.</p>	<p>Releasing final product for dissemination.</p>	<p>Implementation of instructional materials at other facilities.</p> <p>Eliciting and receiving information and preferences from other users based upon operating experiences.</p>

TABLE 1. Curriculum Development

The creation of materials which correspond to the above guidelines will improve transferability and will increase the feasibility of establishing a central clearinghouse for dissemination of computer-based educational materials. The functions of such a clearinghouse would be to: (1) collect and catalogue materials, (2) validate and certify materials, (3) distribute materials, (4) process user feedback, and (5) update materials. When such a clearinghouse is fully operational, computer-based educational materials should transfer with the current ease of the textbook; the computer may then become an educational resource worthy of its cost.

Cost Factors of Computer Based Education

The data of greatest interest to people considering the development of computer-based education are those involving the cost. The costs of computer-based education may be grouped into the following categories:

The development of an educational computer resource requires the commitment of a large sum of money, either for the acquisition of a well-documented, proven, reliable system, or for the refinement of an experimental system. The cost of a computer system may vary over such a wide range that it is almost meaningless to talk about figures. Minicomputer systems may be purchased for as little as \$10,000, or large systems costing multi-millions of dollars may be shared by a large number of users. Equipment selection should be based upon long range plans and not on expedient purchase. In addition to hardware, special operating systems required for educational application must be available.

Courseware development costs refer to all costs involved in getting a set of computer-based instructional materials into final form for presentation. This is often the most expensive part of computer-based education. As stated previously, potential users have the option of adopting material developed elsewhere or generating new material. Should suitable courseware be located, the transfer costs can be significant unless the material was designed for transfer. Before a commitment to acquire courseware from an external source is made, a full audit of the quality and completeness of the materials should be made as well as estimates of

the cost necessary to bring the material up to acceptable standards. Courseware development costs have been estimated by numerous sources to be approximately \$1000 per hour of lesson presented with computer aided instruction (CAI). The actual cost will vary with the complexity of the material and the presentation techniques.

Computer operating costs or lesson presentation costs are charges for computer operating expense which are specifically chargeable to an individual interaction with the computer. For shared facilities, the allocation of costs can be very complex and often becomes almost arbitrary. For CAI presentation, a cost in the range of \$0.75 to \$1.50 per student contact hour is generally used. The cost will go up as the complexity of the material increases.

Terminal costs include the capital, maintenance, communications, and supplies costs associated with the student terminal. Purchase cost of the terminal may vary from \$700 for the least expensive ten-character per second teletypewriter to over \$10,000 for a graphics terminal. The curriculum designer should be aware of the terminal capabilities and costs when considering special terminal functions. Cathode-ray tube terminals (CRT) provide silent operation and higher speeds; however, some applications require paper output for future reference. The cost of special paper must be considered for those terminals which require it. Communication costs can become a major item if a student terminal is located at a long distance from the computer. In many cases, a maintenance contract can be purchased; but if a large number of terminals are owned by the institution, reliability can generally be improved by having a trained technician on the staff to do maintenance.

Among the numerous ways to reduce the cost of computer-based education are the following:

1. Acquire courseware from others at reduced cost. (This implies that anything new that you generate yourself should be of sufficient quality so that it can be used elsewhere.)
2. Select the optimal media for achieving the educational objectives. Not all curriculum is appropriate for computer presentation.

3. Consider group presentation where appropriate. Video projectors can present an on-line interaction to a large class and retain much of the feeling of involvement which generates enthusiasm at an individual terminal.
4. Create a student handbook containing precise instructions on use of hardware and courseware. This can save much student time and result in more efficient use of facilities.
5. Schedule facilities for as many hours daily as possible, thus increasing availability.

Conclusion

This paper presents some of the current PROJECT C-BE suggestions for those investigating the possibilities of using computers for an instructional resource; each section could be elaborated upon in more detail. For further information on any particular topic, please consult the attached bibliography. Our aim has been to stimulate your thinking with regard to both the problems and the potential of computer-based education.

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