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ABSTRACT

The management guidelines are divided into three parts. Part I contains a number of questions which site staff ought to try to answer when establishing or while operating a computer-based education (CBE) site. Each question is followed by a brief commentary. Part II contains suggestions for selection and training the staff of a site. Part III contains recommendations and suggestions about topics not previously introduced. The author suggests that all administrative staff responsible for the (proposed) site read those sections of the guidelines which are relevant to their situation. The questions are arranged roughly from general to specific and, though they frequently refer to features and situations found on the PLATO IV system, most of the suggestions provided apply to other CBE systems which offer the author great flexibility in designing courseware. (Author)

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GUIDELINES FOR ESTABLISHING AND MANAGING A COMPUTER-BASED EDUCATION SITE

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Introduction

The management guidelines are divided into three parts. Part I contains a number of questions which site staff ought to try to answer when establishing or while operating a computer-based education (CBE) site. Each question is followed by a brief commentary. Part II contains suggestions for selecting and training the staff of a site. In order to keep the commentary to the questions in part I brief, detailed discussions of some topics have been placed in part III of these guidelines. Part III also contains recommendations and suggestions about topics not introduced in parts I and II. For succinctness, some terminology common to CBE is used without previously defining the terms.

The author suggests that all administrative staff responsible for the (proposed) site read those sections of the guidelines which are relevant to their situation, return to part I to answer the questions for their project or organization, then compare their answers to those of other administrators. The commentary following most of the questions should help in formulating decisions.

A critical incident study was completed as a prerequisite for preparing these guidelines (Steinberg, 1977). References to the individual cases in that study are given in pointed brackets, "<X>".

The questions in the following section are arranged roughly from general to specific. As can be seen from the table of contents, the second half of part I relates only to sites wishing to use the PLATO system as an instructional medium.

In order to provide specific detailed advice and examples, this document frequently refers to features and situations found on the PLATO IV system (Lyman, 1977, Wood 1975). Nevertheless, most of the suggestions provided apply equally well to other CBE systems which offer the author great flexibility in designing courseware.

The staff members of the Military Training Centers (MTC) Group and the PLATO Educational Evaluation and Research (PEER) Group, contributors to these guidelines, have gained much of their experience through working with CBE developments within the military. In addition, the staff have all had experience with civilian, academic, or industrial CBE implementations. In general, we have found classification in terms of site objectives, cognitive level taught, etc. more useful than classification by military and non-military. Therefore, situations specific to military users are noted throughout the guidelines rather than in a separate section.

PART I--FUNDAMENTAL ISSUES IN PLANNING A CBE SITE

SITE OBJECTIVES

To what agencies, offices, and organizations does the CBE group report? What objectives do these people have for CBE?

This is a very important consideration for the future of a site, additional funding, etc. One cannot simply read the charge or charter given to the CBE staff and assume the goals stated there are complete or accurate. In fact, they have often been found to be unrealistic or hastily-written. For example, one reason for implementing CBE may be to gain recognition and enhanced public relations. Although this goal would necessitate high public visibility, the "official" objectives might refer only to educational uses and purposes.

In many cases it is imperative as a first step to bring the organizational expectations for CBE into line with reality, gently, so that no one loses interest or respect for the abilities and opportunities of the CBE system.

To what extent do the various administrators and agencies supervising the site agree on the objectives?

Disagreements on philosophies of education, orientation towards operational training vs. research, etc. have seriously hampered efforts at several sites (Himwich, 1977). Do not opt for a middle-of-the-road position just to satisfy people-- it is often untenable. For example, the "operational teaching vs. research" issue is basic and cannot be resolved simply by allocating manpower within a single project (e.g., two staff members for research, four staff members for instruction). The divide-and-appease strategy may work when several projects are available, but the constraints of research are nearly always in opposition to those for teaching.

Lastly, don't assume that because you have assembled everyone in a room, gotten their consensus, and even signed documents to that effect, that your job is now over. While such a step is important, it is generally taken early in a site's history, before impressions have developed. It it necessary to keep in touch with everyone (especially non-project staff) to maintain their support and cooperation.

Does the implementation of CBE at the site satisfy a single purpose (i.e., the fulfillment of a project commitment) or multiple purposes (i.e., general support of its parent organization)?

These guidelines distinguish between single purpose and multiple purpose sites and the suggestions appropriate to each at several points later in the text. Typically a single-purpose or direct-support site has a definite, limited staff engaged in fulfilling a research or development contract of a fixed length and for a limited audience. In contrast, a general-support site exists as a learning resource. It must attract authors to write lessons, but can seldom pay them or exert much control over their product or process. This type of site acts as a utility, distributing resources and services to a roughly-defined group of users.

Now, let us consider the answers to the question.

Direct-support only. In this case the objectives and management are relatively straightforward. CBE users have only a single objective and the site has only one way it can succeed. For example, a course director given two years, a staff of four and ten terminals to see if CBE could be cost-effective in an inventory control course would set up a direct-support site.

General-support only. A CBE site organized to provide general support to many small projects and to a dive se set of users and purposes is termed a general-support site. For example, a department or school which has 20 terminals and hires some trainers, consultants, and classroom proctors so that its instructors can try out CBE and use it in their classes would set up a site of this kind.

At a general-support site, it imperative to establish and examine the objectives of the site carefully: CBE terminals have sometimes become a solution in search of a problem. Converting general ideas about possible benefits of CBF into a half-dozen or fewer specific objectives for a site is an appropriate way to start. Reviewing these objectives every three or six months can help channel CBE resources into the most promising developments.

Both. If the answer is "both," relative priorities must be established early to avoid conflicts. General-support tasks can easily fall to the project staff, excessively burdening them with unanticipated and unwanted jobs.

Objectives for a General-support Site

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* Managers of direct-support sites may wish to read, but *
* not answer, the questions below. *
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Do you already have clients? Will the first task be to generate interest?

Some people will tear the keyset out of your hands to get to use CBE. They can see its potential and how they can use it. They are willing to spend the time to learn what they need to do to apply CBE in their work. Other people are busy, cautious, and skeptical. They have seen too many educational innovations come and go. Often after two to four years they will accept and embrace CBE--after they have seen materials in their field teach their students, for example. Short-term projects and innovations are troublesome company. Deep-rooted commitment develops slowly.

What are criteria for apportioning terminals, staff time, etc. between types of users, e.g., instructors vs. students, research vs. instruction, organizational use vs. private use (income tax, games), and groups within one user type: chemistry students vs. biology students.

Example situation. An instructor or his department reserves time for students to take lessons assigned for a class. After a few weeks, half or fewer of the students are using the CBE classroom at the reserved time. Many have found it more convenient to work late at night during unscheduled times, others can be presumed to be letting their assignments "slip," and there may be some dropouts. Problem: the CBE classroom is reserved, but the terminals are now under-utilized. Who can use the classroom, under what conditions, and how can scheduled students be protected?

Another example. The psychology department requests use of terminals, not for teaching or research, but for access to recreational lessons. They normally pay "volunteers" and wish to use CBE games as a reward for participation in their experiments. Can they use CBE this way or does this create a double standard? Why can't the history department schedule recreational use for their students and staff?

How focused and structured will the project be? Will it offer a service to all qualified to use CBE? Can students not enrolled in a course use the computer? Can any staff member use it as s/he sees fit or will only designated staff work towards limited goals use CBE? Will CBE projects require approval?

Will on-site programming consultation services be provided? Can a user expect to have programming done by a programmer?

If you wish to attract new users, or if you can't provide much released time for potential authors, the presence of a friendly programmer may mean the difference between moderate and miniscule lesson development. In fact, depending on the characteristics of the expected lesson developers, it may be unreasonable to invest only in hardware and/or computer services without also including funding for support staff <3B1.4>. Note: 3B1.4 is the number of a case from the critical incident list (Steinberg, 1977).

What amount of resources can be expended towards cheap, but-non-objective-fulfilling uses?

A typical situation: at a site trying to improve the training of electronics technicians, the instructors from the medical group at the school find there are lessons available which they would like their students to work through. Other than good will, the medical usage won't help the evaluation of the electronics course. What do you do?

Because of the vast courseware available on the PLATO system, this problem arises frequently. Furthermore, early in a project, when few locally-written lessons are available, the terminals are generally under-utilized, making refusal difficult. If permission is given to use terminals, instructors begin to depend on the PLATO lessons and are indignant when they can no longer use them because the time and terminals are reserved for other lessons and students <2A3.1>. Acceding to such requests consumes more than terminal resources. Typically disk space for routers, courses, and comment files is needed. Because the "outsiders" are unfamiliar with operating the system, additional time must be spent setting up the routers and teaching them how to enter a class roster and monitor student progress.

Much good will is earned and often new and successful projects get started from such informal beginnings, but it also happens that these efforts have drained talent and resources from a struggling site. The key is to identify those services which can be provided with the lowest comsumption of scarce resources and which will generate good will in the most promising places.

Objectives for a CBE Project

(The following questions related to project goals should be asked of EACH potential general-support user.)

Why is CBE being implemented?

The general answer to this question comes in two forms: "We think we can do 'X' better if we have CBE" or "We have some problems which we think CBE might solve." Both are reasonable answers, but the latter suggests some additional advantages. In order to justify the use of CBE in the first case, one must find unambiguous measures of "better" and then appraise the value of the improvement. For example, how much is it worth to increase the final test score of commercial pilots from 80% to 90%? Or how much is it worth to decrease dropouts by 10% and increase course attitudes to half a standard deviation above the school average? There is the also the problem that if CBE is declared better, someone else is implicitly determined to be poorer.

The questions above are relevant but have a different perspective whenever CBE is introduced because someone has identified problems such as unacceptably low performance on a final test or a high dropout rate related to poor student attitudes. When CBE is introduced under these conditions, it is probable that other methods have been tried and found insufficient; hence any solution is likely to be welcomed by all. Furthermore, the introduction of CBE terminals is less likely to be interpreted as a threat or an insult to the teaching abilities of the current staff.

In what domain do you expect CBE to show an advantage?

Reduced time and costs. When and if accomplished, this is one of the most easily-justified reasons for implementing CBE. One of the most difficult tasks in performing a comparison of costs for CBE and other media is the determination of the costs for the alternatives. The costs for developing and delivering materials via conventional media have a tendency to get "built into the system" and hence may be overlooked. For example, photocopying charges may get moved from the training budget to the administrative budget or costs for transporting students to an instructional center may come from the travel budget rather than the training budget. It is possible, however, that a given CBE implementation may eliminate certain of these costs, thus enhancing its cost-effectiveness. To become aware of such areas of savings, one must diligently search out all cost items for the conventional instruction. Saving time (and thus money) often means shortened training and reduced staff. Unless the time and staff can be used elsewhere, there is no real saving.

CBE costs are also difficult to calculate since amortization periods for courseware development and hardware are not standardized. Furthermore, when new development is occurring it is difficult to accurately apportion the effort directed towards maintenance so that a true "operational" cost can be determined. If a CBE site is new, it is hard to estimate how much of the initial training and set-up costs are one-time charges that should be treated differently than other recurring costs.

Because the measurements of costs and savings are complicated, a special effort beginning at the inception of the project, should be made to gather, record, and analyze cost data.

Enhanced student performance. Enhanced performance includes broader student skills, higher proficiency levels, or higher cognitive levels. Measuring an improvement in student performance requires a valid measurement instrument. In many cases this might be a standardized test of achievement. In others, it might be a criterion such as the percentage of students passing the bar exam, the proportion being admitted to a college, medical or graduate school, or the number of mechanics or realtors receiving certification on their first attempt. In cases where an accepted "yardstick" is not available, a considerable effort may be required to generate and validate appropriate measures.

Attitudes and motivation. Improvement of attitude and motivation are often expected to accompany innovations. However, unless poor attitudes and motivation have been observed and blamed for other problems, "happier" students and staff are not necessarily viewed by administrators as an asset worth increased costs.

Questionnaires and rating forms are the most popular ways of measuring attitude, but tangible actions are probably more convincing indicators (e.g., the fraction of students taking another course in the subject, the number choosing a career in the field, the attendance record or the voluntary dropout rate).

New services. The opportunity to take advantage of new services not available previously is frequently cited as a reason to acquire CBE service. For example, it may be impossible to offer realistic simulations without a CBE facility. Although this reason is valid, it usually has a more fundamental base in one of the other reasons cited above, e.g., to enhance student performance by providing (simulated) experience requiring higher cognitive skills such as analysis, synthesis, and decision-making.

Research. PLATO services provide tremendous opportunities for research. The availability of vast kinds and quantities of student performance data allows finely-tuned educational research to be carried out. The flexibility of the computer and terminal allows investigations of human psychology to be quickly set up, implemented, analyzed, and dismantled. Rather than reworking hardware to adjust timing, images, or control of the experiment, the experimenter can merely modify programming. The standard terminal peripherals are sufficient for many experiments and the terminal's ability to control other devices extends its flexibility. By putting all the directions on the computer, the experimenter can eliminate subtle differences in the directions given to various groups. Directions can be precisely controlled over a long period of time despite changes in staff, etc.

General Considerations. Many worthwhile goals cannot be measured immediately (e.g., ease of updating knowledge, success in non-classroom situations). Nevertheless, they should not be eliminated from the list of reasons for acquiring CBE services.

A frequently-overlooked point is that CBE *per se* cannot fulfill the objectives for its implementation listed above. That is, simply writing and/or using CBE lessons will not automatically improve attitude, performance, retention, or offer the other advantages available. CBE services offer a medium through which such advantages *may* be realized--not a guarantee that they *will* be simply because CBE is being used. If students using CBE lessons have shown higher retention, it is because teaching strategies which provide high retention have been used. Because many of these strategies require a CBE system such as the PLATO system to handle their complexity, people have erroneously attributed the effects to the system rather than to the effects achievable *via* the system. This misunderstanding has led some sites and projects to "write some lessons and measure how they are better"--a path primed for failure.

Since cost-effectiveness always seems to be an issue of foremost importance, we have prepared a list of uses for CBE which are potentially cost-effective. Naturally, many factors determine the actual cost-effectiveness of any endeavor, but the uses suggested have shown or suggest a higher-than-average potential. The list is found in part III of these guidelines.

How will cost-effectiveness be measured?

This question cannot be answered until the definition for cost-effectiveness is broken down and clarified. If the site or project must show cost-effectiveness, must all parts of it be cost-effective? That is, can some research or service efforts be carried at a loss because of their overall beneficial nature? For example, consider a site which is nearly "breaking even" and is also supplying free statistical and computational services to departmental and agency staff. Even if the users of the statistical packages cannot be made to pay for the service, perhaps the value of the service provided to them can be reckoned and subtracted from the expenses of the site. It also may be practical to show that some groups or operations are cost-effective, though not all are.

A second consideration revolves around the time period for which cost-effectiveness is calculated. If one includes courseware development costs, the amortization period is important. Also one must consider whether courseware development costs for CBE lessons should be measured against courseware development costs for traditional media. If a new course has been written to incorporate CBE lessons, one must measure cost-effectiveness in terms of the costs for replacing the CBE materials with conventional instruction.

A third consideration is whether cost-effectiveness must be demonstrated while the terminals are under-utilized. For example, consider a course which saves \$100/student for 100 students/year. If the CBE terminals are in use 1/3 of the time for that course and cost \$20,000/year, one has two ways to calculate cost-effectiveness. Assuming fewer terminals cannot service the class, one can point out that <u>costs</u> exceed savings by \$10,000/year. On the other hand, extrapolation of the costs and savings to full utilization of all terminals indicates a <u>savings</u> of \$10,000/year.

What features of the CBE system do you intend to use?

This question is discussed more thoroughly in part III, "Why Use a CBE System Like PLATO?" That discussion suggests that using only a single feature of the PLATO system may not be justified: less sophisticated devices may provide more cost-effective computation power or graphic terminals or large networks. Use of a system like the PLATO system is especially justifiable when several such features are needed together and/or when the exact nature of the task cannot be pre-specified. For example, if one knows the best way to teach bookkeeping, one may be able to choose a CBE system (or other medium) which just meets the needs of the training and provides no extra capabilities.

What is the nature of the project effort?

This question is important for deciding the number of terminals, choosing the staff, and planning the overall goals for a project.

Indirectly instructional. This would include experimenting with hardware and software; using PLATO notefiles and communications network for surveys, etc.; employing lessons and packages for graphic, electronic, and mechanical design or statistical routines; or studying CBE as a computer science subtopic. These uses require few terminals and little coordination; only a small support staff would be needed in most cases.

Instructional research. A research effort would require moderate amounts of lesson design, little effort devoted toward establishing and operating a classroom, and high emphasis on collecting and analyzing data. At least one person with high programming proficiency would be required.

Operational teaching/training. The major emphasis here would be toward efficient production of high quality materials. A curriculum designer and the lesson designers would form an important part of the staff. Liaison with students and instructors requires appropriate personality characteristics within the staff. The goals of low-maintenance, easily-proctored lessons and standardized classroom procedures distinguish this from other types of use.

What is the magnitude of the project effort? What is the total number of hours of material to be prepared? What is the total quantity of human resources available?

These are important questions whose answers must be compared to see if the resources match the task. In many cases project planners have failed to calculate the rate of production required to meet the stated goals. In other cases they have developed more materials than the site's terminals can deliver. They failed to calculate the available terminal hours per week and compare that to the class size <2D1.2, 2D1.3, 2D1.4>. Directions for appropriate planning calculations and obtaining estimates of expected values are given in part III of these guidelines.

How important is it that the products (lessons, service routines, packages) from the project be used at other sites?

Although widespread usage is often a good, objective indication of the general value of a series of instructional materials, it is difficult to force. When the materials are well-written and effective, users may flock around without encouragement from the developers. However, taking steps to guarantee that materials will gain rapid acceptance in several institutions may be counterproductive. Generally, in order to promote acceptability, the proposed courseware is planned, outlined, and critiqued by a committee of proposed users. Finding formats and strategies which are widely acceptable may result in wringing the "life" out of the instruction. On the other hand, ignoring committee recommendations may limit the number of users. In summary, widespread use of lessons is a worthwhile goal which may sometimes best be pursued indirectly. Efforts to produce high-quality lessons which are easy to use and which are widely known through seminars, brochures, etc. may be more effective than efforts to create a product acceptable to all potential users and compatible with their ideas.

A frequently-ignored issue is that a project or site evaluation is necessary <u>whether or not</u> research questions are being answered. Also, the evaluation must be planned as the project is being initiated, not as it nears the end <4A2.1, 4A2.3>. Below are examples of issues to be negotiated and questions to be answered during the initiation of a project or site.

SITE/PROJECT EVALUATION

(A site manager reading this section should substitute the word "site" for every occurrence of "project".)

For the project to survive and thrive, who MUST be pleased? Who else SHOULD be pleased, if possible? For each of them, what will constitute a satisfactory project?

The general categories here are: the level above the project (sponsor, supervisor), the project level (colleague, instructor), and the level served by the project (client, student). This question might be restated as "What are the current problems of each CBE-related group?" and scrutinizing those problems which CBE might alleviate or exacerbate.

Administrator. In order to fund CBE, a president or board of directors or sponsor might have to be shown one or more of the following indications of "success":

(a) cost savings,
(b) total dropout/fail rate cut in half at a cost of less than $500 per student retained,
(c) overt evidence of strong acceptance by instructors (CBE-related publications, requests for transfers, CBE time and/or terminals), probably accompanied by media coverage,
(d) "remarkable" improvements in student attitude, attendance, enrollment or performance.

Instructor. Most instructors would be satisfied if their total workloads were decreased or if their students showed heightened interest. Instructors would be happier if grading, test preparation, paperwork, and remedial teaching were reduced, giving them more time for classwork. They may fear losing their job to CBE, particularly when "cost savings" are mentioned. Lastly, they want to feel that they are an essential part of the instructional process.

Students. Students would be pleased to do "something different," spend less time on "busy work," and work at their own rate. Some would like to learn to program and others would like to play games. They don't want to have to learn another skill (using the CBE system) in order to learn the course material. Unfortunately, some may dislike the thoroughness and attentiveness which are required in order to complete a CBE lesson--they can't sleep in class. Students enjoy the ability to make mistakes privately, the immediate feedback supplied by CBE, and the fact that they control the speed of presentation.

Whose responsibility is it to see that project goals are realized?

Experience has shown that even when sites have carefully considered and chosen objectives early in the project, they have sometimes failed to see them met because (a) the objectives are never discussed with and supported by the project staff, (b) because progress towards meeting long-term goals is seldom checked by management, or (c) because responsibility for meeting certain objectives is not assigned to anyone. An example of the last problem is that at one site it was generally agreed that "enlisting instructor support" for CBE was critical to the attainment of project success. The executive manager felt that the task would be done by the manager, the manager felt that the the task could best be done by his staff, and the staff felt that liaison was the manager's role. The circular logic was discovered when the traditional staff exhibited resistance to viewing or using CBE lessons. Though the CBE project had been set up to solve a widely-recognized training problem, the traditional staff was unaware of the project's goals. They perceived the CBE staff as an outside group who thought they could bring in a machine and, without working with the current teaching staff, do a better job.

Does the project have a definite end or re-evaluation point? At what points in the project are evaluations of success/failure going to be made?

Failure to realize that nearly every project does have potential ending points can be unfortunate. Furthermore, it is essential to realize that most go/no-go decisions will be made prior to the actual ending date or contract period. Thus the extra effort needed to prepare an interim report of successes and achievements may be a far more effective investment than effort devoted toward writing a final report once all the data has been collected <3B5.1>.

If hardware delivery, courseware production, or student usage goals cannot be completely met, can a reasonable evaluation be made?

Although optimism is important, it is only prudent to consider and prepare for potential problems. In a sense, these guidelines are a detailing of potential problems for a site or project; the section "Contingency Planning" in part III of these guidelines lists specifically some predictable problems and options. A report edited by Steinberg (1977) examines over 100 incidents in the evolution of PLATO projects. By learning about possible difficulties, a site manager can take steps to protect and stabilize a site.

Will the evaluation assess the attainment of a pre-established goal or involve a comparison with an existing course or program?

This is a basic question that determines the character of the project and the evaluation. A description of the pros and cons for each type of evaluation is presented in a chapter in part III. Briefly, it is extremely difficult to avoid comparisons with other teaching media and techniques even if the formal evaluation does not require it.

What dimensions will the evaluation examine?

Because project objectives vary so widely, this section can provide only suggestions about what might be measured and a few warnings about commonly-overlooked items. The suggestions below should be regarded as a "shopping list" from which to select measures important for the objectives of the project.

Quantity of use

Contact hours (The PLATO system automatically records hours/terminal, hours/site, and hours/user, but it doesn't distinguish between recreational and instructional lessons.)

Number of students or users

Number of instructional staff involved

Cost

Production (Are training costs included in development costs? If so, costs will be rather high initially. If not, an appropriate amortization rate must be chosen.)

Delivery (If development is going on simultaneously, it is difficult to apportion costs between these two activities.)

General (When considering costs, add overhead of retirement, fringe benefits, space, etc. As noted elsewhere, the manner of reporting costs is important. In one case the costs for developing PLATO materials was 4.7 times higher than for conventional materials, but the number of users attracted to the PLATO materials was 9 times more.)

Value of new services (Even if no one will directly pay for using the CBE system to help do engineering homework problems, end-of-course grade averaging, and statistical processing, the value of those services can be estimated.)

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* If the objectives of a project or site are instructional, *
* some of the following measurements may be relevant. *

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Student performance and attitude

Consider using these: scores on standard tests, class grades, attitude ratings, pass/fail ratios, absenteeism, attendence at voluntary sessions, lesson completion times, test completion times, error rates in lessons, use of self-tests and voluntary review, extra practice problems done, retention of training, number who take follow-up courses, number in current course who enrolled based on recommendation by prior students.

Quantity of lesson production

Hours, on-line averages or replaced hours may be measured. (A complication: how can routers, computer-managed instruction (CMI) routines, or packages for circuit design, statistics, etc. be included? They have no "completion time.")

Non-terminal time savings (reduced homework reported by students, reduced test preparation and grading reported by staff, etc.) may be recorded.

Quality of lessons

At least five different measures are possible: use by others (number of users, amount of use); colleague opinion (formally or informally assessed); student opinion (questionnaires, on-line comments, the number who take follow-up courses); student interaction data (error rates, proportion and type of unanticipated responses, requests for -HELP-, fraction of questions answered correctly on first attempt); and the need for proctoring (number of students one proctor can handle).

Note: Many of the suggested evaluation variables were taken from the October 18, 1972 PLATO Evaluation Note entitled "Some Evaluation Variables for PLATO Authors," by R. Allen Avner.

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* If students' performance and attitude variables are to *
* be examined, the following questions are relevant. *
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What is the total flow of students? How many times will classes start during the evaluation period?

The flow rate is a critical element in determining the structure of any evaluation. It imposes an upper limit on the number of students who can be included in the evaluation. Because formative evaluation during lesson development requires student "guinea pigs" to test the lessons, the rate at which validated lessons can be produced is dependent upon the frequency of new classes. Because evaluation plans may also need revision and refinement, courses which frequently have new classes forming are easier to evaluate. For example, a one-year evaluation period may be sufficient or even excessive in a military training situation where classes of 10-20 students start every two weeks. In a college or university setting only two or three classes would start during this same period, and a primary or secondary school environment would provide only one opportunity to test the students. No matter how many students are available, a one-shot evaluation is extremely hazardous.

What is the total impact on students in terms of number of hours on CBE or the total fraction of training they receive from CBE? Is the impact significant enough to produce a measurable effect?

Giving half the students in a class a four-hour CBE lesson in the middle of a 16-week course is unlikely to produce a measurable difference on the final test. The sensitive and thorough data collection features available via CBE make many immediate measurements of effectiveness easy, but long-term effects of small or moderate amounts of CBE exposure may be difficult to detect.

In order to perceive a measurable effect on <u>course</u> variables (dropout rate, course attitude, etc.) 10% or more of the course may have to be taught via CBE lessons. Fortunately, individual chapters, modules, or sections of a course (1-2 hours) can be successfully evaluated if one can examine uncontaminated "micro" variables. For example, performance on several test items covered by the CBE instruction and measured immediately after the instruction or within a week or so may show an effect (if there is one). However, it is less likely that the same variable measured at the end of the semester (when other studying or sources of information are likely to supplement the student's knowledge) will show as sharp a difference between treated and untreated groups.

Can you design a measure which is fair, but which is sufficiently sensitive and specific so that student compensation for good or bad instruction won't wash out differences?

A test which asks questions related to examples or problems given in a CBE lesson is unfair to students not learning from CBE. But questions which are fair can also be self-taught by extra study.

If non-CBE instruction for a topic is terrible, CBE instruction is excellent, and students (particularly highly-motivated ones) know that they will be rated, graded, or selected on the basis of their knowledge about the topic, their motivation may cause them to compensate by studying extra hard: differences between types of instruction may be erased.

Can students and instructors be sufficiently controlled so that students in a non-CBE section really get none?

Hysteria about being denied CBE training has not reached the level which medical research must deal with, but the free-flow classrooms associated with college/university settings, combined with full review privileges may lead to adulterated samples when highly-motivated students feel they are missing out on something. Conversely, CBE-trained students who felt CBE training was incomplete have been known to study the notes and texts of students from control groups.

Will students be compared to existing standards?

If existing standards are used, the value of the CBE lessons may not be clear. Because CBE lessons are likely to be recently constructed, they may teach topics which standardized tests do not cover yet; because they may use simulations and inquiry techniques to teach to a higher cognitive level than was possible previously, old forms of tests may not indicate the greater effectiveness of the CBE materials.

If one creates new tests, how can performance on two different tests be compared? The best answer to this dilemma is to duplicate testing. Continue to use old test forms for a while to show (hopefully) equally good results with the CBE materials. Simultaneously develop new tests, show that they measure appropriate knowledge or skills (i.e., validate the tests), then measure the performance of students receiving both traditional and CBE instruction. It's a lot of work, but the only way out of the dilemma.

Are standardized end-of-course tests available?

If so, and if the tests in use are valid for the project objectives, you can save a great deal of time by not developing new tests.

Are any tests given upon entrance to the course?

If entrance tests measure background and aptitude for learning the subject, you may be able to use them to verify the validity of an evaluation. For example, when dividing classes for a comparative evaluation, it's useful to show that both classes are equivalent. Such measures may also be useful for statistical control or for assessment of aptitude-treatment interactions.

Will the evaluation assess the project itself? The staff? The training? The management?

Who will carry out evaluation: project staff or an outside group?

PROJECT PLANNING

What proportion of the total available terminal hours/week are being set aside for project use?

This question is designed to prevent overscheduling of terminal resources. In ordinary circumstances, one finds that terminals are used about 30-40 hours per week. At open-use sites such as universities an additional 20-30 hours per week are logged during night and weekend periods. Some interpretation of these numbers is needed. One can and should schedule more than 30-40 hours/terminal/week, but one should not expect that actual terminal use will be 100% of what is scheduled. Students who finish early, students who are absent, and classes that don't use all available terminals contribute to a "shrinkage" of the utilization rate. The 20-30 additional hours cannot ordinarily be scheduled because students may be unwilling to take the risks of lost data or uncertain computer availability.

What is the basic orientation of the staff in charge of the CBE site?

Three types seem to dominate: computer scientists, educational specialists, and departmental staff. They each have strengths and weaknesses.

Computer scientists. They master the system quickly and they may be able to perform maintenance, but some of them have a predilection for disassembling equipment and/or connecting additional equipment, either of which makes use for ordinary purposes more difficult.

Fducation specialists. Their abilities with instructional design may be a significant help in producing high quality courseware, but their concerns for instructional design may lead them to decide that only experienced designers should be allowed to write lessons. In some cases their zeal for evaluation will produce so many surveys and questionnaires that potential users will dwindle.

Departmental staff. When a department acquires CBE terminals there is sometimes a tendency towards unreasonable possessiveness; no matter how under-utilized the terminals are, no one but students or staff from that department is allowed to use them.

At the end of the project, who will own or control the equipment: the sponsor, the principal investigator, the department or group funded, or the parent organization?

This is one item that should be answered by a careful reading of the contract rather than by requesting an oral or written opinion from an administrator.

FINANCIAL CONSIDERATIONS

Will the terminals and computer equipment be insured?

Items should be inventoried so that insurance policies or other protection will apply to stolen or vandalized equipment.

Will a department, agency or group which uses CBE be rewarded in their budget for being innovative or charged for using an expensive resource to lighten their load?

Both of the views above seem logical: a department should not be penalized for taking advantage of CBE, but, conversely, they should be charged in some way if teaching burdens are lightened. Perhaps the only benefits are to the students. In any case, justifications for such administrative decisions are subject to criticism from either side and should thus be considered in advance.

Who will own lesson copyrights and collect royalties?

Funding Agency--It may want them to be free for all users, but it can't provide maintenance or updated versions.

Parent Institution--It provides office space, possibly terminals or more.

Department--It may provide terminals, released time, and students.

Author--He may claim authoring was done in "free" or "research" time (in academic circles, this is similar to acting as a textbook author).

Have you prepared a complete budget?

The list below includes some frequently-overlooked expenses incurred by CBE sites.

Long distance telephone calls (Troubleshooting terminal problems is normally attempted this way. The large distances between most CBE sites increases normal telephone usage.)

Staff acquisition (Interview trips, etc.)

Conferences (Since exchange of information is vital in this rapidly changing field, staff members must travel to conferences.)

Consultation (Experienced CBE staff are hard to find. A site may have to engage consultants to provide certain skills and services.)

New journals and library acquisitions

Postage and shipping for repair parts and repaired terminals

Above average copier usage

Room preparation (Lighting, sound absorption, air compressors and pipe, extra electrical power)

Furniture (Terminal carrels, chairs, study tables)

Printer supplies (Paper, ribbons or ink)

Supplies for peripherals (Microfiche, audio disks, illustrator fees, film, developing, tape recorders)

*. See Francis (1976) for estimates.

ENVIRONMENT AND PHYSICAL PLANT

Where should the terminals be located?

Unfortunately, some laboratory environments are too hot (over 80 degrees F), too dusty, or contain corrosive atmospheres. Some sites have installed telephone lines to small classrooms, demonstration rooms, and offices so that a few terminals mounted on carts can be shared among infrequent users. In lighter moments, this is referred to as "terminal à la cart."

What is the size of your proposed CBE classroom?

Be sure to include room for carrels, communication equipment, audio units or other peripherals, air compressor for microfiche, microfiche library area, proctor location, and possibly a study area for off-line activities.

What is the distance to the CBE classroom from other normally frequented areas (housing, food centers, other classrooms, or libraries)?

Surprisingly, one of the strongest consistent dislikes college and university students have expressed about PLATO is the distance to the terminals. Several otherwise-promising military uses were discarded when it was realized that the time savings achieved by PLATO instruction would be offset by the time needed to get to and from the PLATO classroom. On the other hand, usage statistics suggest that scattered, small classrooms (6 to 8 terminals) are often inefficient in utilizing their terminals.

What physical arrangements are planned: a learning resource center, a media center or CBE classroom? Will there be separate locations for authors? Will authors use terminals in a separate room, or have reserved terminals? Where will demos be held? Will individuals have terminals in their offices?

Terminals in offices often have low use. An authoring/demonstration room may be advisable so that students are not disturbed by visitors. Install only a few terminals so that all are nearly always occupied and authors must overflow into the student classroom. Because it is more likely that authors will use "student" terminals than that students will use "author" terminals, total terminal utilization will be maximized with this arrangement. A further benefit is that authors will be able to observe what's happening in the classroom.

Will project staff members have their own offices? Where in relationship to those of other staff?

It is often valuable to give staff with part-time CBE appointments a second office near the CBE installation in order to encourage them to devote a fair portion of their time to CBE activities. It is a mistake to establish a CBE office area away from the offices of subject matter experts and instructors working in related topics. This tends to promote polarization and to increase liaison problems.

How many hours a day will terminal access be permitted? Who will maintain a schedule? Who will proctor the terminals? How will access to student and author areas be controlled?

The answers depend on the type of site and the type of use, but several points seem to find general agreement: (a) it is inefficient to employ authors as proctors, although in small sites (fewer than 8 terminals), it may be necessary. Good authors have a talent which is too rare and costly to warrant interrupting their production with details which could be handled by a proctor being paid a lesser wage; (b) it is inefficient to lock up the terminals after 5:00 p.m. if there are potential users for evening hours; (c) unattended, unproctored terminals quickly accumulate food and beverage debris and have become targets for vandalism in a few cases.

Will study materials, tests, microfiche, etc. need to be checked out from a proctor or library?

These needs are additional considerations which may influence the location and layout of a PLATO site. Since many sites have only microfiche needs, several special arrangements have been found to be workable. Some sites which service only a limited user population (which needs only a few microfiche) seal the slide selector door from the inside so that the microfiche can be permanently left in the terminal. When several different microfiche are needed at one site, lessons may be designated to work only at certain terminals. Some sites check out microfiche from a nearby library. Both kinds of sites have found that theft-prevention procedures are needed.

STAFF SELECTION

Staffing a Direct-Support (Project) Site

Will the staff be recruited from inside or outside the organization, department, course, etc.? Can new staff be hired, or must existing staff be rearranged?

In order to acquire staff experienced in CBE, one generally needs to look outside the organization. However, if the staff contains too large a fraction of new people, the project may be considered an outsider's venture. Some existing staff members with numerous, broad-based contacts (not necessarily "old-timers") should be included for purposes of liaison, especially in a project whose goals include operational teaching and training <2C3.1, 2C3.2>.

Will the CBE project have a separate staff or will most or all of the staff hold other/previous department affiliations and supervisors?

There is a potential problem "collecting" the released time promised by departments--especially when the fraction of released time is 25% or less. Also, if control of assignment, recommendations for promotions, etc. is retained by another department, there is an authority vaccuum for the director of the CBE project. Unless the "home" departments are strongly committed to CBE, staff members may be rewarded for ignoring their CBE duties in order to participate in departmental committees, tasks, and functions. On the other hand, if it is necessary to fund a CBE project with "soft" money, it may be possible to lure talented staff only by giving them status and a position with an established, on-going department.

Will authors work full time or will they divide their time with other teaching, operating, or research tasks?

This topic is discussed in greater length in part II, "Choosing a staff." Briefly, full time may be too much for some positions, such as authoring, but as noted elsewhere, structured tasks such as teaching tend to get more than their proportionate amount of effort compared to unstructured tasks such as authoring CBE lessons. <2C4.1, 2C4.2, 2C4.3, 2C5.1, 2C5.2, 2C5.3>

For example, one half-time author who taught in higher education attempted to prepare lessons in the morning and teach classes in the afternoon. He found that his mornings were punctuated by students dropping in, meetings with course staff, and "rush" jobs from his teaching tasks: writing tests, grading lab books, etc. In contrast, few PLATO requirements were so major as to cause him to miss a lecture or not supervise a lab session. He summarized: "If you don't have a lecture ready or a test graded, you'll get people very upset. If the PLATO lesson isn't finished, you just give a lecture instead. No one gets upset. No one can say how long it should take to write a CBE lesson."

Will authors work independently or as part of a team?

This question is discussed in part II as well as in Mahler, Misselt, Schell, & Alderman (1976). Briefly, team structures are advised when a rapid start-up is needed or when it is not practical to teach the subject matter experts to become CBE authors <3C3.3, 3C4.1, 3C4.2, 3C4.3, 3C4.4>.

Will everyone who is trained in CBE authoring be expected to become part of the project?

The discussion in part II suggests that if possible, a non-prejudicial escape option be provided so that people who are not removed by early screening procedures can later be moved to and fro. other projects, tasks, and assignments within and outside of the CBE project. This requires that job descriptions and staff expectations be prepared with such moves in mind. Frequent within-project re-assignments have been: an author who had difficulties with TUTOR or with instructional design becomes a subject matter expert; an author with exceptional skills becomes a reviewer and, later, an instructional designer; a programmer with inherent instructional design skills becomes an author; and colleague reviewers who have learned TUTOR become authors <2C3.1>.

Will promotions change job descriptions and force staff to leave or upset the project organization?

Particularly in the military services, but to a degree in civilian employment, promotions may disrupt the orderly progress of a project by forcing new leadership roles on the promoted group member or by forcing these workers to positions outside the project. The potential for this problem should be analyzed as part of staff selection and contingency plans should be prepared <2C2.3, 3A3.1>.

Staffing a General-Support Site (Volunteer Authors)

This kind of site is sometimes found in conjunction with a project (or direct-support) site and often occurs in public higher education institutions. Typical examples would include universities or medical schools where the authors are professors or instructors who wish to create courseware for their own courses. They might wish to draw upon the talents of a programmer pool and to consult with an instructional designer. The degree to which each would learn CBE skills would vary, but many would not wish to try to become experts in yet another field.

Who is available to be an author? What are the practical limits and what rewards are available? Must existing tasks be rearranged or may new staff be added?

Some agencies have erroneously believed that merely providing access to CBE services is sufficient. There may be false economy in not providing a large enough support staff to aid and direct appropriate use of the facilities <3B1.4. 3B1.5>.

Can a university author count lessons he has prepared as "publications."?

Up to now the answer has generally been "no," but this issue may be negotiable and feelings about it have been changing. The main stumbling block has been the absence of "jurying" or a "review" comparable to that a publication in a professional journal would receive. With or without a substitute for this "review" it is worth trying to get courseware counted towards publications since this issue could be pivotal to a professor already pressured for time. At least one project has hired respected authorities to critique their CBE production and has used the critiques as support for their arguments to give publication credit for CBE courseware.

AUTHOR TRAINING

Where will new authors be trained?

If a site has been able to hire staff members of sufficient background and experience to train the rest of the group in the CBE language, instructional design, and using the CBE system, the answer to this question is obviously "on-site." Because experienced staff are rare, many sites are forced to rely upon outside instructors. The advantages to training one's staff off-site seem to slightly outweigh on-site training.

On-site. If the trainers can be brought to the site, costs are typically lower because fewer people must travel and additional staff can be trained or can consult with experienced users for only the cost of their time. Though the advantages of being trained by several different trainers is lost, it may be compensated for by a longer training period (made possible by lowered costs).

Off-site. Training at a large CBE center provides trainees with much broader experiences than they could receive while staying at home. Important experiences include: visiting a functioning classroom, meeting other authors and subject matter experts in the same field, arranging for reviewers and users for future materials, and viewing or using optional devices available such as terminal peripherals.

If many staff are to receive CBE training, but only a few terminals are to be installed at the new site, there may be an advantage to obtaining training at a large CBE center where terminals can be reserved for training classes.

Can the staff get credit for the CBE training?

It is important for staff in the military service, as well as many primary, secondary, and community college staff members to receive written certificates documenting the satisfactory completion of training.

How can the project staff be protected from the normal jealousy associated with special projects and advanced equipment?

Many of the keys to preventing jealousy and maintaining cooperation have been mentioned previously: avoid hoarding equipment and terminal time, include part-time as well as full-time staff, indicate with words and actions the important role of non-project staff to the overall project, demonstrate regularly and fervently the common goals being addressed by both project and non-project staffs.

The need for liaison to promote good will between CBE and non-CBE groups is nearly always underestimated. The introduction of a new technology which is not familiar to all the staff is rather threatening. The possibility of getting left out or left behind is clear. Efforts should be made from the beginning of any project to orient and introduce staff to the CBE system. The construction of the CBE classroom should make it easy for non-project staff to observe what is happening and use the terminals themselves without feeling they are intruding <2A1.1, 2A1.2, 2A1.3, 2A1.4, 2A2.2, 2A2.3, 2A2.4>.

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* The remaining questions in part I of these guidelines *
* refer to situations in which the CBE system is to be *
* used primarily for instruction. *
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COURSE DESCRIPTION AND ISSUES

Throughout the next section it is important that the concept of a "course" is clear. We will use it to mean a presentation of multiple concepts during a period of a month or more. Single-concept, short term training presentations will be refered to as "mini-courses."

Is course lock step, group paced, or self paced?
Will this format continue to be used?

Lock step. This format allows for very easy scheduling of lessons and very high terminal utilization rates. In higher education environments, however, students will use unscheduled times and terminal locations, if available. This tendency lowers the utilization rate during scheduled times, but does not affect overall usage rates. Courseware in a lock-step format is easy to introduce into a course: the instructor simply informs the students that they should report to the CBE classroom rather than the lecture hall. Because most students will be taking the same set of lessons during a class period, computer storage (ECS) is efficiently used, and if the lessons are well-polished, little proctoring is needed. Although, by definition, no time can be saved with lock-step usage, the intrinsic self-pacing of CBE will normally force the instructor to make some provision for slower students to finish during a period outside normal class hours. It may also be necessary to provide supplementary materials for those who finish early.

Group paced, Structured study. "Structured study is a situation in which all students in a class spend the same fixed amount of time studying. This situation may be brought about by limited terminal access time or by the limited training day found in some military training environments. In a structured-study situation CBE strategies involving forward branching or pre-testing to skip sections of lessons and thus accelerate the progress of bright or experienced students are found to be self-defeating. They tend to put inordinate pressures on slow students because the self-paced, individualizing nature of CBE separates students in terms of total time to master the topic. Hence a lesson that is judged or proven to be efficient under self-paced conditions may be inappropriate and even inefficient under group-paced conditions. It is especially true that certain strategies "normally" used in CBE lessons will increase lesson production time without saving student time. This occurs because the rate of the slowest student determines the rate of the group.

In both lock-step and group-paced formats, students finishing early can create problems. They must be released from class or given recreational lessons or lessons on optional topics. (Giving them lessons used later in the course would only put them farther ahead). Slow students may have to retake a lesson in an atmosphere of shuffling chairs and/or "pinball alley" (i.e., while other students are loudly enjoying recreational lessons). As the slow students struggle to finish, they realize that the progress of the whole class is being held up until they finish. In such a situation both fast and slow students save time by "exchanging answers" to the questions in the lesson.

Group-pacing is often used when the nature of parts of the instruction is such that self-pacing is not possible, e.g., demonstrations, close laboratory supervision, etc. It is often seen as a compromise between self-pacing and lock-step. Because of the existence of the lock-step phases in the training, the number of instructors is generally the same as that for lock-step training. ECS demands on PLATO are only slightly larger than that for lock-step.

Despite the above problems, group-pacing can reduce the training period required while adapting to varying student populations. The latter is an important attribute for the military services whose students may vary in experience with the time of year or the existence of a draft or mobilization effort.

<u>Group paced, Free study</u>. In this situation CBE could be used freely outside class, but the class would still be group-paced. Unfortunately, our experience does not include any examples of this training format. The most typical free-study environment, public education, supplies few, if any, payoffs for early completion. Because presentations and demonstrations typically require the orderly completion of prerequisite materials, this format is of limited utility.

<u>Self paced</u>. Self-pacing is ideally matched to a CBE environment, but it requires stand-alone equipment setups or additional instructor/proctors in cases where laboratory practice accompanies the course. Because students in a self-paced environment often use CBE at random times and places, an instructor is typically unavailable. In most PLATO CBE situations, this presents few problems, since notes between students and their instructors are easily written.

Without firm guidelines, students tend to allow self-paced coursework to be displaced by assignments with definite deadlines. Self-pacing provides both the problem and the solution here. In some institutions, such courses can simply be finished the next term. Alternatively, the instructor can set up intermediate milestones with deadlines that must be met by self-paced students. Because self-pacing suggests that computer-generated or computer-selected quiz and test questions are needed (for test integrity), production of a self-paced course may take longer than for a group-paced or lock-step course. However, administrative problems associated with remediation, absences, etc. can be nearly eliminated.

What are the roles of instructor in each of the training formats?

Lock step. Because this is the familiar, conventional teaching format, it will be used as a basis for comparison but will not be discussed explicitly.

Group paced, Structured study. An experienced military curriculum developer argues convincingly that this mode of operation is the worst possible for instructors. Because the slowest student sets the rate, the instructor cannot sit down to review and carefully teach the slow student--that would mean the group would move at a still-slower rate. All the instructor can do is to prod the student, or sit at the terminal and give him the answers so the class can proceed.

Self paced. In this mode, the instructor can stimulate fast students and help slow students, while the computer carries the burden for most information presentation and testing. The computer's dominant role may bring out the best in dedicated staff, the worst in lazy staff ("If CBE is so good, let it do all the work"). Some instructors take a while to adjust to the idea that they are no longer the "main attraction" knowing all the information and delivering it from high atop the lecture platform. In fact the role of an instructor is much more similar to that of a private tutor. Once instructors adopt this view of their role, they generally find it rather rewarding.

Is the course presently organized into modules, chapters, and lessons?

These may provide convenient divisions for allocating assignments, scheduling production, and organizing changes to a course.

Are course objectives available? Are old tests and exams available? Lesson plans?

If new staff members are to develop course segments, such documents and information are extremely valuable for providing directions. Developers should be cautioned, however, that following old lessons or lecture notes too closely can be far too limiting. Old tests can be used to indicate if the same level of mastery is being achieved as well as perhaps providing some provocative questions for the CBE materials. It is worth some effort to retrieve such tests.

What media and strategies are used in current course?

Film or video cassettes, filmloops, audio tapes. Often the effectiveness of existing materials can be increased by teaming them up with CBE. For example, a filmloop may contain points overlooked by students. A computer-composed test may focus attention and produce greater mastery with little cost.

Lab exercises. In many academic situations, students complain because lab work seemingly has little relationship to classroom topics. This problem frequently occurs because labs must be planned weeks in advance so that equipment and supplies can be fresh and ready. Variations in the class progress means that the lab and lecture get out of synchronization. A potential solution is to tie a short CBE lesson to each lab in order to relate it to topics in the mainstream of study.

Pre-lab simulations can familiarize students with the objectives, apparatus, and procedures associated with an exercise. This solves the problem of students who don't read the lab directions before the lab, speeds equipment set-up thus allowing longer exercises to be completed, and reduces damage to equipment because of misunderstanding and haste.

When the purpose of a lab is to collect, analyze, and report data, CBF lessons can reduce the instructor's lab book grading time by accepting data, checking calculations and analyses, and performing grading.

Drill. A community college math instructor reported that he once spent a lot of class time drilling students. He now can use class time to present concepts and he lectures only once or twice a week while letting the computer supervise the drills. In other cases, complex algorithms for determining when a student should review missed items have been easily managed by the computer.

What are the outstanding strengths and weaknesses of the course?

An analysis of strengths and weaknesses should point out the parts of the course which should be changed, the parts which should be retained, and may suggest a direction to start when looking for solutions to course problems.

If a course is known for its fine case studies, perhaps new case studies which are individually interactive could be added. On the other hand, if the course is known for having fine lecturers, they should not be replaced. Instead, consider developing a series of lessons to grade homework problems, provide prerequisites, or deliver supplementary/enrichment materials.

What kinds and amounts of homework are assigned?

CBE-assisted homework is potentially a way to upgrade performance, but it will not save money directly because homework time is cost-free in most environments.

Will CBE lessons be used during class time or will they be considered like homework--to be done outside of class?

Depending on the way CBE lessons are assigned, students may treat CBE-taught topics differently. For example, students who are used to out-of-class work being practice exercises for what is covered in class will treat out-of-class CBE assignments similarly: students who do not normally complete homework assignments are likely to ignore CBE lessons. However, if most students normally perform out-of-class assignments, new topics and additional material may be taught via CBE without using class time <3F3.4>.

Will the addition of CBE expand the existing course?

CBE developers sometime forget that adding adjunct simulations, practice exercises, computer-aided problem solving, mastery drills, etc., will expand the amount of student time required to complete the course. Although this can sometimes be offset by providing labor-saving routines for statistical analysis, etc., the overall impact on the course length should be examined.

What is the student population for this course--homogeneous or diverse? Does the course have prerequisites? Is there a need for remediation?

Out-of-class remediation for a handful of students may be a cost-effective technique for reducing the completion time of a group-paced class or for reducing the dropout rate.

Is the drop-out rate large and/or problematic?

The answer depends on the situation. In a public education institution, the dropout rate is probably irrelevant unless it is embarrassingly large or unless departmental funding is dependent on the number of students completing the course. In military and industrial training institutions and in privately-supported colleges, dropouts are typically expensive. CBE materials may be part of a potential cure for a dropout problem.

Is the course taught to a level of mastery and/or are grades assigned?

CBE is ideally suited for teaching to a mastery level, but some institutions require some sort of score, grade or other discrimination device.

The decision to teach to a mastery level requires more different forms of tests than are typically used in a non-mastery situation since re-testing to show mastery is necessary.

It should be noted that some students prefer NOT to achieve mastery of the material and find it frustrating when they cannot relax and take a "gentleman's C" for the course. Whatever the medium used, the introduction of mastery requirements eliminates traditional grading. Essentially, everybody gets the same grade!

Will CBE lessons be phased in as they are completed, or will the course be suddenly converted?

Tidy research designs and the practicalities of formative evaluation and operational teaching prescribe different answers. For "tidy" research, the full complement of CBE lessons should be implemented at once (to all students or to half of a randomly-selected group of students). From the point of view of a department or instructor trying to upgrade the training or solve teaching problems or a curriculum developer wishing to tune the courseware to the students, the favored approach is more likely to be to make a subjective evaluation of the value of new materials and implement immediately all those which seem completely debugged <2D1.5>.

Who will decide what goes on to the CBE system? What criteria will be used?

As indicated previously, this question is of critical importance. If instructors or institutions distant from the developers are expected to use the materials, this is a logical point for requesting their input. The criteria for choosing topics for CBE development depend on the project objectives, modified by the considerations of what CBE can do especially well. As much experience as possible should be employed when making these decisions. This is one of the times during a project when an outside consultant may be needed.

Will the lessons written be considered to "belong" to a course or to an instructor-developer? Will future instructors be required to use some, any, or all CBE lessons written by this organization?

In a higher education environment, if the lessons are to be written for a specific course to be used by current or subsequent instructors, it may be important that potential users be involved at all stages. Requesting reviews from non-CBE instructors is often a good first step. Failure to involve others may result in unused lessons when other instructors teach the course. In a military or primary-secondary public education facility, instructors have less choice about teaching materials and the problem outlined here occurs less frequently <3F1.1, 3F1.2, 3F1.3, 3F1.4, 3F2.2, 3F2.3>.

Will lessons be written so they can be used in several different courses?

On the surface, this path seems prudent because it allows development costs to be amortized more quickly. But there are some hidden pitfalls. Normally the backgrounds of students in the different courses will vary considerably. ne group of students will be bored or the other strained unless Herculean efforts at individualization and ability tracking are made. These efforts, of course, boost development time.

A better approach is to write lessons for higher ability students, test and polish it for them. Next, have a few students from another course use the lesson. Note their problems, and modify a copy of the lesson to meet the differing prerequisites of the other users. In many cases less-prepared students will point out difficulties which should be repaired in <u>all</u> versions of the lessons. Nevertheless. it is so much simpler to write a lesson for a single, narrow audience that it is worth the slight additional computer storage and modification time needed for multiple versions. Furthermore, the author will not waste any time installing extra help and remediation which are not truly needed.

THE STUDENT POPULATION

How are students selected for the course? Are any predictive tests administered?

Knowledge about the students is important since many design decisions are based on the breadth and depth of student abilities. Listed prerequisites are often out of date and should not be accepted without examination of current class makeup and/or future needs. In technical and vocational courses, reading level and math skills should be checked if possible. On the other hand, don't spend time administering or retrieving test data (e.g., SAT scores) unless the use for them is clearly established.

Is motivation a problem for students?

If so, improved motivation may be an objective to be achieved via CBE. However, do not expect improvement merely because of the change of medium. Few improvements are automatic. One must use strategies to enhance the relevancy or increase student involvement, for example.

What problems do students have during and after this course?

The effect of CBE can be more than proportionate to the fraction of time spent using it if bottlenecks can be alleviated and hurdles can be lowered. This is also a fine way to enhance motivation.

Is terminal use to be scheduled or free flowing?

Since CBE is inherently self-paced, it is convenient if students can use terminals freely. Thus they can skip classes when they are ahead and they can find vacant terminals when they are behind. In any case, some convenient unscheduled time should be provided for slower students. This brings up an interesting semantic problem. The term "slow student" has become a euphemism for "poor student." Another term must be found to describe students in a self-paced mastery situation where "slowness" carries a much smaller negative connotation.

Do students need additional rewards for achieving high performance?

For example, some sites allow students to play games as a reward. It is probably as motivating (and certainly cheaper) to install a publicly-available "record book" for displaying the score of high achievers within instructional lessons. One successful format incorporates programming to eliminate the recording of embarrassingly low scores and to cause the premature obsolence of, say, the sixth through tenth best scores. The latter feature deletes some old scores so that achieving a "recordable" score does not become impossible.

How pressured are the students for time? for grades?

CBE will not be popular if students already pressed for time perceive that CBE assignments take longer than assignments for conventional media. Similarly, the use of CBE-given grades (or grades from any mastery-type training) must be carefully considered for students who are especially anxious about grades (e.g., pre-med students). It is generally inappropriate to "curve" scores from mastery exercises in order to provide "grades." Another problem with grades based on performance in a CBE lesson is that some lessons can be repeated by a student. Which grade should be recorded: The first? The last? The average of all attempts?

DEVELOPING A CURRICULUM

Are you preparing a curriculum, not just lessons?

Although some reasonable uses of CBE involve the creation of a single lesson not terribly closely related to other topics being taught, one usually wishes to integrate the CBE lessons with each other and with materials in other media. However, because many users start out thinking small (especially at a general-support site), it frequently happens that a course eventually contains a collection of lessons which cannot be transformed into a curriculum.

It is folly to develop a lesson without adequately planning for its integration into an educational context. If you are not planning to modify a whole course, but rather are creating a few lessons to present some difficult-to-teach topics, the concept of a mini-course may be the best approach. A mini-course is an integrated cluster of on-line and off-line materials which teaches a single, limited-range topic. The critical features of such a cluster are: (a) well-defined, but limited prerequisites (b) consistent terminology, objectives, and perspective and (c) a definite ending point (from which another mini-course can be launched).

Creating lessons without a master plan can be inefficient. For example, one developer explored the use of the CBE system writing several kinds and styles of lessons. He introduced the CBE system, the keyboard, and checked the student's math skills in each. As he developed clusters of lessons, he found that the students were being re-introduced to the CBE system (and having their math skills tested) again and again. Furthermore, several lessons just would not "fit" into a cluster. Eventually all lessons had their introductions removed, and some lessons were divided into several parts so they could fit into clusters.

Will the lessons be used for mainline instruction or as an adjunct to other instruction?

Mainline lessons provide an easier format to justify costs and show savings, but they require more care and testing during creation and implementation (because they are the sole source of information about a topic). If sufficient time is available, one path which is often successful is to use the lessons in an adjunct mode initially until any problems are eliminated (or a skeptical audience is won over) and then use them as mainline lessons replacing conventional materials. This conversion from "adjunct" to "mainline" should be phased in beginning as soon as possible because student standards for each type of usage are likely to be different and the elimination of the previous mainline materials may reveal some oversights.

Are you modifying an existing curriculum, or creating a new one?

Most people realize that unless they modify their curriculum somewhat, they won't be able to make good use of their CPF system; fewer realize that if their modifications are too ambitious, they may not be able to handle the twin tasks of curriculum development and mastering a new medium.

The decision about where to strike a balance depends on the experience of the group with respect to curriculum development and CBE instructional design as well as the manpower available.

Because of the vast possibilities and the great number of choices available from a CBE-based curriculum, sites with moderate curriculum design experience (in limited media) have become mired and have fallen short of their goals. Furthermore, some kinds of evaluation are virtually impossible if a major revision is made simultaneously with a change in media.

Although writing an entirely new course is a very difficult task, the result may not be so threatening to current instructors. Furthermore, one may be able to use the CBE system to avoid capital costs associated with labs or demonstration devices.

Will media other than CBE be used? Who will be responsible for deciding what media to use for each topic and for insuring that the media are interfaced?

There are significant problems with teaching large portions of a course only via CBE lessons; CBE resources are expensive, they are inappropriate for some uses, and they have unneeded power for some applications. Mixing media is more efficient, but requires someone to integrate from the beginning all materials written on a topic <2D4.1>.

What offline materials or paper copies of CBE lessons will be made available? on what conditions?

One of the greatest shortcomings of PLATO CBE materials produced so far is that they attempt, unsuccessfully, to be totally stand-alone. Although providing manuals, worksheets, study guides, outlines, and summaries to accompany CBE lessons is very sensible, it is seldom done. As a result the cost-effectiveness of some applications may be reduced. For example, students who want to have something to study after they have left the terminal are forced to take notes. Note-taking is an effective study strategy for some kinds of learning, but cheaper alternatives than copying from a CBE terminal are available. Forcing students to take notes from the terminal may change a lesson which saves time (and money) into a lesson which takes extra time.

Instructors may fear that students will skip the CBE lesson if they can pick up a summary of what they must learn. If a summary sheet can adequately express all the concepts which must be learned, there is no reason that the CBE lesson should be used. If the CBE lesson is truly necessary, but the students are lazy, the instructor might wish to make summaries available only after the student has successfully completed the lesson or only several days before major tests <3F1.2>.

Will published lessons (written at other sites) comprise a significant amount of the courseware used?

Yes. It is a major task to interface the topics and courses taught at one's own site with lessons selected from curricula written elsewhere. Someone should be given responsibility for gathering lists of available materials and aiding instructors in the selection of lessons based on more than their titles. As in textbook selection, a problem sometimes occurs because materials which are optimized for students may seem unstimulating and unappealing to an instructor <2B2.5>. Suggestion: include several students on the lesson selection committee.

Modification of lessons written at other sites often entails a great deal of work unless the changes involve only the addition or deletion of displays and text. Documentation is frequently lacking and there may be problems in finding the author and receiving permission to modify his work.

No. Unless terminal delivery is phased, the decision not to use materials written elsewhere will result in a long period of under-utilized terminals. Furthermore, the relatively large development costs associated with CBE may threaten cost-effectiveness if some existing lessons cannot be employed. An insightful comment by a well-known educator unfortunately applies to many CBE developers: "Researchers and educators frequently demonstrate a strong resistance to the use of someone else's innovation. It has been said that if there were a Nobel prize for educational research, we would have to nominate an entire generation of researchers for their co-discovery of the wheel," (Molnar, 1971).

Are lessons to be written simultaneously for all parts of the course or will you start from one end working toward the other? Which end will you start from?

All parts simultaneously. This may be necessary if several authors with different sub-specialties are employed. Spreading the effort may make testing more difficult and may require more effort to assure that objectives and prerequisites match up.

Beginning at the end. When large, consecutive portions of a course are to be rewritten to include CBE instruction, it is frequently advantageous to begin lesson writing and implementation at the end of the course. This intuitively-wrong order has the following advantages:

1. The first materials seen by a student (those most likely to turn him on or off to CBE) are those written when the authors and staff are most experienced in CBE development.

2. The process follows the order of a formal task analysis: if mid-way through the development, one finds students unable to understand the material, one can easily add prerequisite topics because the development of prerequisite topics is always "down the road" in terms of time. If a part of the task analysis must be postponed, development can nevertheless start immediately.

3. If the course is being converted from lock-step to self-paced as the CBE materials are introduced (a common occurrence), students can move through the conventional materials together, then finish the self-paced part of the course at their own rate. If the course were rewritten beginning at the start, students using the self-paced CBE materials would have to catch up or wait for the whole class to begin the conventional lock-step section of the course. Any

time savings realized from self-pacing and CBE lessons can be taken advantage of, even during preliminary testing phases.

4. If for some reason the development effort falls short of its goals in terms of quantity of lessons produced, it is less likely that the evaluation plan will be completely invalidated or impaired. As noted above, actual time savings can be measured, not estimated; CBE-influenced attitudes will be "fresh"; and the higher-level cognitive skills (often taught near the end of the course) for which CBF can often show cost-effectiveness will be present in the completed portion of the course.

LESSON TYPES

Will tests, as well as lessons, be programmed for CBE usage?

Some sites have used CBE almost exclusively for testing because of the capability for computer-generated test items, easy recording of test item statistics (e.g., reliability, difficulty level, discrimination index), and the opportunity for feedback (Guerra, McDaniel, Kaufman & Fuller, 1977). Other instructors have felt more comfortable using CBE lessons, but keeping their tests in a conventional format. Still other users, faced with an evaluation plan calling for a comparison of students taught via CBE lessons with students taught conventionally, have realized they must test conventionally in order not to give unfair advantage to students familiar with the CBE system.

What problems with test security exist?

To avoid embarrassment, test security should be checked thoroughly before items are entered on-line. Procedures for checking student identification should be planned and built into tests. Allowance for system failures during testing must be made.

LESSON STANDARDS

Will all lessons produced on-site have to meet a set of standards?

In general the idea of "maintaining standards" is a sound, practical one. It may be difficult, however, to impose such standards on professionals using the terminals at a general-support site. Fortunately, the need for strong standards is greatest in a direct-support project situation. The question of creativity vs. control cannot yet be answered easily and objectively. An affirmative answer to the above query naturally raises the issue of what standards will be set, who will enforce them, and how the enforcement will be implemented. Previous attempts to impose standards by regulating storage space for new lessons have quickly raised authors' ire. In other cases, the "enforcer" had a lower pay or rank than the authors and programmer and hence was ignored by them.

It is overly-optimistic to expect new staff to prepare polished lessons in their first attempt. Phased-in standards are likely to be more app opriate. For example, the first lesson might be written without the imposition of any formal standards. When the second lesson is written, a copy of the standards could be provided, along with a justification for using them. As later lessons are prepared, the use of standards would be encouraged and enforced. If necessary, the initial lessons written would be brought within the guidelines. Drawing up the standards with the aid of the author staff promotes motivation and understanding of the need and use of lesson standards.

What kinds of standards might be imposed? What purpose does each serve?

Documentation. An appropriate level of documentation protects the investment of the sponsor, agency, or department by insuring that another user wishing to update, correct, or modify the programming can do so in an efficient, reliable manner. It also insures that the author himself will not waste time trying to interpret programs he wrote long ago.

Standards for ECS, CPU, and DAPM. These are abbreviations for lesson size and the demands which an operating lesson places on the computer. If the demands are excessive, the lessons will be unusable, ineffective, or will reduce the lesson access for others at a site. Standards for usage of computer resources such as these insure that the reputation of the site, authors, and system will be protected and that students trying to learn from the lessons will not be annoyed or impeded.

Lesson format. Several aspects of a lesson's format might be subject to standards. If strategies inappropriate to CBE are used, cost-effectiveness will become a problem and expensive development time will be wasted. For example, lecture-like lessons are sure "losers" yet are commonly prepared by some authors. The presence of a title page, statement of objectives, and author name on each lesson can provide a cohesiveness among lessons which students find comfortable and efficient. The inclusion of restart points protects a student from system failures and allows him to leave the system and return without re-doing part of the lesson. By including data collection standards, a general support site can insure that authors who use site resources also generate information to provide a basis or justification for the continued support of the site. Data collection standards can also prevent errors in lessons from going undetected and plaguing subsequent groups of students.

Some sites include a requirement for a criterion-referenced test at the end of each lesson. Properly constructed, such a test will allow a student to get "credit" for a lesson only after mastery of the material has been demonstrated. Without such a test, some students feel that completion of the lesson means that further study of the topic is unnecessary. Authors of succeeding lessons may find that students are unable to understand those lessons because of inadequate mastery of the prerequisites.

Most sites include some sort of subject matter and editorial standards as well in order to assure that all facts are accurately stated and all grammatical, semantic, spelling, and typographical errors removed.

If lessons from other sites are used, will they have to meet the same criteria? Who will modify and upgrade them?

MANAGING FORMATIVE DEVELOPMENT (EVALUATING LESSONS)

What criteria will be used to determine when a lesson is finished or validated?

Although few lessons are ever truly "finished," we use that word here to indicate that a lesson may be used by a class of casually-proctored students. Some combination of student use (involving both the total number of students and the number of testing/revision cycles) and colleague review should be established (and adjusted with experience) so that lessons do not reach students prematurely.

How will lessons be evaluated? How often will they be evaluated? Will they be examined after they are finished or validated?

Evaluations during both formative development and as part of a summative development are warranted. At some sites nationally-known experts in a field are brought in to review lessons which the site staff consider finished.

The aspects of a lesson which are normally evaluated include: the programming, the instructional design, the conformance to site standards, and the subject matter accuracy. In many cases the evaluation is broadened to include student performance results, student and instructor comments, and data concerning the quantity of usage. For a more detailed discussion of the aspects of formative development reviews, see Francis, Goldstein, and Call-Himwich (1975) and Call-Himwich (1976).

Are student "guinea pigs" for testing lessons readily available? Whose responsibility is it to provide them? What rewards can they be offered for their cooperation?

A group of eager students, possessing about the right background for the material and a readiness to try out lesson fragments, can be an enormously valuable asset for a site. The absence of such a population allows authors to create too much material before testing it with students. Since authors tend to do this under any circumstances, one must present them with many easy opportunities t. btain student feedback.

If sufficient terminal time is available, it may be possible to "pay" students bv giving them time in recreational lessons. The amount of time they earn is proportional to the number and value of their comments.

Are lesson objectives available? Will they be written? Who will write them and when will they be written?

There are advantages to choosing a course for which the objectives have already been prepared. It is easy to be deceived, however, unless one obtains copies of the objectives and reviews them carefully: the written objectives are often outdated and do not reflect the content and emphasis of the course. In many cases they are so general that they have little value. Written objectives also tend to record only those topics which can be explicitly taught and tested. Looking at such too-narrow objectives may limit the potential applications of CBE. For example, the goal of having a student ask questions, plan an investigation, and carry it out may be an unstated and unmet goal which CBE exercises could provide. Similarly, the objective of training for discrimination of sounds may have been deleted because appropriate hardware was not available prior to the installation of the CBE system.

Who is responsible for verifying that the objectives are appropriate in terms of content and level of knowledge?

Are objectives needed?

This question arises frequently, especially among staff who have had unpleasant experiences with writing and using objectives. Former classroom teachers may have been forced to use objectives by administrative fiat and may harbor a grudge against objectives because they seem useless.

Furthermore, it is true that learning objectives are sometimes so obvious they need not be stated. For example, the need for students to solve a particular type of problem may be well recognized (e.g., two-dimensional, frictionless, collision problems or non-disproportionation, oxidation-reduction equation balancing). In these cases the objective is to be able to solve any problem of that type and the test is to give the student a problem and let him solve it without aid. A more formal, written objective is not needed because any subject matter expert seeing the lesson topic could immediately determine the material being taught.

Typically, the lesson developer is not so lucky as to have such "tidy" topics to teach. Instead, the depth of the instruction (Are exceptions to the rule to be included?) and the breadth of instruction (Where does this lesson end?) must be determined as part of the lesson development process. Because a CBE lesson will probably interact with more students than a classroom instructor, the CBE developer can and should spend more time in the planning and objective writing than the lecturer. A well-written set of lesson objectives can provide the developer with guidance and act as a touchstone so the author knows what is relevant to the lesson and what is superfluous, when the lesson is done, and how to determine if the lesson is adequate.

PART II--FUNDAMENTALS OF CHOOSING AND TRAINING A CBE STAFF

ESSENTIAL SKILLS

When considering what staff to hire, an administrator typically begins by forming job descriptions, then looking for people who match the job descriptions. Because of the limited availability of staff with CBE-related experience, we suggest considering the skills needed for the project rather than roles or job titles to be filled. Below we have listed ten skills typically needed within a CBE development staff. In a small project, two or three people may have to provide all the skills listed; even in a large project, several roles are generally combined. Because skills are present to varying degrees in different staff members, premature combining of skills into a job description should be avoided. Analyze the contribution of each candidate in terms of which project needs he could serve and what flexibility his talents would offer.

Administrative/managerial. This skill is needed to coordinate the project, maintain standards, and expedite non-clerical details. This is a general project support role--to smooth the path and monitor progress. It entails less decision-making than the skill of leadership, discussed next.

Leadership. This important skill provides direction, gives rewards or prods, sets a pace or an example, makes decisions, and initiates changes.

Curriculum coordination. This skill is necessary to insure that the curricula or modules produced are well-integrated packages. It requires the broadest subject matter experience. Although this skill requires much coordinating, it is not necessarily the manager's function.

Subject-matter expertise. This skill is employed when preparing objectives, providing content, writing text, choosing examples and non-examples, describing typical misconceptions, pointing out exceptions to rules, etc.

Instructor experience. This skill is necessary for providing insight about the students' backgrounds, problems, motivations, futures, and typical complaints.

Instructional design. This often overlooked or underestimated skill provides knowledge about the process of planning, designing, implementing, and revising instructional materials.

Evaluation/testing. These two skills each probably deserve categories of their own, but their relatedness means that they are often possessed by a single person. These skills serve to promote, implement, and aid formative and summative evaluation practices. Depending on the project objectives, the preparation of a research design and an analysis of results may also be needed.

CBE/language expertise. This skill is needed in order to program lessons and advise in the efficient uses of the computer. It is also needed to explain and exploit the various communications features, the courseware design considerations, and the system characteristics associated with the CBE system. Experience on other computer systems, particularly other CBE systems, is a frequently-needed compromise in staff selection which may broaden the total base of experience enjoyed by the site.

Editorial skills. These skills enable a site to "polish" the final product, to "debug" the non-programming problems, to sharpen definitions and explanations, to correct grammar and spelling, and to insure consistency and smoothness through the instructional materials.

General support. The following skills are needed to support the efforts of the primary CBE development effort: the skills of on-site hardware repairmen, proctors, secretaries, clerks, photographers, and illustrators.

A very careful assessment of the skill needs and available talent can take advantage of the special backgrounds of the staff. Thus rather than considering that one needs a staff of a manager, secretary, five authors, two programmers and an evaluator, and that one should find people who best meet those descriptions, a wise administrator can choose people whose experiences are complementary even if the candidates' qualifications do not exactly match typical job descriptions. A flexible policy in finding personnel might allow an administrator to choose a staff composed of: a subject matter expert (SME) with curriculum development experience in another field; a programmer with some testing experience; a current course instructor who has subject-matter experience; an evaluator who has worked in instructional design; a subject matter expert with computer science courses, but no teaching experience; a CBE author with a 'obby related to the subject matter; a secretary who was a Journalism major for a year; a manager who is an experienced course instructor and has written or revised many of the course materials; an SME with some courses in learning and instruction as well as an artistic flair; and an SME who was a technical writer in industry.

We emphasize flexibility in staff selection because the most consistent finding of a study of PLATO courseware development procedures in military and civilian environments (Mahler, et al., 1976) was that courseware groups changed their organization one or more times during their comparatively short (two to three year) project lifetimes. The changes in staff roles caused by reorganization can be somewhat minimized by emphasizing skills over positions. Skills will change rather gradually, and provide continuity during periods of reorganization.

Staff reorganizations caused by weaknesses of the members are sometimes simplified if skills rather than job titles are emphasized. If a staff member is unable to perform satisfactorily and discharge and replacement is not feasible, reassignment of duties may be the answer. For example, an author having trouble mastering the CBE language might be assigned only SME responsibility. Alternatively, that author might be used as a proctor or lesson editor.

SKILL COMBINATIONS

When choosing project staff from available candidate pools, one is forced to look for individuals who can provide several of the ten talents and skills listed above. One must also be prepared to make compromises in filling positions and consider the flexibility of individuals should their role or the project change. Suggested below are several common skill combinations which result in high productivity.

The leader of a project often has the additional responsibilities of curriculum coordination, project management, or both. It is, however, important to see these as different, but related, roles. An overworked project leader can, if necessary, assign these responsibilities to others while still maintaining his authority and position.

Assumption of the leadership and evaluation roles by a single person is most common in research projects. Furthermore, in several rather successful courseware development projects, the leader acted as instructional designer for the group. We would suggest this combination be employed in those instances where an instructional designer has exhibited managerial skills or vice-versa.

The curriculum coordination is often performed by an especially experienced subject matter expert. Experience and breadth of knowledge are more important than depth, however.

Instructor experience is generally accompanied by subject matter expertise. However, military training instructors are not so likely to be true subject matter experts. The lesson plan and training materials are often sufficiently specific so as to allow persons with narrow subject matter expertise to be effective as military classroom instructors, but they may not be able to perform more general roles such as a reviewer for a CBE development site. These instructors must be supplemented by "genuine" subject matter experts; they should definitely not be expected to supervise the curriculum development.

TEAM AUTHORING

One of the decisions that will affect staff selection is the organizational structure of the staff. At a general-support site, all the authoring may be done independently, but most project sites adopt some sort of "team approach." The concept of an authoring team varies from site to site: at least three different things are meant by a "team."

1. In the loosest sense, any group of several authors working toward the same set of goals and helping each other may be said to comprise a team. However, unless they share responsibilities for programming, instructional design, etc., we classify them as independent authors rather than as members of a team <3C3.1>.

2. At the next level of team association, a single staff member makes the decisions about the design, content, and programming, but "subcontracts" site support staff to furnish the content and/or the programming.

3. The strictest team approach divides the tasks of designing, furnishing content, and programming so that no single person makes decisions about all three of these areas. This approach may be compared to an assembly line where once a lesson has completed one stage of development, the control and responsibility passes to the developers of the next stage. In practice, loops built into the process give development groups a "second chance" to see and modify the lesson.

The first approach requires the least coordination and allows the most flexibility for staff to enter or leave the project. However, because few authors possess all of the ten or so skills needed for effective CBE development, there is the potential danger for creating an uneven, inconsistent set of lessons.

For that reason, many sites starting out with the first approach described above modify it to become more like the second approach. Groups of two to four staff members are placed together so that the strengths and weaknesses in the various skills can be compensated for. In general, the result is enhanced productivity and greater uniformity. In some cases, authors who have been successfully using the independent approach are allowed to continue in that mode.

Management needs for the small-group teams are somewhat greater because of the additional effort to organize and coordinate the teams. Generally, however, it is the manager's decision to assume a larger administrative burden in order to achieve greater control of the project <3B2.1, 3C3.3, 3C4.1, 3C4.2>.

In a team authoring structure the productivity of individual members is more difficult to measure and the loss of one staff member affects the whole team. On the other hand, because the team members need not possess so broad a range of skills, they are more easily replaced.

Our experience with the strictest form of a team approach indicates that for authors familiar with other authoring modes, the lack of identification with a lesson seems to offer fewer internal rewards. However, from an administrator's point of view this reduction of ego involvement may be a desireable outcome (Francis, 1976, p. 32). The most frequent implementation of the "sub-contract" form of team authoring occurs when subject matter experts plan and design a lesson, but delegate the programming responsibilities to someone else.

Evaluation of the efficiency and effectiveness of each of these authoring approaches is confounded by effects of the quality of the authors and the objectives of the site. Highly-skilled authors tend to prefer and perform best in an independent authoring mode. Generally, when this mode has been tried and discarded, it was because the authors' inexperience precluded their writing lessons with sufficient quality or in sufficient quantity to meet project goals. Reduced author independence has typically been viewed as a technique for increasing the quality of the average lesson and/or increasing the production rate.

A rather extensive discussion of authors, teams, and the dynamics of authoring structures found on PLATO has been prepared by Mahler et al. (1976).

STAFF SELECTION GUIDELINES

In this section, we offer some comments concerning the selection of key staff members. The roles of director, instructional designer, and author are discussed, and brief comments are made about several other positions.

Director

As is typically the case, the choice of director is critical to the success of the project. Therefore this position is discussed in the greatest detail.

In general the following have been found to be true: (a) a directorship typically cannot be handled part time when the staff numbers three or more, (b) the director must have sufficient time available to be able to watch students use CBE lessons, (c) the director must be open-minded enough to ignore preconceptions and intuitions gained in other media or with other student populations, and (d) the personal interests and background of the director must be matched with site goals (e.g., don't hire an instructional designer for a hardware project and vice-versa) <2B1.1, 2B1.2, 3A1.3>.

A frequently-overlooked problem is the question of the "distance" of the director or other higher administrator from the project. The project director must be far enough away from the day-to-day problems of authoring so that these matters don't obscure the long range view. Some directors have tried to add directorship responsibilities to their full-time author duties <3A1.1, 3A1.2>. At the other extreme, some directors whose jobs entailed non-CBE duties have been frustrated when they are circumvented in the decision-making process because they had too little time to familiarize themselves with the current problems and potential solutions.

When a project-oriented site is to be started, some additional insights can be offered. It is most important to obtain the director as early as possible--as much as 6-12 months before the arrival of the full complement of staff and terminals. This is especially important if the director is not familiar with instructional development in CBE. An "early start" has given many directors a chance to gain experience and make a few mistakes without incurring large penalties. If the director cannot be acquired early, he should be available at least at the beginning of the project; those projects which had no leader or a known-to-be-temporary leader have tended to founder until the director was appointed <2B1.1>. In order to be sure that the project objectives are well-understood, it is highly desirable that the project director participate in the goal specification phase of the project.

At a general-support site, the director need not exhibit the leadership, curriculum development, or subject matter skills that his counterpart in a direct-support site must. However, both share a need for managerial, CBE, instructional design, and media selection expertise <2B2.1, 2B2.2, 2B2.3, 2B2.4, 2B2.5>.

Instructional Designer

The role and responsibilities of an instructional designer are neither well-known nor well-defined. Even practitioners may find it hard to express concisely what they do. Therefore let us look at several aspects of instructional design in an attempt to define it by interpolation.

The ancestors of instructional design (and the sources of the jargon and principles used in it) are:

Programmed Instruction
Systems Analysis
Educational Psychology--especially learning theory
Educational Technology (audio/visual equipment, etc.)

Hence, one may expect to find one or more of these skills in the vita of an applicant for an instructional design position.

There are several things that instructional design sounds similar to, but is distinct from:

1. Curriculum development may include instructional design, but is often more oriented towards the content being delivered than towards the strategems or techniques for delivery.

2. Educational psychology research provides the basis for much of what an instructional designer does, but the instructional designer is oriented more toward applications than toward formal research. Because CBE employs new and unexplored technologies, however, instructional designers may well turn up valuable research data.

Staff with broad instructional design skills may be hard to find. Some who have worked only in another medium (e.g., programmed texts) may apply their experience immediately and directly, but be slow to adapt or develop techniques effective for CBE.

Author

In these guidelines we have used the term "author" to specify the individual who bears the largest personal responsibility for the development of a lesson. The term "author" has been applied to individuals in so many different roles and with so vastly different skills that trying to establish a firmer definition of what an "author" is does not seem to be a profitable pastime. The next section describes several typical sources for authors, the advantages and limitations of each, and their availability and/or ease of recruitment <3B1.1>.

Many subject-matter experts become authors by learning the CBE language and beginning to prepare lesson material. Because becoming this type of author requires only the qualification of subject matter expertise, such staff are comparatively easy to find. However, SMEs suffer from at least two shortcomings. Some of these author recruits find it difficult to learn to program quickly and efficiently. Others, lacking experience with teaching students or with the development of instructional materials, may create lessons which tell rather than teach (e.g., their lessons are non-interactive page turning). They may have to rediscover for themselves the principles of effective, efficient instruction <2C1.1>.

Some authors are instructors who have been taken from the classroom and taught the CBE language. Equipped with knowledge about teaching and about the student population, they are more valuable and perhaps more expensive than SMEs. For example, "robbing" the classroom of its experienced staff may not increase financial costs but will exact other costs in other ways. Former instructors share many of the potential problems of the subject matter experts discussed above. However, their familiarity with the students is an asset that will allow them to avoid some of the difficulties. Authors who retain some traditional instructor duties may receive valuable information and insight from their dual role <2C1.2, 2C3.1>.

Authors who are primarily programmers can learn the CBE language rapidly and produce their first products well ahead of other kinds of author staffs. They may have a different under-standing of what a "finished" lesson is, however, since revision of programming for esthetic or educational purposes is not a familiar concept. Though it is common to teach the CBE language to subject matter experts and instructors, it is unusual to teach programmers the subject matter or instructional design (except when the skills are rather basic and can be quickly taught). Thus programmers have this fundamental weakness: they tend to design well-written programs which fail to teach effectively. Conscientious programmers may find they have to spend a large part of their time consulting with SMEs or instructors, rather than programming <2C3.2>.

It is unusual to use evaluators or instructional designers as authors. They are ordinarily too hard to find and too expensive for this purpose.

Lest the reader come to the conclusion that effective authors cannot be found, we should point out that most of the shortcomings of the various types of authors listed above can be eliminated or alleviated by selecting a site staff with balanced abilities and a director who can coordinate the sharing of these talents. The purpose of this section is to make a project director aware of potential staff weaknesses.

Other Positions

Programmer. The number of programmers needed depends on the degree to which authors are expected to program their own materials. In the case of highly-paid professionals (e.g., M.D.'s, lawyers) or manually-oriented technicians (e.g., machinists) it is probably more cost-effective to consider employing programmers rather than training the SMEs to become proficient programmers. At the beginning of any new project, when the staff is new and inexperienced, there is often a great need for programming skill. As the project or group ages, the ratio of programmers to subject matter experts may decrease (although the total site expertise in programming has increased). When SMEs do none of the first draft programming, a ratio of two or three programmers per SME has been suggested by several project directors <3B1.2, 3B1.3, 3B1.4, 3B2.2>.

Proctor. Even when a project is too small to justify such a position, the responsibility for this duty should be unambiguously assigned. For example, rather than stating that any staff member present in the room is to act as a proctor, designate one staff member for specific days of the week or hours of the day.

Subject matter expert reviewer. Persuading non-CBE staff to act as reviewers can bring many benefits. Liaison is facilitated, rumors are squelched, lessons are improved, and a feeling of working toward and meeting common goals is promoted.

Editor. Though this may seem a rather small function, experience shows that unless the responsibility is assigned to someone, small errors will greatly detract from otherwise highly-respectable lessons.

General Comment

Although this section hopefully provides site managers with some guidance toward selecting a staff, it is very probable that one or more staff members will be selected who are rather incompatible with the job responsibilities. This is especially likely if the staff members are new to CBE. One should anticipate this problem and consider how to solve or alleviate it. Because new authors' abilities with the CBE language and with instructional design are generally obvious during training, it may be prudent to train more authors than will ultimately be needed. Note that the final selection must be carefully handled to avoid bad feelings about not being chosen.

A selection process which may avoid attaching a stigma to people not selected involves offering the training to all members of an institution. Special invitations and encouragement can be given to people whose backgrounds are promising. The trainees who learn quickly and show early potential to be good authors can be offered to be supported by the CBE project. Those performing less well can be allowed to continue without support while working toward their own teaching goals. Even though many people are trained and only a few unsupported trainees will continue, the CBE training serves to familiarize the staff of an institution with the techniques and objectives of CBE.

FRACTIONAL APPOINTMENTS

This section could be summarized in one sentence: there have been too many full time authors and not enough full time directors. Now for an expansion of this terse statement.

Authors. If current staff members are to be selected and transferred to a CBE group, it often proves effective to let them keep a fractional commitment to their former position. When course improvement via the introduction of CBE is the objective, such a staff member can act as a bridge between current instructors and the CBE group. If an instructor is involved part time with CBE, he can keep abreast of developments in the course and likewise build student enthusiasm and find volunteers for lesson tryouts. Depending on the potential need for liaison and abilities of an instructor toward that end, it may be advisable to carry his full salary but "release" him to work part time in the course. Continued involvement and commitment to the course are helpful for choosing appropriate topics for CBE, maintaining rapport with the rest of the instructors and squelching any unpleasant rumors which arise. Some authors have wished that they had duties in addition to those of writing CBE lessons because they felt the need for other stimulation in order to be creative.

Split appointments are not without substantial problems, however. Because CBE development is often less structured and deadlines are less firm, staff with split appointments often find their teaching or other duties encroaching on their CBE time. That is, tests must be written and lab books must be graded. But a CBE lesson revision may be postponed or skipped, and data analysis may be ignored or done in a cursory manner. Therefore, it is advisable to set aside and enforce separate time slots for each kind of endeavor. Separate office locations are often an aid.

When a curriculum is being rapidly developed by a large group, the time needed for coordination within the group is typically so large that an author with less than a halftime appointment makes little progress. (This is not true for support staff who need not attend all staff meetings.) When independent modules are being constructed by an instructor for his own course, a quarter- or third-time appointment is minimal. The topic of what fraction of time is optimal for various staff positions is treated at considerable length in <2C4.1, 2C4.2, 2C4.3, 2C5.1, 2C5.2, 2C5.3>.

Directors. Because good administrative staff are rare and expensive, there is a tendency to spread their talents too thin. The director ought to have time to regularly see students and staff working. There should be a staff member (called director, manager, supervisor, coordinator, whatever) who oversees day-to-day problems. If there are more than about 3 FTEs or 5 people, that person should be full time, not half time <2B3.1, 2B3.2>.

TOUCHSTONES FOR STAFF SELECTION

General education as evidenced by academic degrees or other awards seems to be helpful. A firm math background makes learning the CBE language easier.

Persons who have recently been enrolled in some sort of formal education classes tend to more quickly learn about CBE and how to operate the terminal.

Master teachers with 20 or more years of experience have been found to be invaluable sources of information about students, their problems, crisp examples, scenarios, etc. but many of them find it difficult to learn to program. Instead of expecting them to become proficient in the CBE language, one can exploit their knowledge to organize content, suggest lesson strategies and review the final product.

A greatly-needed personality characteristic is the ability to take criticism and to learn thereby--a sort of humility. The staff member who portrays a "the customer is always right" attitude and encourages constructive criticism is one to choose. The presence of such an attitude can be judged from the attitudes and practices such as the following:

> Does the candidate submit only final-typed versions of his papers and memos for critiquing by colleagues (and thereby suggest that comments are not really wanted)? Does the candidate request critiques at all? Are revisions made on the basis of them? Do student comments on test items cause improvements to be made? Are student comments taken seriously? As an instructor, has the candidate ever sought opinions of others about how to teach or test a topic? Does the candidate regularly revise classroom handouts?

Experience in teaching is naturally a valuable asset. Note that experience in an individualized teaching format (e.g., tutoring, TV tapes, programmed instruction) is more valuable than ordinary classroom experience (Avner, personal communication).

Preparing a CBE lesson requires a great deal of technical writing. A candidate's skills may be assessed by examining books and articles. Letters, tests, and directions for lab exercises, for example, should also be examined because they may be judged more easily without reference to their subject matter merit and are more likely to reflect the ability of the candidate unaided by editors. Of primary importance is clarity; next is succinctness. Consider whether the candidate seems to be striving to impress his audience or to communicate.

Specifying the level of subject matter expertise is often difficult. A useful rule of thumb (Avner, personal communication) is that the lesson author should be "one level higher" than the students. Thus a person who just completed a course is not a good choice for authoring a lesson for that course. A recent student can offer very valuable insights, but not in the role of the author. As a further guide toward determining what "one level" means, consider that high school students are considered able to tutor grade school students, college students able to teach high school students. In cases where degrees do not apply, an estimate of two to three years of relevant field experience (not merely two to three years since training) may be equivalent. The topic of students as authors is treated in the next section.

MISCELLANEOUS CONSIDERATIONS

Students as authors. In many academic situations, one finds a talented pool of relatively inexpensive labor in the students of the institution. For a variety of reasons, the students often adapt more quickly to the learning of new languages and the use of the CBE system than do the faculty. In such a situation someone frequently suggests, "Why not let the students write the lessons?"

If programming CBE lessons were identical to writing CBE lessons, there would be no problem. However, unless the students have sufficiently more background than the course they are writing for, they are likely to have difficulty organizing the material in any way different from that in which they were taught. Thus juniors and seniors might write freshman/sophomore level lessons, but faculty should write lessons for the juniors and seniors. Since most students are available half time or less, the problems noted previously for part-time work are present. Furthermore, the previous suggestions about the advantages of part-time employees assumed that the rest of the employee's time was spent in an activity which complemented the authoring tasks; this is unlikely to be true for a student. Finally, expertise built up in students will be lost by graduations unless it can be transferred to other students or permanent staff <2C1.3, 2C1.4, 3C1.3, 3C3.1>.

On the bright side, the low cost of student labor, plus its availability may make so large a payoff that the risks are reasonable. It will no doubt be a valuable learning experience for the student, and a student may be able to introduce and teach faculty about programming more quickly and easily than otherwise possible. However, student-written lessons will probably need extensive revisions before they are ready for classroom use.

Students' abilities to rapidly acquire proficiency with computer languages provide a resource to be tapped in two ways. First, students can be nicely used as programmers in on-site projects. Second, students can kindle the interest of their instructors and thereby start new projects. For example, several university sites which require every student programmer to have a faculty sponsor have found that a majority of their new faculty users are people whose interest was aroused by being a sponsor <3B2.2>. One project which paired students with professors to produce lessons was able to achieve very low production costs and some remarkably good lessons (Grimes, 1975).

Matching rank and role. It is important to match the rank, position, and salaries of staff members to their roles--especially for support staff. For example, when instructional designers or programmers are held in low esteem by virtue of their lack of formal "standing," their inputs (no matter how valuable) tend to be brushed aside. This situation can arise easily when the subject matter experts are expensive professionals such as lawyers, M.D.s, etc. Neither full-professors nor four-star generals have the breadth of knowledge to ignore comments from support staff. Unfortunately, they may have authority to do so <2C2.4>.

If possible, the most experienced and qualified instructional designers or evaluators should have a higher rank than the authors. In several projects where this hierarchy was reversed, the effect was detrimental.

SUGGESTIONS FOR AN AUTHOR TRAINING PROGRAM

Give the new author a student signon to a list of lessons which must be completed with a passing score. Make sure the list includes both good and poor examples of CBE. This is a first step for promoting the author's empathy for the student.

If possible, pair up a new trainee with an experienced and successful author. If no "old hands" are available, pair up two new authors and/or a non-CBE colleague. Set up a schedule so that the group meets two to three times per week to go over progress, problems, and ideas. Verify that meetings take place for the first several months. The important point here is that the author grows accustomed to regularly showing and sharing his plans and products with others. This series of planned meetings will hopefully avoid the "hermit author" phenomenon.

Advise new authors to expect that they will have to try their lesson materials on students at early and regular intervals. The first trial should come no later than eight weeks after the beginning of training. Authors cannot restrict their learning to formal sources such as manuals, consultants, and research reports. They must also learn from contact with students. Encourage or force authors to test incomplete segments of lessons.

Insist that the first lesson be "finished" or set aside and the second lesson started after two to three months. Encourage authors to prepare written (especially on-line) notes and comments as part of their preparation for reviewing other authors' lessons.

Have the instructional designer work with every new author at least once a week. When student testing begins, the evaluator should join the meeting (to suggest data collection and interpretation techniques).

Provide access to on-line typing lessons for authors who are not touch typists. (These lessons are not ordinarily needed by students, however.)

Provide the new author with a repertoire of known, tested strategies and instructional design approaches. Such a repertoire can allow a novice to develop high quality lessons rather quickly.

If training can be given at a major CBE center, make sure that: authors visit operating classrooms; staff meet potential on-line colleagues, reviewers, etc.; staff meet various system consultants, maintenance staff, business office staff, evaluators, etc.; authors, instructional designers, and evaluators visit the CBE center's library to find books and journal suggestions for their home library.

Concentrate the introduction to CBE and language training in as short amount of time as possible. Although it is possible to teach about CBE at a rate of two to three hours per week, it is far more efficient to schedule a concentrated course during a vacation period or even a marathon weekend (with follow-up training at a slower pace).

It is preferable that project objectives, content decisions, responsibilities, course revision plans, etc. be settled completely before training starts. The period after initial training is a good time to review such decisions, but too much time spent then dulls enthusiasm and allows forgetting of recently-learned programming skills.

If staff experienced in CBE can be employed as consultants, the best time to have them is during planning period. If they are familiar with the specific CBE system to be implemented, they should be employed during the first weeks following training.

If some staff arrive early or have free time prior to training (and access to CBE terminals), they should be directed to prepared written reviews of existing materials in their content field. These should not be done from a "browsing" or "can-I-use-it" perspective, but rather as critiques of good and bad styles, things to emulate and things to avoid.

If the staff is composed of members who retain their home departmental affiliations, efforts to foster a group spirit are useful. Seminars with guest speakers, luncheons etc., might be considered.

If high quality lessons written at another site would be useful for students in the target course(s), try to begin to use them as soon as possible. By using well-tested lessons from another site, new authors will get a feeling for how a class should react to their lessons after they are polished.

Note: Additional specific recommendations for author training on the PLATO IV system are found in Francis (1976).

PART III--RECOMMENDATIONS FOR MANAGING A CBE SITE

MANAGING FORMATIVE DEVELOPMENT (PRODUCTION STEPS)

The following are commonly-observed problems at CBE development sites.

Colleague reviews. As noted by Francis, Goldstein, & Call-Himwich (1975) and Call-Himwich (1976), authors have tended to wait too long before showing their lessons to colleagues for a formal or informal review. In some cases, when reviews did take place, problems and errors noted during the review were nevertheless left unrepaired. Both the references cited above contain detailed suggestions for encouraging positive, constructive on-site or off-site reviews of lessons <4B1.1, 4B1.2, 4B1.3, 4B1.4>.

Student testing. Left to their own instincts, inexperienced authors also tend to wait far too long before testing lessons or lesson segments on students. They always have "just one more display" to finish before getting student feedback. Firm managerial control can avoid the problems associated with too much author effort without student feedback <4B2.1, 4B2.2, 4B2.4, 4B2.5, 4B2.6>.

Student response data. Most authors collect sufficient high-quality data about their lessons to provide a very valuable basis for lesson revision. However, because some of the techniques for analysis are new to them and because the storage space available seldom allows a leisurely investigation of the data, some authors adopt a "print-and-stack" philosophy. In order to preserve the data, they get printouts of it, then delete the on-line copy. Although this procedure is preferable to simply deleting the data, it often lulls the author into feeling his job is done. He may intend to examine the data someday, but in fact, that rarely happens. The hardcopy version is not computer-searchable, and the author's memory and enthusiasm for correcting problems diminishes with time. Soon all he has is a stack of paper. The manager of a site must not only allow time for examination of data but also must see that a site staff member experienced in using student response data guides other authors in the use and interpretation of their data (Francis & Weaver, 1977) <4B2.3>.

Revision. The above three topics deal with various aspects of obtaining feedback about lessons to enable the author to make an effective and efficient revision of the lesson. Much of the effectiveness of CBE is possible because of the rapid and specific feedback available from student tryouts. For strategies and topics where the medium offers no extraordinary advantage, one must expect that the first version of a lesson will be no better (and possibly poorer) than the same material in a conventional medium. However, by obtaining and using the feedback available, an author can continually improve the CBE lesson until it is superior to a similar lesson written in a medium without such thorough, sensitive feedback (Call-Himwich & Steinberg, 1977).

In most other media, revisions are difficult to make (especially after "publication"), data is more expensive to collect and analyze, and revised forms appear at intervals of four to six years. With CBE, each new class offers the potential for testing a new revised version with relatively little effort.

It may be helpful to suggest to authors that they view a lesson as an hypothesis about how to teach the material. An hypothesis may be found false or in need of modification without criticism of its formulator. Considering a lesson as an hypothesis de-emphasizes the "grind 'em out," one-shot production mode which some authors too readily adopt.

<u>Lesson integration</u>. The formalities of listing and testing prerequisites, standardizing terminology, cross-referencing, and coordinating lesson content are often perceived to be rather bothersome and unimportant to an author "being creative" with CBE. However, unless these topics are attended to, the result will be difficult to mold into a curriculum and will remain just a collection of topics on a subject.

<u>Standards</u>. The need for lesson standards and lesson documentation has been discussed in part I. Unfortunately, such standards are frequently outlined, discussed, and adopted at the beginning of a project but ignored ever after.

<u>Production goals</u>. All the previous items might be solvable if authors could be given additional time to prepare each lesson. Although realistic timelines are essential, both over-generous time allocations and the lack of short-term goals are a disservice to developers and a waste of resources.

CBE suffers from a lack of reliable production yardsticks: any two "topics," "teaching points," or "objectives" can differ widely in the effort needed to convert them into an effective, efficient CBE lesson. "Student contact hours produced" is no better a measure because it rewards the production of long-winded, inefficient materials. Nevertheless, a manager must set goals and deadlines for authors, estimating the difficulty of the tasks and the abilities of the author. It is difficult, but necessary, to strike a balance between a too-rigid enforcement of deadlines which frustrates authors and lowers quality and a too-relaxed observance of undefined goals which may allow some authors to make a career of a single lesson.

<u>Liaison</u>. Liaison problems often drive authors into seclusion: it is easy to imagine a committee haggling over

the content of a lesson, course, etc. Normally an instructor simply teaches as he wishes even though fellow instructors may teach somewhat differently. This "leave me alone, so I can do it my way" approach works reasonably well in a lecture format where the instructors are competent and are responsible for all the teaching. However, such an attitude in a multiple-author project means the lessons may not be coordinated; in a one-person project, it means that few other instructors will ever take advantage of the large courseware development effort made by the author.

CLASSROOM MANAGEMENT

To what extent will recreational uses be permitted?

Site directors usually answer this question: "To the extent that recreational uses don't interfere with other uses." The following suggestions are an attempt to put this general answer into a specific, practical format so that serious workers taking a break will not feel guilty, but non-productive users will not compete with or detract from site operations and goals.

Terminals. If there are recreational users present, there should always be at least one additional terminal free so that a potential user does not have to dislodge a recreational user and/or wait to have the user finish. Because game players may switch to non-recreational uses when asked to leave, and because priority users may leave rather than confront a recreational user, the "waste" of a free terminal must be tolerated by second-priority users. If a site is large (more than 12 terminals) it has often been found appropriate to have two or more vacant terminals whenever recreational users are present. A site policy regarding terminal use can be partially implemented on the PLATO system via the "current usage controller" or CUC.

ECS usage. The use of lesson storage space (ECS) can also be controlled by the CUC of the PLATO system. Users working in their own lesson spaces can, however, consume space that would be used by high priority users, were it available. Therefore, the site proctor of a general-service site must regularly check the contents of unfamiliar lessons.

Noise and clutter. It has been widely observed that recreational users tend to have a variety of habits which may be bothersome to other users. For example, many games require or encourage rapid banging on keysets. Because recreational users are frequently limited to late-night and early-morning hours, food wrappers, bottles, and other debris may accumulate near the terminals.

Opinion and impression. One of the greatest detriments caused by excessive recreational use is that people who are casually acquainted with a site may begin to associate CBE with recreational use, i.e., non-academic, non-serious endeavor. Fortunately, this negative impression is usually formed only when game playing is excessive (i.e., to the practical exclusion of more legitimate uses); the occasional use of recreational programs as a diversion by hard-working staff seldom leaves a bad impression.

Who can give demonstrations? When may they be scheduled? Can site resources (such as terminals) be reserved or given priority during demonstrations?

Because of the novelty of CBE, there is a tendency by site staff and higher administrators to "show it off" rather frequently. Unless this tendency is controlled and managed, a large amount of resources can be spent without furthering the objectives of the project or site. At one site in our experience, the entire staff lost a day's work preparing, waiting for, and re-hashing the outcome of each demonstration. A separate demonstration room with a limited-length standard demonstration is a partial solution to this problem.

MAINTAINING STAFF MORALE

The following is a list of suggestions for rewarding individual staff members. It is often desirable to grant small, non-monetary rewards for hard work, competence, or other exemplary habits. Like students, staff members respond to positive feedback. The list below includes tasks which provide strong internal rewards and thus contribute to overall job satisfaction and also management actions which can provide reinforcing feedback to employees.

If a lesson is working reasonably well, the author generally gets an ego boost each time students use it. The student and instructor comments will always include a few new compliments and the (hopefully) rather minor corrections needed will remind the author of just how polished the lesson has become.

The respect of colleagues is sought after by staff in all fields. The PLATO system offers an additional dimension: on-line colleagues. Because of the PLATO system's communication features, it is possible to become acquainted without ever meeting face-to-face. This allows a relatively inexpensive method for exchanging professional opinions and finding additional users for courseware. Since it is a compliment to have one's courseware in use in wide circles, the PLATO system's geographical dispersion provides a "coast-to-coast" vehicle for rewarding the author.

Recognition of the contributions of staff can be made on the title page of a lesson; in site brochures, reports, and proposals; and in references and co-authorships for journal articles.

For most staff, it is a compliment to be asked to give a demonstration of the CBE system and the courseware of the site. Giving demonstrations (or speeches) or being a project representative at meetings carries a reward in proportion to the responsibility the task requires. A smaller but still substantial reinforcement is given when a staff member's lesson is used by someone else for demonstrations.

Lesson reviews, because of their basic nature tend to be discouraging to receive. The most important way of reducing the negative aspects of lesson reviews is to avoid giving an author a review which suggests massive revisions. This can be done by providing frequent, careful monitoring of the content and instructional design. Several short reviews throughout the development of the lesson are more useful and more palatable than a massive review at the end.

Releasing scarce resources such as signons and lesson space for personal use by staff members (or their families) is a substantial reward.

More than in most environments, the work that one does on a CBE system can be performed at any hour of the day. If coordination requirements are low, it may be possible to offer extremely flexible working schedules. In fact, because the potential flexibility is obvious to all, failure to offer it may produce discontent.

EVALUATION ISSUES

The two obvious directions for an evaluation are a comparison of the CBE materials against a pre-established goal or their comparison to an existing situation.

Non-comparative Evaluations

The well-known difficulties of insuring exactly equivalent conditions for a "new vs. old" comparison leads some people to make a "new vs. goal" evaluation. That is, rather than comparing the new CBE materials to the traditional non-CBE course, they measure the extent to which the CBE materials met the objectives stated. Some people feel that they can thus avoid setting up a complex research design, dispense with the interpretation of statistical analyses, and generally eliminate the hypotheses, assumptions, control groups, and detailed reports associated with a "formal comparative analysis." They replace these difficult and time-consuming procedures with production or operating goals and then merely determine "if they made it."

For example, under this mode of operation, objectives might be to "produce 10 role-conflict simulations" or "teach 100 students to use the Wheeler-Whitson apparatus each year via CBE." The evaluation of the latter projects seems simple: one determines if the simulations have been written or if the students have completed the lessons.

Although this form of evaluation may be appropriate during the early stages of an evaluation, its use as a sole summative measure is shortsighted. One simply cannot avoid a comparative evaluation. Comparisons may be made with little basis and few facts, but students, colleagues, and administrators will decide: Was it worth the effort?, Should we continue?, etc. Skeptics may suggest alternative uses for the monetary and personnel resources, use of a different CBE system or a totally non-CBE medium, adoption of a different curricular or instructional design philosophy, or implementation under different conditions. For example, a site may "successfully" create its 10 simulations, only to find them challenged as unrealistic, not requiring CBE, or boring. Or the simulations may be highly respected, but too expensive to support.

Because administrators in some fields (e.g., engineering) may be used to accepting as "success" the fact that something new has been found or created, they may allow "meets the objectives" evaluations initially. However, comparisons with alternatives are ultimately inevitable. Therefore, because of this inevitability, project staff should be encouraged to gather information and prepare an evaluation so that the predictable evaluation questions can be answered on the basis of well-documented facts rather than on speculation.

Comparative Evaluations

The watchword for making comparative evaluations is (what else!) "objectives." Unless you carefully consider the objectives of the evaluation, you may be saddled with one of several common problems.

The first problem is trying to measure (and compare) everything. As noted in the discussion in part I, there are a multitude of comparisons that can be made. Only a few are relevant and important in each situation. Rather than spreading an evaluation effort too thin in order to measure many parameters. one should examine the objectives of the evaluation to determine which measurements are critical, and concentrate on those. A set of contingency plans for the evaluation should be drawn up simultaneously.

The second problem is often found to be illusory after it is investigated, but it nevertheless produces great frustration until that time. Here is the apparent dilemma: If you use CBE to teach topics in the way you used to, you haven't exploited its potential and it will probably not be cost-effective for most applications. However, in this situation the testing is comparatively simple: you can use the same tests that were used before for CBE-taught students. On the other hand, if you use CBE lessons which teach at a higher cognitive level via simulations, modeling, role-playing and other techniques which require a computer, you have two choices with respect to testing. If you use the old pre-CBE tests, they will be a fair comparison for the original topics, but will not indicate that students taught via CBE may have learned new, high-level skills. If you write a new test which measures the high-level or CBE-taught skills, it will not be possible to compare results from the two different tests. It is not fair to give the new test to students taught without the CBE lessons because the CBE-taught students would have an unfair advantage.

The way out of the above dilemma is (naturally) to re-examine the project objectives to answer the following question: "Are the old objectives satisfactory as they stand (and are you thus looking for an improvement in teaching techniques, motivation, retention, etc.) or are the objectives inadequate or obsolete? If the old tests are good tests of the objectives and are reliable, they should be kept. If the objectives have changed or if the old exams do not adequately measure them, test development is needed.

Evaluating "CBE"

It should be noted that it is very difficult to "test the effectiveness of CBE itself" apart from the lessons, strategies, and implementation of the CBE system. This is another way of saying that CBE is a medium, not a treatment. One <u>can</u> evaluate the ability of a CBE system to <u>allow</u> various teaching strategies and kinds of lessons, and to facilitate particular implementations, but most other evaluation questions depend on the way in which the lessons were written or implemented. Thus the question, "Did the CBE system increase the student scores?" should be rephrased, "Did the lessons written for the CBE system increase student scores?" As reformulated, the question suggests the possibility that another set of lessons might have done a better or poorer job of increasing student scores. It thus clarifies the focus of the evaluation and hopefully prevents <u>post hoc</u> speculation about whether the results were obtained because of or in spite of the CBE implementation.

THE PROJECT MANAGER'S LIST OF WARNING SIGNALS

The director of a CBE project and the supervisor of such a director should both be alert for "smoke" that indicates smoldering "fires" within a CBE development effort. The list assembled below is not complete, but is useful both as it stands and because it suggests other danger signals.

If touch input, microfiche, and audio output are incorporated into lessons, but are not used when testing the student, their use may be trivial and decorative only. If these features are needed to teach, they are normally also needed for testing. Similarly, lessons which use animations, simulations, and case studies to teach probably need these techniques to test. If they do not, a brief investigation may be warranted.

If microfiche images and drawings are presented with no questions to check the students understanding of them (e.g., "Here is a framis") the high cost of producing these illustrations is not being recaptured by making effective use of them. Likewise, check to see if expensive drawings, attachments, and recordings are being used more than once. Can a drawing that costs $250 to create and reproduce be justified if students view it for only a few seconds?

If you can complete a lesson by successively trying each multiple choice answer or by entering nonsense answers until you get the correct answer, the quality and validity of the lesson should be examined. Clearly, a student's completion of such a lesson indicates little unless the lesson is followed by a comprehensive test. For most students, lessons with "paths of least resistance" such as those outlined above produce robot-like behavior but little learning.

If student response and area summary data are not examined within a week or two after they are collected, and are merely stored on-line or printed out and stacked for later revision, there are serious questions about the effectiveness and efficiency of lesson revision. It is a simple matter to ask an author a few questions shortly after students have used a lesson he wrote. It is appropriate to ask to see where the data is, what analyses have been made, and what changes have been incorporated into the lesson. Other useful inquiries are, "How long does it take to look through that data on-line?", "Do you analyze each student run?", and "What changes have you made on the basis of student response data?"

A student notes or comments file is normally attached to a lesson or to a course in order to gather student suggestions about a lesson. Reviewing these comments can be insightful, though all comments cannot be taken at face value. If some of the suggestions have basis or merit, a discussion of the student views with the author may indicate the author's view toward students. The presence of authors who ignore student comments out of hand indicates significant problems.

By asking an author about the topic and status of lessons written by his colleagues, you may be able to simultaneously make two observations. First, the author's answer indicates the level of involvement he has with others, e.g., if the author has become a hermit. Second, it indicates the level of inter-colleague reviewing. Note that the question should not force the author to render an opinion about the quality of the rest of the staff, just what they are doing. Also, it may be useful to ask the author if he has reviewed any partially-completed lessons. Authors who are requesting reviews during (rather than after) development should be reinforced for this action.

If several months after training, an author cannot explain why he is writing objectives or documenting the lesson, further training and guidance are needed. Likewise, if an author cannot show the orderly relationship between the objectives, the test, and the body of his lesson, the manager must reluctantly conclude that the instructional design training hasn't been understood or accepted.

The number of students who can be handled by a single proctor is a good indication of the degree of polish of the lessons. Though "polished" lessons are not necessarily good lessons, any lessons which have been used by more than 50 students and which still require heavy proctoring (fewer than 12 students per proctor) are probably not getting the attention they need.

There is a set of commonly-used computer routines on the PLATO system in what is called the "library." If authors of 3 to 6 months of experience don't know of the existence or the contents of the "library," they may be spending time re-inventing routines that are already available. A review of on-line resources is appropriate.

A list of all the lessons being developed or in use is found on the PLATO system in the "catalog" lessons. To be sure that authors are not ignoring already-available courseware, a manager should ask the author about other materials available in the subject area, the relationship of those materials to lessons currently being developed by the author, and the feasibility of incorporating segments of already-written lessons into new materials.

MISINTERPRETATIONS

Two misinterpretations have been observed often enough to warrant warning site managers about them.

Some authors misinterpreted the zeal with which CERL instructional design consultants promoted data collection, use of answer-judging rather than multiple choice, and inclusion of feedback for specific wrong answers. They felt these things were being promoted by CERL staff because CERL wanted powerful features of the system exploited for organizational glory. In fact the CERL staff felt that these were fundamental features (not esoteric ones) and that if such features were available, but unused, there was little justification or need for employing a medium as expensive as CBE. Only through use of the powerful software features can one justify using CBE.

Authors misinterpreted reviewers' critiques of the positioning of text, arrows, and feedback as well as their implementation of touch panel input. Authors tended to regard these issues as unimportant esthetic considerations. They felt that so long as the subject matter was present and accurate, there was little need for further revision. In fact, CERL and other groups have accumulated substantial evidence to indicate that one can efficiently "hide" information on the screen by placing it incorrectly and that casual implementation of features such as touch can significantly reduce test scores (Avner, personal communication; Venezky, R., Bernard, L., Chicone, S., & Leslie, R., 1975).

POTENTIALLY COST-EFFECTIVE USES OF CBE AND PLATO

A CBE system itself is neither cost-effective nor non-cost-effective. It is only the uses to which the system is put that determine cost-effectiveness. To guide new sites and projects towards uses of the CBE system which are more likely than average to be cost-effective, we have prepared the suggestions below.

Simulations of expensive training equipment (including hardware simulators) have been found to be cost-effective (Crawford, Hurlock, Padilla & Sassano, 1976).

It is a mistake to discard all conventional teaching materials and replace them all with CBE lessons. Often workbooks, filmstrips, video tapes, or programmed texts can be supplemented with CBE. By supplementing, high development costs are avoided, the high cost of equipment and materials continues to be amortized, and the rate of preparation and validation of the improved instruction is increased. For example, if a video-taped training movie has become incomplete and obsolete after three years (or if students don't seem to completely comprehend it), the tape could be followed with a short CBE lesson which covers a bit of new material and corrects some obsolete nomenclature. Then an interactive quiz over both the tape and the CBE supplement could be administered. Even if some comparatively expensive CBE animations must be programmed, that may be cheaper than re-shooting the entire video tape. Because many "home-made" training movies forget to point out a mechanism, note an exception, or focus attention at the right time and place, they sometimes fall short of their potential. A small investment in supplemental CBE training might thus yield large instructional benefits.

Because of the PLATO system's high flexibility, it may be advantageous to design other computer teaching systems or instructional materials on PLATO, even if the final product is to be delivered by a less sophisticated computer or medium. For example, the evaluation and validation of instructional materials (including tests) may require several iterations of product development, the gathering and analysis of substantial data, and the preparation of detailed documentation and reports. It may be cost-effective to do all the development work on a PLATO system, then print the materials in final, validated form as conventional or programmed texts. Similarly, a CMI system capable of being implemented on a mini-computer might be better designed on a powerful computer such as the PLATO system, then converted for the smaller, cheaper computer. By using the PLATO system initially, some options which would be difficult to install on the mini-computer could be implemented: only those options which were found to have great value would ultimately be installed on the mini-computer.

When group pacing is being used with conventional materials and media, it may be cost effective to provide individualized remedial training for slow members of the group during evening or free hours. Since in group pacing the speed of the group is set by the slowest member, a relatively high cost for a few students can be offset by the savings of several hours by all members of the class.

Similarly, when costs for drop-outs are high, remedial courses via CBE may be cost-effective. In some circumstances it may be possible to combine two courses teaching the same topic to students with different backgrounds (e.g., with and without a strong math background) by providing an individualized supplement for some of the students.

There are two approaches for analyzing the question: "What size course is optimal for CBE lesson implementation?" By focusing on development costs, one can show that a course which has many students can more quickly amortize these costs. By focusing on delivery costs, one can demonstrate that instructor costs for small classes are very high and an easy target for cost effective CBE lessons. Furthermore, small classes are typically taught infrequently, thereby inconveniencing students and perhaps lowering total enrollment. Once developed, a low enrollment, self-instructional class might be quite inexpensive to deliver and may provide high royalties if other small institutions wish to offer the course to their students. If cost effectiveness is to be achieved via time savings, one should choose not only a course where substantial time can be saved, but also a course whose students are being well-paid for their time. For example, the money earned by saving one hour of an executive's time probably pays for more hours of CBE time than does saving one hour of a clerk's time.

In the situation of the impending loss of an irreplaceable instructor, CBE may be able to catch his best moments, most thought-provoking problems, and most efficient teaching strategies--and do so far more effectively than any other medium.

Travel expenses for continuing education, updates on new technology, etc. can be reduced or eliminated by implementing on-site continuing education (or refresher) courses via CBE. In some professions, however, trips to take refresher courses are treated more as vacations than as training sessions. In such cases, a CBE replacement for these trips will not be popular.

Some testing situations require the simultaneous testing of a team of students (e.g., replace a truck motor). Because above average students may compensate for weaker students, individual competencies and weaknesses are difficult to find, reward, or correct. Such performance tests are typically long and expensive to administer and difficult to grade. CBE simulations offer a way to test for each student the cognitive portions of the task (e.g., order of procedures), with less cuing and prompting present than with other media.

Training in safety and safe-practices is often done perfunctorily, with no enthusiasm and little effect in many industries. Unions and government bodies require monthly safety meetings which are sometimes more of a "rest period" than a learning experience. CBE lessons offer the possibility of simulations for procedural tasks which include "built-in," random calamities to be dealt with. Accident prevention can result if the training can be shown to have a measurable impact on daily procedures and personal behavior.

Calculations about cost-effectiveness must include all the constraints and conditions. A good example of how an over-simplified comparison might produce misleading results is found in Lackman (1975). In Lackman's study, medical simulations were prepared in both PLATO CBE format and as paper-and-pencil exercises. When one calculates the development costs for the simulations in each medium, one finds the CBE format costs 4.7 times more and thus appears to be the most expensive. However, the simulations were used by practicing M.D.'s at conventions, professional meetings, and informal courses--always with voluntary participation. The actual use of the PLATO CBE simulations was found to be 9 times greater than that for paper-and-pencil simulations. Hence, on a "per use" basis, the development costs were only half as much. In a similar fashion, one must carefully consider how best to calculate cost/hour for CBE materials. If one spends time to improve a lesson by allowing students to complete the lesson more quickly, the change makes the cost/hour less favorable even though the lesson is better.

When considering the cost effectiveness of CBE compared to other media or alternatives, consider what options are actually available. For example, it may be cheaper to use another computer to do some numerical integrations, but if the other computer is blocks away or offers only overnight service, a CBE system with higher costs, but faster turnaround might be preferable. Likewise, video tape might be the most appropriate medium for a topic, but if you lack video equipment, CBE animations might be the most cost-effective option available.

It may be more cost-effective to write new courses using CBE than to convert existing courses. This is particularly true when substantial capital costs for equipment, texts, rooms, etc. have already been made. Even if a CBE-simulated lab is cheaper and teaches better than actual lab experience, the fact that the cost of existing lab equipment and special classrooms has not yet been amortized may mean that switching to CBE simulations is impractical.

Much of the time savings arrived at by converting a conventional lock-step, lecture-format class to one which is computer-based are due to time saved through self-pacing. Some opponents of CBE argue that only the savings of CBE over and above that for other self-paced media can be considered when calculating cost-effectiveness. However, the management function of CBE is often the key to being able to implement and operate a self-paced system. That is, without CBE's management capability, it would not be feasible in some cases to design a self-paced course using other cheaper media.

WHY USE A CBE SYSTEM LIKE PLATO?

The decision to use CBE, and the PLATO system in particular, may already have been made when the site manager assumes his duties. Nevertheless, it may be prudent for the manager to review the decision. Below is a brief list of characteristics of the PLATO system which make it worth using.

It is a computer and can do things computers do.

For example, it can store and process data. On the other hand, it is not a general-purpose computer: it has restricted database operations and relatively slow input and output from terminals.

It has a uniquely powerful language for teaching and performing other special functions.

TUTOR is widely recognized and imitated because of its powerful features. Moreover, it continues to add new, useful features. However, TUTOR programs are not readily transferable to other computers.

The PLATO system is equipped with a unique graphics terminal as an output device.

The terminal and the auxiliary devices which can be attached to it offer a broad potential for nearly any important kind of interaction with a user. However, unless the training requires these features and the lesson developers make use of them, the potential is wasted.

The communications network provided by the PLATO system is unmatched in terms of the breadth of types of users and types of information communicated.

Lesson writers can not only share courseware, but can co-develop lessons, review lessons during development, etc. Nevertheless, there continues to be duplication of effort and missed opportunities for inter-site communication.

The ability of the PLATO terminal to control external devices makes it ideal for running psychology/education experiments.

Student interaction data related to educational goals can be gathered rather automatically.

Timing, presentation of graphic and other stimuli can be interactively controlled.

Both the hardware and software are designed so that a student can begin to use the terminal after 2-3 minutes of orientation. No computer jargon, programming skills, or technical abilities are required.

One can find somewhere on another computer or in some other medium most of the features cited above (with some exceptions, such as the TUTOR language). If only one of the features is needed, it can probably be obtained more readily or inexpensively elsewhere than the PLATO system. However, one of the great virtues of the PLATO system is the fact that many useful facilities are available from and integrated into a single computer system.

Some examples of these fruitful combinations:

Computer-management of CAI and off-line materials.

Realistic CBE simulations via graphics, database, and interterminal communication features and terminal peripherals.

Powerful teaching strategies involving sophisticated branching algorithms, drill paradigms, computerized diagnosis of student weaknesses, and student control of sequencing.

On-line conferencing with immediate (telephone-like) or delayed (letter-like) response among large populations.

CONTINGENCY PLANNING

Few laws are so invariant and oft-quoted as Murphy's: "If anything can go wrong, it will." Realizing the wide applicability of this law, it is only reasonable to construct contingency plans for some of the predictable crises in the life of a CBE site. Below is a list of likely problems and plausible alternatives.

The system or local site experiences a "down" period longer than one class period--as long as several days.

Teach conventionally in lecture format using lesson authors as instructors.

Use hardcopy version of CBE lessons prepared before the downtime period.

Postpone training.

Lesson production goals are not met, or substantial loss of experienced personnel occurs.

If available, hire expensive experienced staff.

If time permits, train new staff.

Reduce the scope of the project.

Extend the term of the project.

Hire outside contractors to complete the development.

The student enrollment in target courses becomes so low that evaluation statistics will not be reliable.

Extend the project to increase the sample size.

If you are dividing the students into experimental and control groups, make them all experimental and use previous classes for control.

Modify the materials to teach a high-flow class.

The student enrollment becomes so large that there are too many students to schedule, or access to terminal time is reduced so that sufficient terminal time is not available.

Reduce the amount of authoring and the number of terminals devoted to authoring.

Schedule authoring for weekends and evenings.

Teach part of the students conventionally.

Allow students to self-schedule themselves during non-prime time.

There is a persistent problem with obtaining sufficient computer storage (ECS) for all student lessons.

Schedule classes so that students are likely to be sharing a lesson in ECS. Essentially this means reducing the self-pace mode and adopting a more lock-step orientation.

If practical, invest the time of programmers to divide very large lessons.

The funding or ability to perform the project is suddenly terminated.

Prepare hardcopy versions of all completed instruction.

Re-program the materials for other computers or rewrite the materials for other media.

Although none of the potential alternatives is supplied with a caveat, each should be! Note also that this list is far from complete. One of the main purposes of these guidelines is to present examples of situations, problems, and alternatives. A more complete list of contingencies would contain options for problems with poor lesson quality, personnel problems, skeptical traditional instructors, etc. The manager of each site should prepare his own list, and if necessary, get it approved. Such advanced planning allows for thoughtful procedures such as the "backwards implementation" discussed in part I.

GUIDELINES FOR CONSTRUCTING PROJECT TIMELINES

One of the most important problems encountered in planning and managing a CBE site is that of estimating the size of the staff and the total time needed to complete a major lesson development effort. Sites frequently over-estimate their production efficiency or fail to take account of non-production tasks and are thus unable to complete the intended project. For that reason these guidelines have already recommended that sites allow for "soft" failures or ways to demonstrate success despite not achieving all original goals.

Although "soft" failures are better than "hard" ones, what is needed is a better basis for determining the magnitude of the task and the productivity of the staff. The ability to make accurate forecasts will lower the frequency and severity of mid-project adjustments and reduce the uncertainties of CBE courseware development.

The following discussion assumes that CBE is new to nearly all staff members at a site. (After a site's staff members have experience, they can make estimates by extrapolation, but during the planning stages of a site, no lessons have been written. Yet this is the period when the best estimates are needed.)

In spite of the fact that local situations create issues which cannot be answered by generalizations, we feel that we have gleaned some insight which can be used in project planning and management. In order to make the problems and constraints as realistic as possible, we have prepared the following example of how NOT to use estimates of lesson production time to plan a project.

Project History of NNL

The NeverNeverLand project staff read several reports which indicated that groups similar to theirs had spent 250 author hours to write each hour of lesson material. The NNL project wished to create 100 hours of CBE material and calculated an author working 2000 hours per year could develop eight lessons. They thus requested and received authorization to hire 13 staff for two years. They were told that if the evaluation results were good, the project would be continued. All the authors, programmers, illustrators, and technicians were working full time within three months after the project started, and within six months they had learned enough of the authoring language to be producing lessons.

The fact that the last three months of the project were set aside for evaluation and could not actually be used for development did not bother the project director because the rate of lesson production was faster than the assumed rate. During the second quarter of the first year of the project, the average production time was 250 hours per hour; the third quarter, it was down to 150 hours per hour! Though the fully-operational lesson development period was to be only 15 months (24 months minus 6 months arriving and getting trained minus 3 months evaluation), the production rate achieved at NNL seemed destined to be twice as fast as had been predicted.

The project director was surprised when the fourth quarter production rate rose to 175 hours per hour rather than continuing to decline as he thought it would. Feeling his authors had become a little too relaxed, he put on the pressure to produce. During the fifth quarter, it took an average of 150 hours to produce each one hour lesson, but two authors disliked the pressure and quit. With only six months left, hiring untrained staff was out of the question; instead one experienced, but expensive, author was hired to replace the two who had quit.

Before the final evaluation period began, several problems reared. The NNL project director's boss asked to see some evaluation data to show department administrators so that the project could continue to be funded. The boss understood that the evaluation period had not begun, but he needed some evidence that the CBE system should be kept, and he needed it before the end of the current contract. He would even be happy with lesson validation data, he said.

Unfortunately, lesson validation data was in short supply. The project director admitted that the lessons used during the evaluation period would include some which had not been validated prior to the evaluation period (i.e., they had not yet been shown to teach effectively) and some lessons which were not even written yet but which hopefully would be finished during the evaluation period. The difficulty was caused by the fact that only three classes a year were scheduled (Fall, Spring, and Summer). Most lessons were revised twice before they were validated and hence few lessons written during the second year had had enough use to have reached their validation criterion. Most of the validated lessons were those written the first year, when production was slow and experience was minimal.

Lacking sufficient data on which to base a decision, the department was forced (rather unhappily) to grant the project an extension for only a few months, until the evaluation phase could be completed. The department was willing to continue the project, but needed evidence to justify that decision to a budget-conscious administration.

During this extension period, the NNL staff divided their time between running the evaluation and finding new jobs in more stable environments. Though the evaluation results were seemingly positive, only one class of students was included in the evaluation sample (because only three classes started a year and only one could be run in the three months set aside for evaluation). With such a small sample, statistical tests had only limited power to detect differences in student performance. Furthermore, some skeptics said that summer school students were so atypical that the results would not be applicable to the students in the other sessions.

Faced with a depleted staff, positive evaluation results, and another long training period for new staff, the department funded CBE support for continued student operations and lesson maintenance, but no more new development. Some members of the administration felt that the department had been used as a training ground for CBE authors, who left for better jobs after being trained. Though they acknowledged the student satisfaction and the enhanced performance, they discouraged any new lesson development.

The reader should be advised that although there is no NeverNeverLand site, the details of this fictional account are a composite of events from the case histories of several actual sites.

Let us examine the errors and misconceptions of the NNL staff in planning their project.

Post mortem Analysis

The story ended in the place where the planning should have started: the evaluation. After choosing objectives, one should begin immediately to decide how to evaluate the project. Using "power analysis" techniques (Cohen, 1969), one can determine the minimum number of subjects one needs during the summative evaluation period to have a reasonable chance of detecting performance differences. That information, combined with average class sizes, can be used to determine the length of the evaluation period. As NNL found out, the need for evaluation data comes before the last day of the project. Because final evaluations are usually not completed before the end of the project, it is necessary to collect and interpret some preliminary data. That can come from the formative development or validation data or, if several classes of students participate in the evaluation period, from data from an early class.

Assume that power analysis indicates that 100 students are needed for the evaluation. If classes average 40 students and are taught three times per year, the entire final year of the project will be needed to gather summative data. If the lessons require two revisions before validation, three groups of students must use each lesson, thus adding perhaps another year to the project. (Because initial testing and formative evaluation can be conducted with students from other courses in many cases, the one-year validation period can often be shortened.)

At the beginning of a project, staff are learning about the language and CBE; lesson development may be slow for 4 to 6 months. Using the assumptions above, one finds nearly 30 months are needed for training, validation, and evaluation alone. Development time must be added to the 30 month sum. Unless the validation or evaluation periods can be shortened, such a project must be more than three years in length.

Projects which attempt to perform summative evaluation simultaneously with lesson validation have the following problems. Since the lessons are changing during the evaluation period, the summative data collected are not comparable. Furthermore, problems with one lesson affect other lessons, making detection and location of pedagogical stumbling blocks more difficult than if the lessons were validated individually.

includes. Most staff who prepare lessons also spend time revising lessons, giving demonstrations, using the lessons to teach, reviewing lessons of other authors, constructing routers, aiding the evaluation, and training new staff. Half or more of the time of staff may thus be spent in duties not directly related to lesson production. That is why the NNL seemed to be doing so well. A rate of 250 hours may have characterized the entire NNL project effort (e.g., the total time consumed by each author during all stages of the project divided by the output of the project). Production of first draft lessons generally takes less than that 250 hours per hour and certain individual lessons often can be programmed in very much less time. A further source of confusion in reporting production rates is deciding which author-support time to include. The time of programmers is certainly included, but should time for proctors, secretaries, illustrators, and hardware repairmen also be counted?

Courseware production times can be misleading for several reasons. When starting with an inexperienced staff, a project director finds that the "learning curve" reduces production times quickly. The first lesson each author writes may take 600 hours to produce, the second 300, the third 200. Furthermore, each lesson tends to improve in quality. The production time seems destined to continue decreasing. Instead, three factors tend to make the production time level off or even increase.

A major burden for authors mid-way through a project is the increasing quantity of data gathering, interpretation, and revision activities required. Initially, an author has only a few lessons to revise; he can spend most of his time creating new lessons. There may be only a few periods when there are students at an appropriate place in their course to use his lessons. After a year or so, the author must devote a includes. Most staff who prepare lessons also spend time revising lessons, giving demonstrations, using the lessons to teach, reviewing lessons of other authors, constructing routers, aiding the evaluation, and training new staff. Half or more of the time of staff may thus be spent in duties not directly related to lesson production. That is why the NNL seemed to be doing so well. A rate of 250 hours may have characterized the entire NNL project effort (e.g., the total time consumed by each author during all stages of the project divided by the output of the project). Production of first draft lessons generally takes less than that 250 hours per hour and certain individual lessons often can be programmed in very much less time. A further source of confusion in reporting production rates is deciding which author-support time to include. The time of programmers is certainly included, but should time for proctors, secretaries, illustrators, and hardware repairmen also be counted?

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A second factor tending to increase courseware production time is the finding that the "learning curve" typically shows "setbacks" (Avner, personal communication) during which a new author may drop back to low production rates. Avner discovered that these plateaus usually happened when the author was perfecting a new instructional technique. Each new technique added to the repertoire of the new author would show a "learning curve" of production efficiency as it was applied to more and more lessons. Until an adequate repertoire was developed for the specific needs of the author's project, it was quite common to see erratic shifts of from 20 to 600 hours per hour as an individual author added and exploited each new technique. In areas where a wide range of techniques are required, it took a year or more to develop a repertoire adequate to make full use of the capabilities of CBE. However, once the repertoire was present, exceedingly efficient production of effective material often resulted. Taking into consideration the amount of time needed to learn these skills and the amount of effort often required of an author for other duties, it is not realistic to expect that many one-hour lessons will be produced by a new author in 17 hours during a 3-year project.

This need for training of users of a medium should not be surprizing. Few would expect a group of novices to make effective and efficient use of even well-established media such as film or videotape without a substantial period of learning and practice. At the same time, it is easy to be misled by the apparent ease with which a novice is able to produce first-draft materials in almost any medium (film and CBE included).

As a project matures, its authors gain additional responsibilities. When few lessons have been written, there is very little need for routers, for bookkeeping about the names and locations of lessons, and for scheduling and proctoring classrooms full of students. These activities are added to the tasks of authoring, reviewing lessons and preparing for the evaluation. These accumulating duties act as a third force to slow lesson production during project maturity.

A final problem suggested by the NNL example is that estimates of the number of developers needed should be adjusted upward to allow for non-development staff such as proctors, illustrators, repairmen, etc. These staff may be needed only part time during limited phases of the project. Their skills are important, but one cannot expect to replace development staff with support staff and still meet the same production goals.

A cautionary note about the production rate of 250 hours used in the NNL example is necessary. Several projects have derived or used a value of 250-300 hours for overall production time including training, revision, etc. We cannot endorse this or any other "rule of thumb" value because of the vast differences between sites and projects. In the earliest stages of project planning, it might be reasonable to estimate 300 hours per hour of material to approximate the scope of a project. After the scope is established, the objectives determined, and an evaluation sketched out, one should request several independent CBE consultants to refine the plans and provide estimates of project milestones, staff needs, and timelines. Providing rules for making such estimates is beyond the purview of these guidelines. The consultants' estimates must be verified during the first year of the project, observing the caveats noted in this section about the fickleness of trends.

If it is not possible to obtain the aid of a qualified consultant, you should use very conservative estimates. Avner (personal communication) indicates that, based on a study of 27 new authors, one could be 90% confident that 75% of a group of experienced teachers with good verbal skills (all were college graduates) would be able to produce an hour of material during their first year in about 430 hours or less of effort. This estimate includes only minimal formative evaluation. A rule-of-thumb based on these data would thus suggest that a project with a one-year lesson development phase should allot no more than 5 hours of material to each new author during the year and tnat 4 authors be provided for every 15 hours of material to be produced.

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