DOCUMENT RESUME

ED 083 804		EM 011 513

AUTHOR	Bunderson, C. Victor
TITLE	Team Production of Learner-Controlled Courseware: A Progress Report.
INSTITUTION	Brigham Young Univ., Provo, Utah. Inst. for Computer Uses in Education.
SPONS AGENCY	National Science Foundation, Washington, D.C.
REPORT NO	BYU-ICUE-TR-1
PUB DATE	1 May 73
NOTE	25p.; Preprint of published proceedings of the International School of Computers in Education (ISCE), Summer, 1972
EDRS PRICE	MF-$0.65 HC-$3.29
DESCRIPTORS	*Computer Assisted Instruction; Course Organization; *Curriculum Design; English Instruction; Higher Education; *Instructional Design; Junior Colleges; *Man Machine Systems; Mathematics Instruction; Program Descriptions; Remedial Instruction; *Teamwork
IDENTIFIERS	Brigham Young University; BYU; CAI; Courseware; *Learner Controlled Instruction; MITRE Corporation; Modular Instructional Design; TICCIT CAI System

ABSTRACT

A project being conducted by the MITRE Corporation and Brigham Young University (BYU) is developing hardware, software, and courseware for the TICCIT (Time Shared, Interactive, Computer Controlled Information Television) computer-assisted instructional system. Four instructional teams at BYU, each having an instructional psychologist, subject matter experts, an instructional design technician, an evaluative technician and packaging specialists, are developing courses in remedial algebra, elementary functions, remedial English, and freshman English for junior colleges. The system uses a color television to display digitally generated characters and graphics and also employs audio and video tapes and alphanumeric entries from a typewriter. Major courseware features include three levels of student-machine communication, a modular approach to courseware structure designed in accordance with a taxonomy of instructional variables, and learner-controlled interfaces between the student and the system. The courseware seeks to present the required content to students at a low cost in such a way that they develop content mastery in an effective manner and also acquire improved learning strategies, a positive outlook to learning and greater responsibility for their own development. The courseware will be field-tested at two junior colleges in 1974. (PB)

INSTITUTE FOR COMPUTER USES IN EDUCATION

TEAM PRODUCTION OF LEARNER-CONTROLLED COURSEWARE: A PROGRESS REPORT

C. Victor Bunderson

ICUE Technical Report No. 1

May 1, 1973

Sponsored by:
THE NATIONAL SCIENCE FOUNDATION
Contract #C-729

DIVISION OF INSTRUCTIONAL SERVICES
Brigham Young University
Provo, Utah

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Preprint of published proceedings of the International School on Computers in Education (ISCE) based on materials presented at the School, Summer, 1972.

The ideas expressed in this paper are the product of cooperative effort among many individuals. In particular, Dr. M. David Merrill played a leadership role in the design of the major primary instruction logic, the advisor, and team production techniques. Dr. Gerald W. Faust contributed in many ways to the design, and as head of production; to the organization and training of the teams. Stephen R. Fine provided the major leadership in specifying the learner control command language and the coding forms for packaging.

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THE DESIGN AND PRODUCTION OF LEARNER-CONTROLLED COURSEWARE FOR THE TICCIT SYSTEM

Early in 1971, the National Science Foundation funded two organizations, the MITRE Corporation of McLean, Virginia, and the University of Texas CAI laboratory, with two separate but related contracts for investigations leading to the further development of MITRE's TICCIT computer system concept. TICCIT stands for Time-Shared, Interactive, Computer-Controlled Information Television. The concept of using mini-computers, television and cable distribution to produce a low-cost CAI system had been developed extensively by MITRE on the strength of a substantial internal commitment prior to this time.

MITRE was to design and develop hardware and software, and Texas to develop courseware in freshman mathematics and English, the entire system targeted to meet instructional needs in junior colleges. A needs survey conducted under the University of Texas contract resulted in the finding that the major needs of junior colleges lay in so-called remedial mathematics and English. Substantial additional courseware development was required, and it was proposed that additional courseware teams be established at Brigham Young University's Instructional Research and Development Department, under the direction of M. David Merrill. NSF subsequently funded MITRE for follow-on work with Texas and BYU as subcontractors for courseware systems design and development, coordinated by the Texas lab.

The story of the origin of learner-controlled courseware and the "factory" to produce it is a story of cross-fertilization between these three organizations. Unlike manufacturers of computing equipment, the not-for-profit MITRE Corporation was able to respond with highly flexible and creative systems-engineering solutions to software and hardware requirements implied by the instructional needs and goals generated by Texas and BYU. The capabilities thus developed in turn stimulated the imagination of the developers at the universities. The research of the Texas laboratory in learner control and in instructional design and packaging for computer-based systems provided a base of expertise in courseware development for CAI. The research in instructional psychology and instructional design and development at BYU provided empirical and theoretical perspective free from the self-limiting constraints which exist in yesterday's systems (in this case the IBM 1500 at Texas) but not in tomorrow's systems.

Because of the unusual Instructional Services Division at BYU (providing production facilities and personnel of unusual scope for all forms of educational technology), and the depth of instructional psychology talent among the faculty and graduate students in the Instructional Research and Development Department of this division, the director of the courseware project at Texas, C. Victor Bunderson, his associate, Gerald W. Faust, and half a dozen other key staff members elected to move to BYU in the summer of 1972. The Texas subcontract was terminated by MITRE because of the management and budget advantages of consolidation. The 30 terminal TICCIT system was installed at BYU in early summer, 1973. Further development of software and courseware on this is scheduled to occur in 1973 and 1974, with refinements to be made based on extensive student tests. In 1974, TICCIT systems will be installed at Phoenix College and

Northern Virginia Community College in Alexandria. Educational Testing Service will evaluate the ensuing demonstration. With so much work yet to be done, this paper must constitute a progress report.

This background is necessary to place the TICCIT system and learner-controlled courseware in context, for it has been developed in a unique manner, and in many ways is a substantial departure from any form of CAI developed on the available products of computer manufacturers or at single universities or centers.

Before the courseware design and authoring system for TICCIT can be explained, it is necessary to outline the principal features of learner-controlled courseware. In this discussion, keep in mind the capabilities of the TICCIT terminal. Using a Sony Color TV display, it can present digitally-generated characters and graphics, usually on a grey background, in any combination of white, black, red, yellow, green, blue or blue-green. Free-form contours as well as computer-generated graphs can thus be displayed. The color and graphics are extremely powerful for prompting and cuing of various sorts. Pre-recorded audio messages can be switched, random access, to the terminals, as can short video-tapes originating from cassette players. A standard typewriter keyboard permits upper and lower case alphanumeric entry. Another special keyboard at the left permits cursor pointing and cursor movement with flexible editing. A set of special learner-control keys is available at the right side of the keyboard. The keyboard and the display capabilities are a reflection of the courseware systems design.

The courseware systems design, and the team procedures which are geared to the production of the courseware components differ in substantial ways from earlier models for CAI materials. These differences provide the potential that the TICCIT courseware may represent an intellectual and practical contribution of some magnitude. It is an intellectual innovation because the courseware is designed around instructional theorems having sound empirical footings where possible, and theoretical integrity elsewhere. The invention of the primary instruction logic, the objectives and status display, the advisor program, and numerous other aspects of the courseware are also imbued with properties of sound man-machine interaction. The courseware is controlled by the student by means of a high level command language - a characteristic of man-machine symbiosis - rather than administered under computer-control step-by-step after the analogue of teaching machines or programmed instruction. The courseware is a practical contribution because the modular separation of content and logic leads to rapid improvability, transplantability to other systems, differentiated staffing for cost-effective production, and quality control. The practical advantages of design toward appeal for human users of the system, as well as effectiveness and efficiency, can also be of great significance toward the goal of catalyzing a new market.

The courseware design began with an analysis of the institutional needs of community colleges and the individual needs of their students. The problems of increasing costs, low or uncertain effectiveness, and associated student discontent were immediately apparent. With open enrollment, more and more students in community colleges were seen to lack high school mathematics and English grammar and composition.

This analysis of needs led to the specification of three design goals for the TICCIT instructional system: a cost goal, a content goal, and effectiveness goals. The cost goal was to replace the current $1.50/hr. instructional cost with a man-machine system costing no more than $1.00/hr., and having increased throughput. It was hoped that the increased throughput would effect the entire $3.26/hr. cost of community college education by reducing per-capita costs for physical plant, administration, library, and other expenses.

The <u>content</u> goals resulting from the needs analysis narrowed to courses in English and mathematics (the subjects having the 1st and 2nd greatest enrollment figures). It was found that most of the student population needed work in high-school level algebra and English grammar. In selecting and shaping the content for four instructional systems (approximately semester sized in each of Freshman and high-school math and English), no attempt was made to innovate drastically. A small step forward in content approach and organization was sought, with strong efforts to clarify the objectives and structure, and through modularity of design, to provide flexibility for a wide range of implementation patterns.

A novel instructional approach which seeks to teach traditional content in a non-traditional way is at somewhat of a disadvantage. For example, due to the lack of objectives and evaluation in higher education, teachers are now in the habit of "covering" material rather than assuring that students master it. A grade of B or C, or even A, does not tell us which set of performance capabilities implied by the textbook topics the students actually mastered. In TICCIT, we must teach to an operational definition of mastery.

We have selected standard content topics and have confirmation from the colleges involved and from content specialists in the fields of math and English that these topics represent what should be taught. Persons interested in curriculum reform could argue that this content is not in all respects appropriate for large numbers of community college students who are required to take it. Curriculum reform, and "selling" a new curriculum, was early seen as being well beyond the scope of this project. In addition, changing another variable makes even more difficult the introduction of an already novel and threatening system into a traditional educational establishment.

The TICCIT Algebra course is designed to provide instruction in basic arithmetic skills and the traditional beginning algebra and intermediate algebra courses. Also, it includes a treatment of common logarithms, systems of linear equations, permutations, combinations, arithmetic progressions and geometric progressions. The topics are arranged to provide a modular curriculum selection. Together with the elementary functions course, it provides a modular structure for precalculus mathematics. A concerted effort is made to emphasize statement problems and to illustrate applications.

The Elementary Functions course is designed to provide a treatment of the function concept with extension to elementary functions including the polynomial, trigonometric, exponential and logarithmic functions with a brief coverage of the conic sections and coordinate geometry. It requires as a prerequisite successful completion of the traditional Algebra II course or the TICCIT Algebra course. Emphasis is placed on intuitive understanding of the concepts involved, with prudent and sparing use of rigor. Graphic interpretation of problems will be used whenever possible; pains will be taken to help the learner acquire a "feel" for and a common sense attitude toward the material and its place in the subject matter.

Remedial English is essentially a writing course which focuses on very basic writing skills which enable the student to compose a standard expository paragraph. The course features many of the latest techniques in teaching writing - usage drill, editing exercises, generative rhetoric, and other useful techniques - while avoiding an over concentration on formal grammar. The end objective of the course is to prepare the student to enter a college-level composition course; or, if the student does not wish to take college composition, to enable him to write well enough to meet his personal and vocational goals.

Freshman English is the first quarter or semester of the traditional composition course. It offers maximum student practice with immediate feedback on many aspects of the student's writing. This course incorporates a writing laboratory in which the computer handles specific instruction in grammar, mechanics, diction, sentence structure, and paragraph development. Assessment and evaluation of writing skill are left to a trained instructor. The one objective of the course is to enable the student to write clear and otherwise effective prose in general standard English.

Our market analysis indicates that these four courses will account for approximately 20% of the total student contact hours of instruction in the average junior college. Each course covers from three to six semester hours of traditional junior college curricula, and the average student might require about 50-60 hours of terminal time to complete a course.

The effectiveness goals established early in the project are based on the recognition that community college students need more than skill in math and English. Thus, there are five effectiveness goals:

Mastery - Measured by scores on lesson and unit-level criterion-referenced tests (which may also be diagnostic) and, if the student elects, separate AB level tests over additional or more difficult material.

Efficiency - Measured basically as a weighted ratio of objectives passed to responses required.

Improved Strategies - Inferred from improvements in efficiency scores, accompanied by fewer requests for strategy advice on the part of the student.

A positive attitude toward the subject matter, and a desire to learn, as measured by the extent to which the student will voluntarily choose to work on (approach) optional material rather than avoid it.

An attitude of responsibility - measured primarily by the extent to which the student meets commitments he makes to achieve certain levels of mastery within certain time periods.

COURSEWARE DESIGN TO ACHIEVE EFFECTIVENESS GOALS

Three broad concepts which characterize learner-controlled courseware are: 1) the concept of three levels of discourse in student-machine communication; 2) a modular approach to courseware structure, and its relationship to a taxonomy of instructional variables; and 3) the interface between instructional system components and the student - the learner control command language and the advisor program.

Levels of Discourse

A model for student-machine communication developed by Pask (1967) provides inspiration for the three levels of discourse implemented in TICCIT. Pask asserts that all communication between student and computer can be described as taking place in one or more special languages. The flow of instructional information sequenced according to fixed algorithms within the computer, and the answers to questions and problems entered by the student comprise what Pasks calls the L^0 language. Discussion about the instructional process itself, and attempts by the student to control the process in some way, take place in L^1. It is possible also to define an L^2 language in which control processes can be discussed and modified.

In the TICCIT system, we speak of progressively higher levels of discourse, analogous to Pask's languages. In Level 0 the computer presents information and asks questions; the student makes pacing responses and answers questions. Level 1 contains Level 0 plus capability for student to command the computer relative to strategy (defined primarily as sequence within a well-structured set of instructional components.) Level 2 is Levels 0 and 1 plus ability of student and computer to converse (in a highly structured way) about high-level concerns (strategy, attitudes, motivating contingencies, etc.). The student can take action to modify his processes of controlling the system, using control keys and commands.

Level 0 is implemented primarily within files of instances (examples and non-examples of concepts and rule usage) where students may look at worked examples or may practice. Level 1 is implemented as a "learner-control command language" using a special keyboard and a few control words. Level 2 is implemented by an advisor program, which refers to a set of student historical data (monitor) and communicates through "status displays" at course, unit, lesson, and segment levels. The advisor also communicates through audio, and through blue-colored visual displays.

The implementation of Levels 1 and 2 makes it possible to seek student growth toward the important goals described above of approach rather than avoidance, improved strategies, and responsibility in addition to those of mastery and efficiency.

MODULAR COURSEWARE STRUCTURE AND ITS RELATIONSHIP TO INSTRUCTIONAL VARIABLES

The design and implementation of the learner-control command language and the advisor was made tractable only through the development of a modular courseware data structure. This structure is based on the assumption that the great majority of instruction, particularly at the junior college level, can and should be represented as concept learning (classification behavior) and rule using. A corollary of this, by the way we define classification behavior and rule-using behavior, is that the structure of instructional material analyzed into these categories is hierarchical. Thus, the TICCIT courseware is hierarchically organized into four levels. These levels are represented to the student by special displays that present the hierarchies, list the topics, access the objectives, and display status after the student has worked. These are:

Course Level: Course objectives and status display (course map).

Unit Level: Unit objectives and status display (unit map).

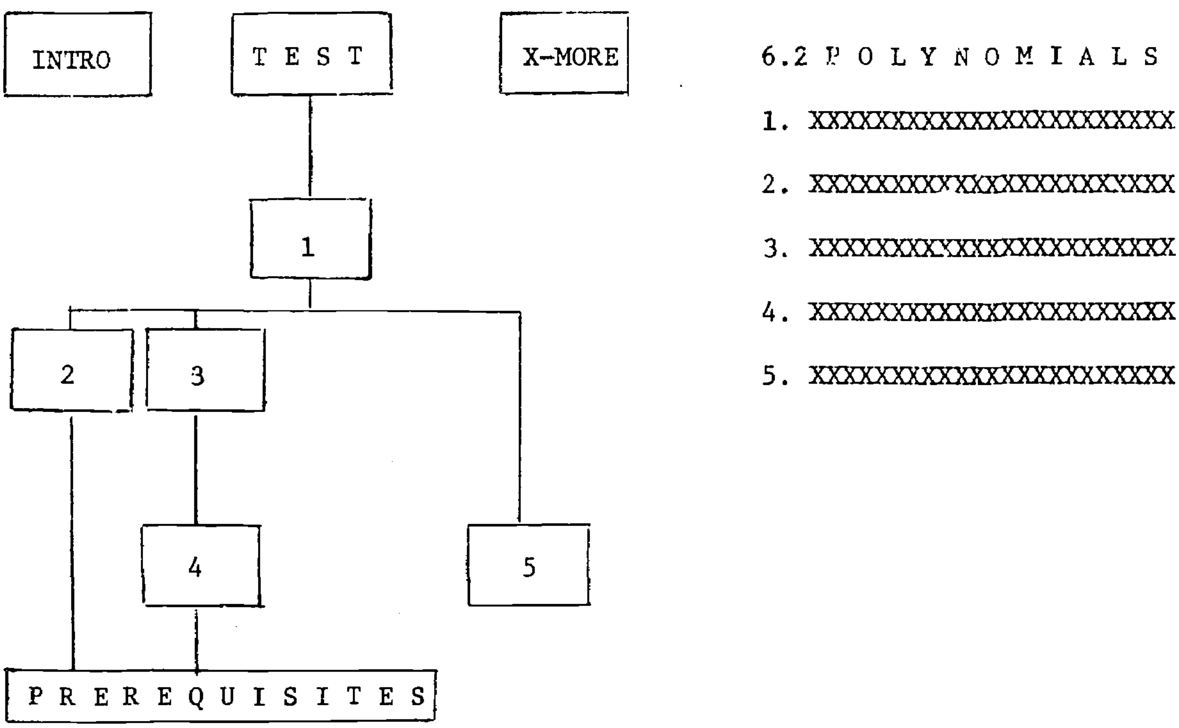
Lesson Level: Lesson objectives and status display (lesson map).

Segment Level: Primary Instruction Components

Objectives and Status Display (map)

A simplified map is shown in Figure 1. The screen displays a hierarchy on one side and topics on the other. To survey, the student may look at introductory options (usually a videotape), or type integers or P. Typing an integer gives a cartoon illustrating the segment objective, or "P" the prerequisites. STATUS is indicated by coloring the boxes red, yellow or green to indicate trouble, uncertainty, or clear progress. Typing "X" gives a similar map for AB test, AB work, and games, simulations and other "fun options."

Figure 1



At the course level, the boxes represent unit objectives; at the unit level, they represent lesson objectives; at the lesson level, they represent segment objectives.

On a course or unit map when the student selects a box, he pushes the "GO" button and drops to the next lower map. On a lesson map, when the student selects a segment, he pushes the "RULE" or "EX" (example) or "PRACT" (practice) button to interact directly with the content.

A strategy consists of a survey and planning phase (using maps) and a learn-test (learning tactics) phase. Tactics are constructed within a segment by the student using segment components sequenced according to his use of learner-control commands (with assistance from the advisor as necessary).

Learning components are constructed according to Merrill's Taxonomy of instructional variables (Merrill and Boutwell, 1972) so that a wide range of individually effective microsequences can be effected by the students who will work with TICCIT courseware.

Merrill's taxonomy involves three classes of variables: presentation form, inter-display relationships and mathemagenic information.

Presentation form may be of four types, generalities, or instances, either of which may be presented either in expository or inquisitory form. The system deals primarily with concept learning and rule-using, so a generality is a definition of a concept, or a rule. An instance is an example or non-example of a concept or a rule in use. Expository means to tell, inquisitory to ask. Inquisitory generalities (e.g., "define a concept") are rarely used.

Inter-display relationships involve the matching and pairing of examples and non-examples, the difficulty levels of instances, the scope of the generalities and instances, and their abstractness-concreteness.

Mathemagenic Information is information which gives birth (gen-) to learning (mathema-). This category involves prompting and cuing and other attention-focusing techniques. Specific techniques include attribute isolation (use of color graphics, etc., to highlight key attributes), search strategies (step-by-step algorithm) mnemonic aids, and production strategies (heuristics to guide the production of student generated products, eg. paragraphs).

THE LEARNER CONTROL COMMAND LANGUAGE

This taxonomy of instructional variables forms the basis for files of instructional material within the computer, which can be accessed by the student through the use of the learner control command language. There are five basic kinds of content files, and additional files for display formatting and answer-processing.

Map files include the objectives and prerequisites for survey, and the introductory options menu for course, unit, and lesson maps.

Generality files provide for each segment a main generality, an easy version, a hard version and a "help" file for the generality.

Instance files include for each segment, a sequence of between 8 and 30 instances. The instances are classified as easy, medium, and hard, and are available in expository or inquisitory modes. For each instance, a help file specific to that instance, is available. In inquisitory mode, answer-processing and feedback is available. Instance files may be defined by generative algorithms as well as by a set of discrete items.

Test files for each lesson are made up of instances similar to those found in the inquisitory instance files. A-B level tests are also available. Unit and course level tests are provided.

Fun options are games, simulations, tidbits of humorous or interesting information, and options to look at extra videotapes of interest. These are made available on the same map with the A-B work, hopefully to induce students to voluntarily choose optional work.

The learner-control command language provides the student with a means to access any file with few restraints. He may be forced to listen to and look at advice if he is going astray, but he is never forced to look at any instructional material that he does not select.

Nine principal buttons are involved in a learner's control of his own learning tactics: RULE, EX, PRACT, EASY, HARD, HELP, MAP, OBJ, and ADVICE. Seven of these deal with events within a segment, while the MAP and ADVICE buttons are more general. The MAP button accesses the next higher MAP for status or survey, and the ADVICE button elicits advisor program comments on strategy and other matters.

The three main primary instruction learner-control buttons are related to the presentation form dimension of the taxonomy of instructional variables as indicated in Figure 2.

	Expository	Inquisitory
Generalities	RULE	
Instances	EX	PRAC

Figure 2. Relation of Learner-Control Buttons to Presentation Form

The nine principal learner control command keys are as follows:

RULE Accesses the main generality for a segment.

EX Accesses the next instance in a file of expository instances. (having matching, pairing, etc. built in)

PRAC Accesses the same instance file as EX, but presents them in inquisitory mode, with necessary answer processing.

RULE may be followed by:

EASY More concrete form of rule (an analogy). Simpler terminology.

HARD More abstract. Technical notation and terminology.

HELP Mnemonic aids to remember the rule. Attribute isolation of key terms or characteristics using color and graphics. These may be followed by an information processing sequence for using the rule or testing instances of the concept.

PRACTICE or EX may be followed by:

HELP Instance specific attribute isolation using color, arrows, sometimes graphics, and sometimes audio. Aids to recall the rule are presented first, followed by a step-by-step walk-through of a good information-processing algorithm for using the rule or testing the concept, specific to this instance.

EASY or

HARD Shifts to easier or harder instances.

EASY and HARD are "inter-display relationship" variables while HELP provides "mathemagenic information."

Matching of examples and non-examples, and a default sequence generally going from easy to hard and covering the necessary range of divergency among the instances is built into the instance files and their controlling logic. Students can override this.

There are keys and commands other than these nine on the learner-control keyboard, and other functions involved in the MAP logics which are vital parts of the learner-control command language. An early description of learner-control commands, many of which are being implemented in TICCIT, can be found in Fine (1972). A full description of the current design exists in project working papers only as of this date.

TEAM PRODUCTION OF LEARNER-CONTROLLED COURSEWARE

The foregoing description of learner-controlled courseware shows a highly modular and redundant system design. This makes possible differentiated staffing so that different members of courseware development teams produce the various content files described above. The separation of content and logic in TICCIT courseware and software design is a key feature in making team production of large volumes of material possible.

There are four distinct teams at work at BYU producing courseware for the TICCIT system, two in English and two in math. Each team includes the following roles, filled by one or more individuals: Instructional Psychologist (IP), Subject-Matter Expert (SME), Instructional Design Technician (IDT), Evaluation Technician (ET), and Packaging Specialist (PS).

The instructional psychologist (IP) may have a general background in Educational Psychology and related subjects, including experimental methodology, human learning, measurement and statistics, and experience in computer uses. He needs a more specific background, not now available in many graduate programs, which will take a design-science (as opposed to a natural science) philosophical approach, provide considerable experience in instructional systems design, development, evaluation and implementation, and be a student of the growing literature on instructional variables and instructional theory.

The subject-matter specialist (SME) is selected for his knowledge of the subject-matter to be taught, his experience and interest in teaching, and his openness to innovative, machine-mediated approaches to instruction. He also must be a good manager, able to meet deadlines, and able to keep a small team happy and productive on a daily basis. He supervises from one to three others with lesser degrees of subject-matter expertise. These may be called assistant authors or author assistants, depending on their assignments. Graduate students, undergraduate students, and non-students are used in these roles.

The instructional design technician (IDT) is a graduate student in the instructional psychology program, filling an internship in development. The program emphasizes a balance between instructional research and instructional development. He gains practical experience in behavioral analysis. He also learns to develop sequences of examples and non-examples, matched and paired, having a range of divergency and difficulty. On the TICCIT project he also learns how to lay out display and response specifications and answer-processing. He also may generate ideas for his doctoral research.

The evaluation technician (ET) is involved in the formative evaluation of instructional materials. He too is a graduate student trainee in the instructional psychology program. With the IP he works out an evaluation design, assists in the development of evaluation instruments, collects data, and documents results in a form maximally usable by the authoring teams for revision.

The packaging specialist role is filled by a pool of undergraduates and non-students under a packaging manager. They serve all four teams. Within this group are artists, who draw graphics from the rough sketches and verbal communication from the authors. "Coders" are also involved, who put the formatted products of the authoring teams into the codes acceptable to the TICCIT software. Typists enter it and debug it superficially. ET's and authoring teams are involved in the more substantive debugging and revision.

The activities of these personnel vary somewhat from team to team, depending on the proclivities of the author and IP who guides it and the strengths and weaknesses of various team members. The products they must produce and the overall schedule is similar across teams. This schedule, basically, is to produce all of the components and their display formats for a complete lesson (except videotapes and AB options) in a five-week cycle. Since the last two weeks are primarily for review and (hopefully minor) revision, the main content files for a lesson can actually be produced in two or three weeks (another one to two weeks are provided for packaging). Authored content for a lesson includes the following:

1. MAP format and its contents
    a. Visualized objectives
    b. Prerequisites
    c. Videotape outline or mini-lesson

2. Lesson Test and A-B Test
    a. Item formats
    b. Items and sequence

3. Generalities
    a. Rule or definition
    b. Easy version
    c. Hard version
    d. Help for generality

4. Instance Files
    a. Examples and non-examples, classified as easy, medium and hard, and sequenced appropriately.

b. Instance file formats:

inquisitory format

expository format

help format

feedback message format

c. Answer-processing specifications for practice instances.

Considerable training is involved in getting a team organized and functioning smoothly. There are many new skills required of team members. Many of these skills have been identified as contributions of the instructional psychologist's field, but we have found that not only the IDT's, but authors and assistant authors pick many of them up. This is most desirable, and cross-training is sought.

Some of the more important skills are:

-- Behavioral analysis of the lesson objective to produce the learning hierarchy and identify the prerequisites.

-- Performing probable error analyses of an initial set of practice items to identify irrelevant attributes and common misconceptions. This analysis also serves as a means to produce the minimum set of practice items, sequenced properly, and with matching and divergency for effective learning.

-- Performing information-processing analyses of practice items to generate an efficient step-by-step procedure from which the algorithms for helps can be developed.

-- Applying techniques of attribute isolation and other attention-focusing or mnemonic aids for constructing helps.

There are technical skills related to the TICCIT software interface required of IDT's and packaging specialists. Some of these are:

-- Formatting of windows on "Base Frame" specification forms which will apply across a set of instances, helps, and feedback messages.

-- Writing answer-processing specifications.

-- Using input commands and editing commands to enter and debug formatted material.

-- Writing item generators, simulators, and games.

Vital to the success of the courseware in being interesting and enjoyable to the students, and facilitating our goal of positive approach, is the creative talent of artists and authors. These skills can't be defined well, but the products either have it or they don't. We look for the following in our graphics and prose, especially those associated with the easy version of the generality, and in the helps and super-helps:

-- Low-key humor.

-- Clever line drawn graphics.

-- Interesting and entertaining videotape scripts.

-- Use of non-verbal communication techniques using color, simple graphics, and contiguity instead of extensive written English.

In conclusion, it must be stressed that we do not feel we have necessarily found the best procedure for developing sizable quantities of quality courseware. We are still learning and improving our procedures daily. We do feel, however, that our system has the attributes of a good theory. That is, we have been sufficiently explicit about the components of our product, learner-controlled courseware, that weaknesses in these components, and in their relationship to the total system, can be identified and improved. Also, although we will always encourage some flexibility in role definition within teams, valuing creativity and spontaneity in the material, we do have the basis for detailed job descriptions. We have the basis for training procedures to reproduce teams should the demand emerge.

In short, if the TICCIT project achieves its goals of cost-effectiveness, and if learner-controlled courseware is well received, our team approach to large-scale courseware development may make a significant contribution to the establishment of a new branch of the education industry. We hope it will make an even greater contribution to students, young and old, who will find that learning from the descendants of learner-controlled courseware systems like TICCIT can be an enormously rewarding experience.

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