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TITLE: AUTOMATED TOOLS FOR THE GENERATION OF PERFORMANCE-BASED TRAINING

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ABSTRACT

The field of educational technology is not a new one, but the emphasis in the past has been on the use of technologies for the delivery of instruction and tests. This paper explores the application of technology to the development of performance-based instruction and to the analyses leading up to the development of the instruction. Several technologies are discussed, with specific software packages described. The purpose of these technologies is to streamline the instructional analysis and design process, using the computer for its strengths to aid the human-in-the-loop. Currently, the process is all accomplished manually. Applying automated tools to the process frees the humans from some of the tedium involved so that they can be dedicated to the more complex aspects of the process.

INTRODUCTION

Educational technology is defined as "the development, appli ation and evaluation of systems, techniques and aids to improve the process of human learning (CET, 1979). Yet, when one examines most texts in the field of educational technology, one does not find a discussion of technologies that support the instructional designer and developer (e.g., Percival and Ellington, 1988 or Alessi and Trollip, 1985). The emphasis has been on the technologies to *deliver* the instruction. However, professionals in education or training are quick to tell you that the actual delivery of the instruction is one of the least expensive steps in the process,whereas the analysis and design processes are the most expensive.

The performance-based training (PBT) process outlined in the recent Department of Energy (DOE) Order 5480.18 (DOE, 1989a) is a good example of this observation. A vast amount of work must occur before not only the development but also the detailed design of the instruction. The core of the PBT process is identification of the knowledge, skills, and abilities that the employee must have to perform the job safely and effectively. However, reality indicates that at many DOE sites the jobs are so specialized that performing the job and task analysis process manually is economically unfeasible. Automated tools are necessary.

This paper is intended to serve as a base for future work on automated tools, as opposed to being "the answer." It begins with a discussion of the PBT process and the parts of the process that are appropriate for automation and continues with descriptions of the existing work in automated tools. It then proceeds with a discussion of particular automated tools that were conceived at Los Alamos National Laboratory and a description of one existing tool. The paper concludes with implications for future work.

THE PBT PROCESS AND AUTOMATION

PBT assumes that job performance can be improved by training based on job-related competencies developed and assessed through properly designed training programs. It consists of five major phases: (1) analysis, (2) design, (3) development, (4) implementation, and (5) evaluation. The automated tools to be discussed here focus primarily on the first and second phases, analysis and design.

The analysis phase identifies training requirements for a specific job position. Training needs are determined by needs, job, and task analyses. Program goals are then established, and the scope of training content is defined.

During the design phase, terminal objectives are developed based on the information from the analysis phase. Skills and knowledge associated with a task are translated into enabling objectives and are organized into instructional units and sequenced to aid the learning process. These objectives form the "blueprint" that guides the development of all training materials, tests, and strategies. All of this information comes from the U.S. DOE Training Accreditation Program Manuals (DOE, 1989b).

These two phases are often performed by trainers in a casual fashion; thus, the analysis results cannot be tracked or studied. This casual approach is not acceptable in PBT, which requires systematic methods, full documentation, and the use of predetermined forms. Because training budgets have not increased significantly to accommodate the requirements of the PBT process, we need to seek more cost-effective ways of meeting the PBT requirements, while at the same time keeping the rest of our operations running smoothly. It is logical to explore technology for a solution.

Taking a knowledge-based approach to this problem, one can analyze the process and extract the parts that could be automated from those that require human analytical skills (see Tables I and II). In these tables one can see that the human-in-the-loop is obviously essential, but the "human" tasks are of a higher cognitive level than the "automate" ones. This sorting was performed using the following criteria.

If the answer to one or more of the following is yes, then automate:

- Does the task require access to a database?
- Does the task require data collection, compilation, or statistical analysis?
- Is the decision made using a set of rules that already exist?
- Is the task currently tedious and repetitious to perform?
- Can the data can be collected by a computer instead of by a human?

If answer to one or more of the following is yes, then humans should perform the task:

- Is the consequence of error great?
- Is this a fuzzy area where answers are not easily collected or answered?
- Is human interaction required to obtain the necessary data?
- Does the task require creativity or common sense to perform?
- Is the required data not appropriate for a database?

As you can see from this list, the local site can be an important determinant for the suitability of automation; thus, the tasks listed in Tables I and II may not match the situation at your locale.

CURRENT WORK IN AUTOMATED TOOLS TO SUPPORT INSTRUCTION

The concept of automated tools to support the instructional developer is a fairly recent one, but a few existing efforts in this area are worth discussing. First, a few specific tools have been developed to support PBT within the DOE. Second, an effort based on Department of Defense (DoD) requirements has resulted in a set of tools to produce training materials that follow the military standard (MIL STD) for training . The third is work on expert systems for the instructional design process. We shall consider each separately here.

The automated tools developed within the DOE are several small data-entry-oriented software packages that do not function together. One supports the task-to-training matrix creation and involves completion of the form and updating it. This limited public domain software is available through the Idaho National Engineering Laboratory (Girard, 1989). Another supports the administration of the survey questionnaire to job incumbents regarding the importance and frequency of their jobs. This software, Questionnaire/Task Analysis (QTA), is described below in more detail and also in a paper by Houghton and Fries (1990).

The DoD-based work in this area comes mainly from a product now marketed by Instructional Systems Associates, but developed by personnel working for the U.S. Navy (ISA, 1989). This product, Instructional Systems Consultant (ISC), offers a computerized method to partially develop courseware that meets the format and maintenance requirements of the DoD (MIL-STD-001379C). It is menu driven and allows for rapid development, review, and revision of this type of courseware. It is equipment oriented, rather than job oriented, which makes it somewhat cumbersome to use for a classic job analysis. However, a subject matter expert can use ISC to generate this type of courseware; an instructional designer is not needed.

ISC is a relatively expensive package ($25K) and requires a substantial investment of time to learn both the software and the underlying MIL STD 1379C methodology. Even after these investments, the software, at best, does only part of the training material development job, producing generalized outlines of the courseware in the form of an instructor's guide, which must be edited to suit the application. In addition, all of the work of actually writing the courseware still remains to be done, which is a major effort.

Some recent work has been done by researchers developing expert systems to support the later stages of the instructional development process (e.g., Kageff and Roberts, 1989; and Merrill, Li and Jones, 1989). These projects have been landmark works in defining the *fuzzy* knowledge base we call the instructional systems development (ISD) process, which is used in PBT. The product by Kageff and Roberts, called TIPS, allows a subject matter expert to obtain a recommendation regarding instructional strategies, after answering questions regarding the content of the instruction. The research product by Merrill and Lee, which provides a blueprint for curriculum planning, including the number and names of modules, has been through several major revisions as a result of the *fuzzy* nature of the knowledge base.

Those of us who have been espousing the systems approach to training for many years have thought of the process as quite precise! Yet, when we must formally represent the heuristics that we use to make decisions in the process, the arguments ensue. Personal style and experience (i.e., the art of the process) emerge as important variables. This paper focuses on automated tools to support the earlier stages of the process, which tend to involve less of the art and more of the science; thus, we can avoid some of the fuzziness.

AUTOMATED TOOLS FOR EARLY PBT PHASES

Tables I and II discuss the specific tasks in the PBT process that might be appropriate for automation. Each of these tasks requires extensive analysis before the conceptualization of an automated tool. At Los Alamos, we have conceptualized a few of these tools (see Table III). However, when one compares the list in Table III with the "automate" lists in Tables I and II, it is obvious that much work must still be done in conceptualization alone.

We have also actually developed one of these tools, the QTA, which is available as public domain software from Los Alamos. QTA is a computer program that provides two capabilities: the questionnaire part gathers numerical rating data on task difficulty, importance, and frequency; and the analysis portion averages and analyzes these rating data using the decision tree recommended in the Training Accreditation Program (TAP) Manual 2-88 supporting DOE Order 5480.18 (DOE, 1989c). QTA is written in the Modula-2 language and runs on an IBM-compatible PC. In its compiled form, it occupies about 50 kbytes of RAM and requires a total of 76 kbytes of free RAM to load and run. Each of its two capabilities is "standalone," so either or both can be run at any time. For the task ratings of each respondent, a separate data file is set up using a DOS file extension of .SUP or .OPR for the supervisors and operators, respectively.

Because of the recommendation in TAP 2-88 (DOE, 1989c) to compare the responses of the supervisors and operators, the analysis section of QTA is set up to routinely perform analyses of the operator's data set, the supervisor's data set, and a combination of both data sets. However, by editing one small file, the analysis part of the program can be used to average and then analyze any arbitrary set of these data files. This capability is useful, for instance, to determine the effect on the analysis results of omitting one person's responses if they are significantly different from the other responses.

IMPLICATIONS FOR FUTURE WORK

This paper was intended as a formal beginning to the systematic development of automated tools to support PBT within the DOE complex. Heretofore, there have been no concerted efforts to consolidate, integrate, and coordinate funding for automated PBT tools. Yet, such development would provide a perfect technology transfer area and cost-savings measure for the complex. If in the cost analysis only one usage site is considered, the cost to an individual institution for development of the tools discussed here is prohibitive. However, if several sites were to use the tools, the cost-benefit ratio would improve greatly. Each of the DOE sites is under the same requirements and funding constraints, and TRADE was formed to ensure avoiding the reinvention of the wheel at different sites, thus facilitating sharing.

There are three implications emerging from this paper:

1. The use of automated tools to support the PBT process can potentially ensure compliance with orders such as 5480.18 and conserve limited resources. The technology now exists to build automated tools to support the PBT process.

2. Automated tool development is sufficiently complex that coordination and sharing among the various DOE sites is required for cost effectiveness.

3. Because of the requirements of 5480.18, TRADE needs to officially endorse the concept of automated tools and also encourage cooperation among sites.

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TABLE I

AUTOMATABLE VS. HUMAN TASKS IN PBT ANALYSIS PHASE

(Steps taken from DOE PBT Manual TAP 2-88 - DOE, 1989c)

Needs Analysis

AUTOMATE:
- Objective analysis of existing training programs against PBT criteria (expert system)
- Database search to determine regulations affecting this area

HUMAN:
- Review of regulatory requirements
- Root Cause Analysis

Job Analysis

AUTOMATE:
- Task list generation software for use by job incumbents
- Validation of task listing
- Administration of survey questionnaire
- Analysis of survey results
- Documentation of survey results

HUMAN:
- Job/position review and categorization
- Selection of job analysts
- Review of validation results and revision of task listing as required
- Preparation of survey questionnaire
- Interpretation of survey results
- Selection of tasks for training
- Validation of the train/no train/overtrain lists
- Analysis of existing training materials

Task Analysis

AUTOMATE:
- Extraction of standards and conditions from subject matter experts (SMEs). This effort replaces interviews
- Compilation and structuring of task information

HUMAN:
- Review of task analysis (revise as required)

TABLE II

AUTOMATABLE VS. HUMAN TASKS IN PBT DESIGN PHASE

(Steps taken from DOE PBT Manual TAP 2-88 - DOE, 1989c)

Terminal and Enabling Objectives

AUTOMATE
- Generation of objectives from task analysis: an expert system based upon Mager's rules (Mager, 1965) for writing performance objectives

HUMAN:
- Review of objectives and revision
- Revision of training setting program based upon local resources

Training Setting

AUTOMATE:
- Task-to-training matrix
- Expert system to determine degree of fit between different training settings and content/objectives

HUMAN:
- Local resource vs. training setting analysis

Testing

AUTOMATE:
- Test administration
- Record keeping

HUMAN:
- Test monitoring
- Test validation
- Scoring system
- Review of test results

TABLE III

AUTOMATED TOOLS TO SUPPORT EARLY PBT PHASES

Trainer's Assistant (TA)

Users: Course developers and instructors

Input: Information regarding the current course (i.e. materials, format, strategies, testing, objectives, lesson plans) and relevant orders regarding compliance.

Output: Recommended changes in the instruction because of current requirements

User Interface: Expert system questions, user answers, and recommendations are given.

Advantages: Addresses sensitivity issues. Many current instructors are not readily responsive to needed changes, making the job of the trainer very difficult. Here the computer makes a subjective process objective.

Disadvantages: Complex rule base for expert system

Task List Generator (TLG)

Users: Job incumbents

Knowledge base: Standard operating procedures (SOP) for job

Output: Task list

User Interface: Users input task statements, given SOP and other relevant background material, and answer questions. Computer provides a compiled task list from all users' input.

Advantages: This process is very time consuming for the analyst, yet much of this information is in the heads of the job incumbents. Automated knowledge extraction is often more effective than interviews.

Saves time.

Disadvantages: The analyst still needs to validate the task list with those who used the TLG.

TABLE III (cont.)

AUTOMATED TOOLS TO SUPPORT EARLY PBT PHASES

Questionnaire/Task Analysis (QTA)

Users:	Job incumbents
Knowledge base:	Task list
Output:	Survey results compiled
User Interface:	Questions asked about frequency and importance of each task
Advantages:	Money saved by speeding up the process and reducing data reduction and analysis time
Disadvantages:	Process of answering the questions sometimes boring for the respondent. Works best when a human monitors the inputting.

Performance Objectives Generator (POG)

Users:	Instructional developer
Knowledge bases:	Task list, SOP, manuals in one and rules and algorithms for objectives writing in another
Output:	Terminal and enabling objectives
User interface:	Human ensures correct data is entered in the system and answers basic questions regarding the knowledge base. Expert system outputs the objectives. Human revises the objectives as required, deleting some as necessary.
Advantages:	The objectives generation process is laborious, yet very necessary. The rules for writing objectives are NOT fuzzy and, therefore, this is a feasible use of an expert system. Many instructors do not develop objectives, or those they do develop are not performance-based. This tool provides the objectives quickly and painlessly.
Disadvantages:	Some of objectives will not be appropriate; thus, the human must screen list and revise before use.

END

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