An Automated Curriculum Development Process for Navy Technical Training

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Abstract. The need to contain the rising costs associated with the production of goods and services has posed challenges for instructional design professionals. This problem is particularly acute within the U.S. Navy's training commands. The outcome of this challenge has been Navy-sponsored research and development in computer-aided instructional design. This article describes some of these efforts.

There is increasing interest in automating curriculum development. The U.S. Navy is interested because (1) it teaches over 7000 different courses, (2) training materials and programs must be frequently updated, and (3) producing one hour of instruction involves 100 to 1000 person-hours at a cost of from $5,000 to $50,000. Experience has demonstrated that time savings of 50–75% can be achieved over conventional curriculum development through automation (Boucher & Goldman, 1986). The Navy undertook automating these efforts to:

- focus subject matter expert efforts more on subject matter rather than on computer operation,
- reduce many repetitive tasks and improve quality, and
- generate curriculum materials in camera-ready formats.

The Navy wanted a system that could:

- support both development and maintenance activities,
- operate with standard microcomputer hardware and word processing and communications software,
- be easy for technical subject matter experts to use, and
- comply with a new military instructional product development procurement standard identified as MILSTD 1379D.

A microcomputer-based program created for the Navy that automates curriculum development is described here.

The Process of Curriculum Development in the Navy

There are at least three forms of curriculum development in the Navy. One is factory training, whereby weapons system contractors develop related training as part of procurement. Another is generic training, whereby teams at Navy apprentice and advanced schools create non-system-specific courses, often with contractor support. A third is revision of existing courses by Navy instructors with contractor assistance.

The Navy's training and curriculum development processes are guided by the principles of instructional systems development (ISD) (Briggs, 1976; Cantor, 1987). These curriculum development efforts are guided by military procurement standards for Navy training programs supporting specific weapons systems.

Training Program Components

The automated instructional development program described in this article was initially developed to support the Navy's Strategic Weapons System Training Program (Cantor, 1985). To understand this automated instructional development application, it is necessary to first understand the particular instructional program components which the application supports. A brief overview of these program components is provided below, followed by the software development process.

Analysis and Design

The first phase of the Navy's automated development program involves ISD analysis and design activities. The software incorporates the structure, formats, and components to support the required training material development. The first step in the Strategic Weapon System Training Program is construction of personnel performance profile tables, which are comprehensive listings of the knowledge and skills required to operate and maintain a system or piece of equipment. (See Table 1.) These tables result from task analyses and are prepared using technical documentation and

TABLE 1

Background Knowledge and Skill Table Format (Knowledge)

Item No.	Knowledge/Skill
1.	KNOWLEDGE
1-1.	Define the terms, abbreviations, and symbols associated with basic electronics.
1-2.	Describe the theory and construction features of semiconductors. a. Diode b. Silicon-controlled rectifier c. Transistor d. Field effect transistors e. Unijunction transistor f. Integrated circuits (chips)
1-3.	Describe operating characteristics of semiconductors.
1-4.	Describe the following tspes of transistor amplifiers and bias classifications: a. Types (1) Operational (2) Audio (3) Tuned b. Bias classifications (1) A (2) B (3) AB (4) C
1-5.	Describe the operation of transistor amplifiers connected in one of the three basic configurations. Include relative advantages of each configuration. a. Common emitter b. Common base c. Common collector
1-6.	Describe the theory and operation of basic types of oscillator circuits.
1-7.	Describe the operation and characteristics of particular oscillators. Include equivalent circuits and type of feedback circuit used in each of the following: a. Armstrong b. Hartley c. Colpitts d. Multivibrator (1) Monostable (2) Bistable (3) Astable e. Blocking

other pertinent data sources. Traditionally, performance profile tables were hand-prepared and where possible stored in computerized data bases. The tables are numbered corresponding to the system or equipment to which they are related.

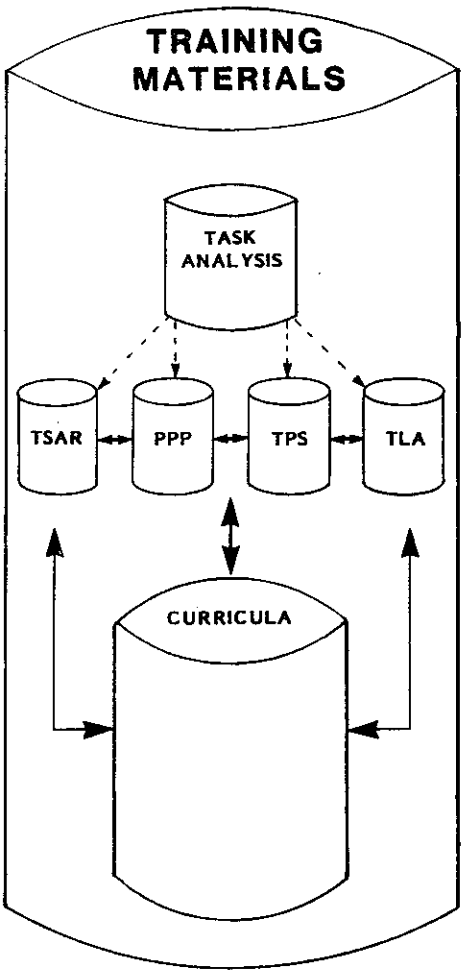
Tables consist of two parts: knowledge items representing the theory, characteristics, functional operation and procedures involved in the operation and maintenance of the system; and skill items representing the abilities required to perform operation and maintenance based on acquired knowledge. Task items are written to encompass all levels (domains) of knowledge.

The next component, the training path system, assigns the occupational knowledge and skill items from the personnel profile to specific Navy classifications in a logical order of job performance and to a defined depth of required knowledge and skill level. The intent is to ensure that personnel assigned to specific training programs receive the necessary skills and knowledge commensurate with their assigned responsibilities. This training system component represents the design phase of the ISD model.

The training path consists of three subcomponents: training objective statements, training path charts, and training level assignments. The objectives define the level of training coverage for the knowledge and skill items to be learned. The training path chart presents a matrix of personnel performance items and objective levels required for each course, as well as the logical course sequence for specific personnel. The training level assignment component assigns the levels of training for specified knowledge and skill items to specific personnel, and also identifies the type of training (background, replacement, on-board, etc.). The software enforces development of a training level assignment chart for each profile within the proposed course. The process of building or modifying the training level assignment chart is greatly simplified and the possibility of error is reduced through use of rule-based algorithmic logic.

Training level assignment charts are an effective management tool within this training program. The training program components and material development process which the software supports are shown in Figure 1.

Figure 1. Training material development process.



DATABASE RELATIONSHIPS

(Courtesy ISA)

The software architecture consists of a series of input screen shells and prompts to assist the subject matter expert in entering task analysis data in response to questions asked by the computer program. This logic flow consists of a generic questionnaire input format which builds a mini data base. Shells represent an empty template which is to be filled in by the operator. This information is then placed in a data base and used by the computer program to generate the output products. The computer programs supporting this automated tool are d-BASE III Plus® and WordPerfect®.

The output of this first phase is the personnel profile tables, training analysis summary reports, and training path systems level assignments, including objectives and charts.

Materials/Curriculum Development

Curriculum development formats and materials constitute a detailed plan of organization for the formal presentation of information and the practice of skills. Curriculum materials are written for several types of Navy training, including background, replacement, advanced, maintenance, and conversion training. For group-paced, instructor-led training the curriculum materials usually consist of the topic learning objectives, instructor guide, trainee guide, testing materials, and instructional media materials.

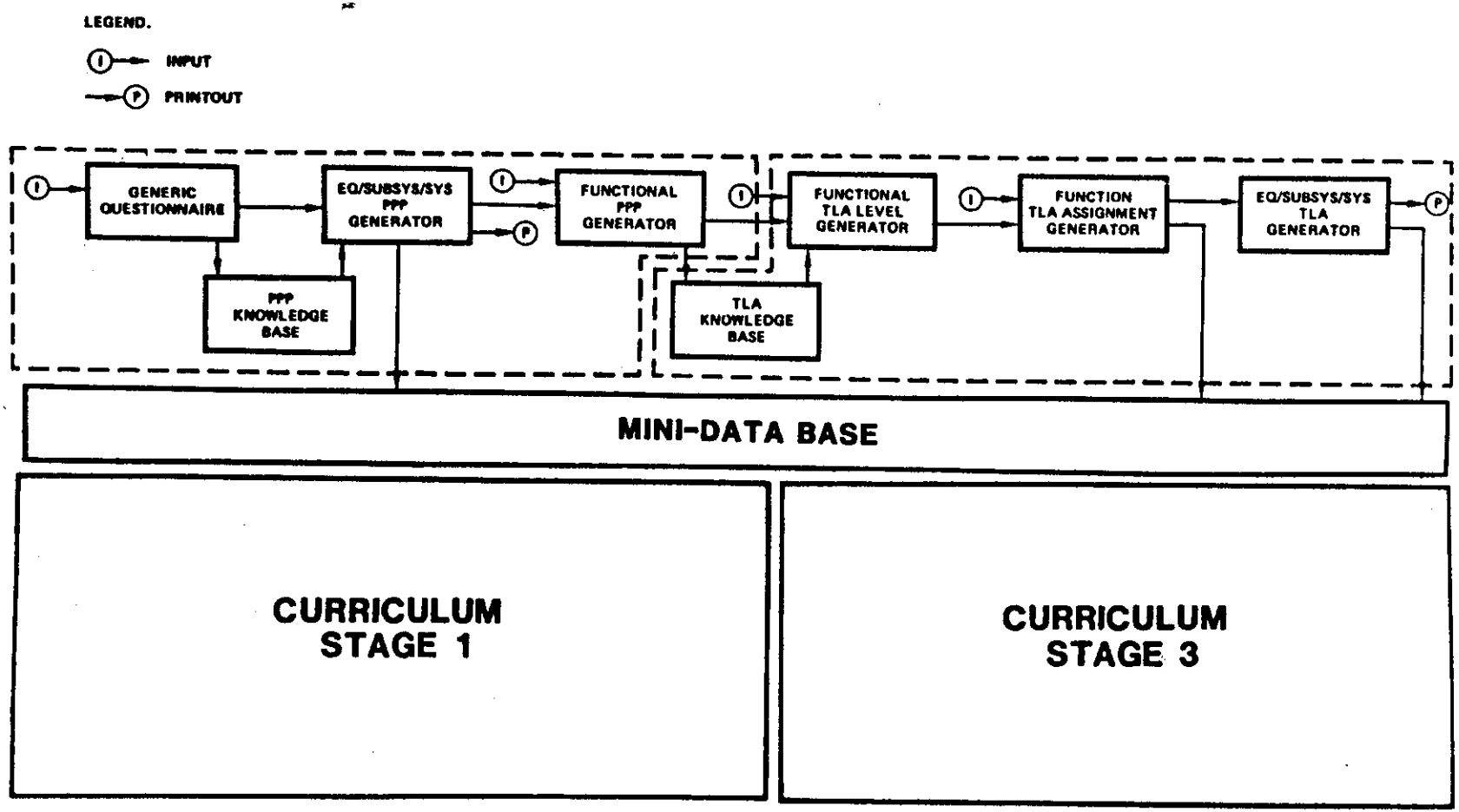
Software Automation

Automated documents are developed through a series of text processing routines which are interactive with the relational data base structure. All of the operations, such as specifying parameters and rules, sorting, and printing, are handled by macros. Macros are automated procedures which consist of stored command sequences appropriate for the applications being used for a particular function. These macros have been developed over time, based upon need as demonstrated through experience. For example, in the case of background and task/function personnel profile tables, a macro was designed to assist in the development of the table structure and in the selection of topic learning objectives and action verbs. For the training path system, the level/assignment generator provides for the file interaction necessary for objective arrangement into a topical outline permitting later sequencing in the curriculum development process. Once built, all training path data will be retained permanently in the training path system data base and integrated with the profiles and curricula data bases for later use in building curricula products. When operationalized by the report generator (a macro), the rule-based system produces tailored model statements to form the output report or table.

Each of the program files is designed to concentrate on a specific area of required information. However, in operation several files may actually operate interactively as a function is performed. This is possible through the use of the data base management software used in the design of this program. By way of example, the first of these program options to be used when constructing a profile will establish the profile number and ascertain whether the profile will contain classified material. Profile identification will continue with the establishment of the profile's name and occupational affiliation.

Unlike earlier attempts at this form of tool (Kearsley, 1986), a relational data base structure has been developed to alleviate data entry redundancy while

Figure 2. Personnel profile/training path system/level assignment development sequence—system flow.



(Courtesy Lockheed Systems)

progressing through input screens. Navy cost-consciousness dictates a need for expediency and elimination of excess labor time. This software tool was designed as an integrated system which allows the data produced by one phase of the ISD task to pass to another, whether forward or backward. This is most important, since a major effort in Navy curriculum development is maintenance of curriculum life cycle. File utility options allow all files created with the software to be stored and retrieved from a peripheral storage device connected to the hardware. Figures 2 and 3 graphically display the logic sequence for this automated process.

The software allows for the development of curricula materials in two phases. The first phase provides for the overall scheduling and planning of the curriculum. Through a series of text processing routines, a text sequence program is operationalized and data pertinent to the curriculum is automatically retrieved from the training path system file. Automated file selection of training level assignment and personnel profile tables is possible. This data is then processed through an objectives generator to develop a preliminary objective assignment chart which is displayed for the operator to review and modify as required.

Upon completion of the preliminary objective arrangement chart, the system automatically generates the section titles, topic titles, and topic learning objectives. The operator is prompted to identify references, training materials and equipment that will be required to support each objective, and stores all data obtained for use in development of the preliminary master materials list.

All materials developed during the first phase are available for review and modification upon the completion of the development process. In practice, it is at this point that we as training contractors meet with the Navy for material reviews.

During the second phase of the development process, which provides for the preparation of all curriculum elements for the pilot course, the balance of the curricula is developed using the same data base created during the first phase of development. First phase revisions and corrections are made at this time. The second phase may be developed individually by part, section, topic, in any combination thereof, or in its entirety, as selected by the operator. The software system generator automatically generates a skeleton discussion point outline, using the topic learning objectives from each topic. This outline is available for review and modification by the operator.

Upon completion of the discussion point outline for each topic, the operator is prompted to identify references, graphics, instructional sheets, equipment, and training materials required to support each discussion point. Appropriate entries are automatically placed in the related instructor/trainee activity columns. As material requirements are added to the curricula, these items are placed on the appropriate topic page, under the heading of trainee/instructor preparation, and in the master material list as required.

The instructional sheets identified to support the curriculum are developed at the completion of each topic. All data previously entered and required during development is automatically

Figure 3. Training path system diagram.

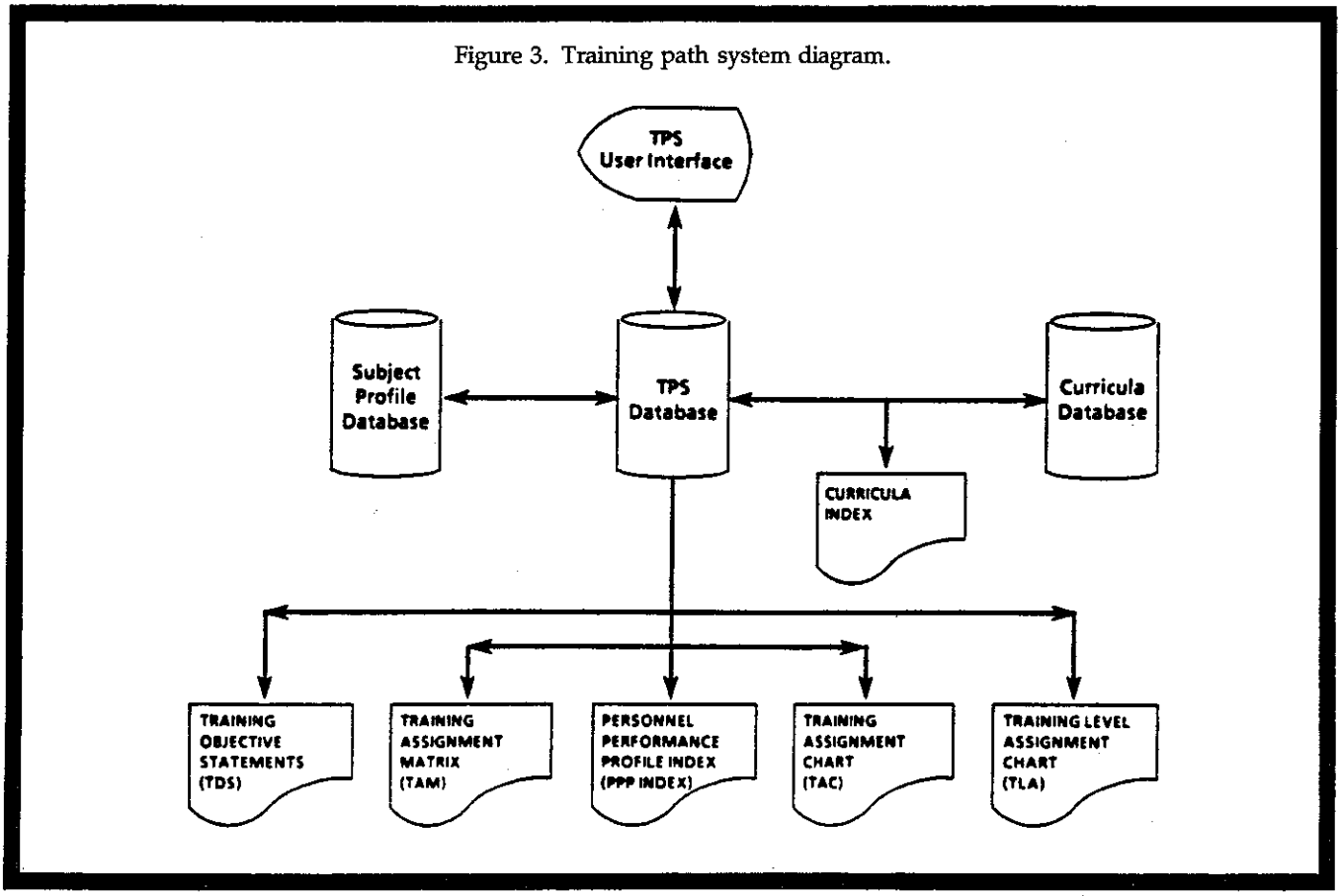
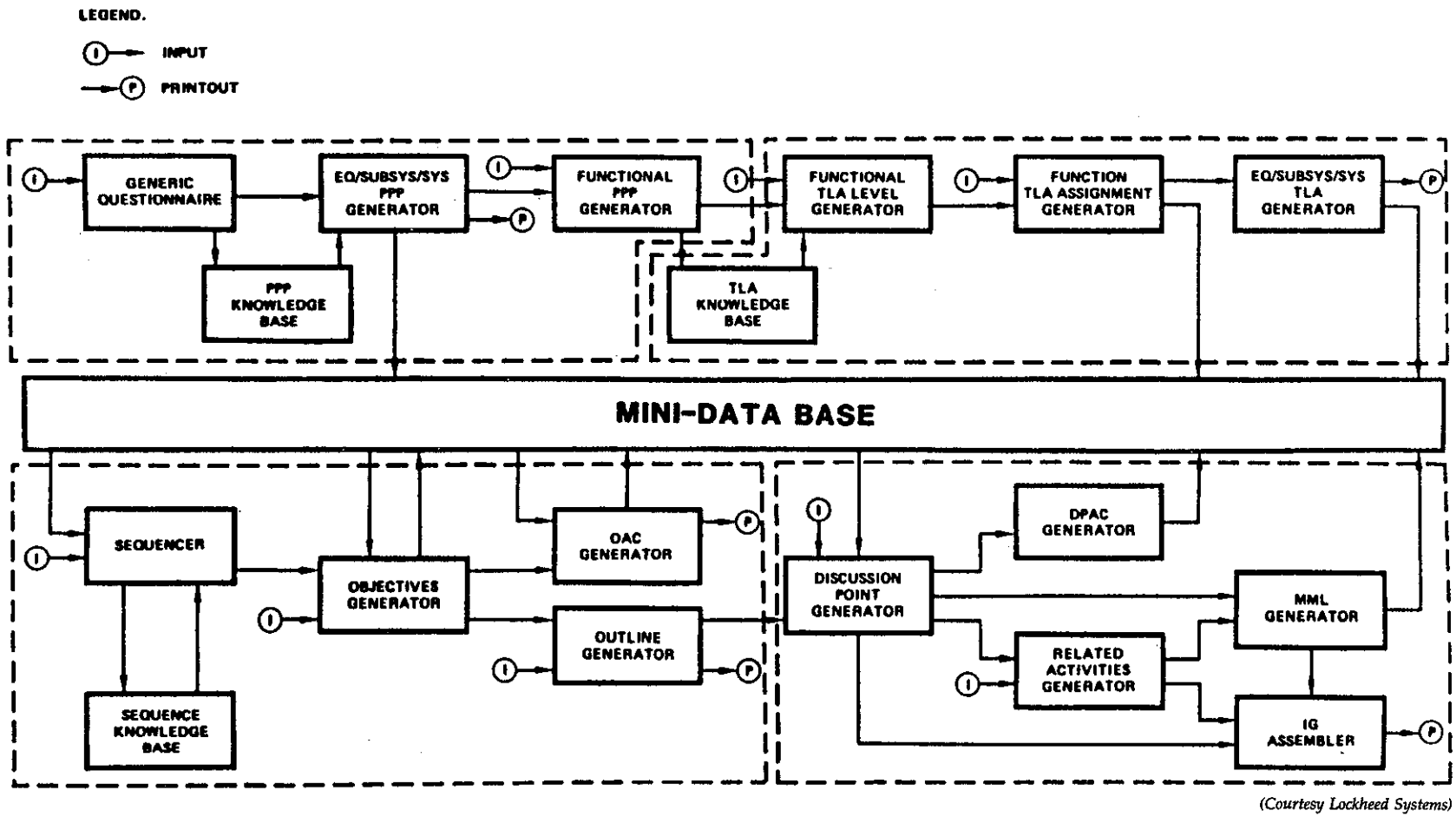


Figure 4. Curriculum development sequence—system flow.



(Courtesy Lockheed Systems)

placed on the instructional sheet. The operator is prompted for any remaining information required to complete the instructional sheet (e.g., study assignments, job steps). The software program runs on an IBM or compatible personal computer. It also has the ability to network with other computers when the hardware is configured with peripheral communications devices. The printer used is a graphics laserjet type, which permits fine-quality reproductions of technical subject matter.

Figure 4 displays the logic sequence for this automated process.

Management of Curriculum Development

The curriculum maintenance options available to the operator include automated statements, change preparations, review of materials, and approval of change materials. Based upon field trial experience, each option is now protected by a required password entry, and the level of access can be estimated for each user.

The automated statement provides the operator with the ability to search any group of materials (i.e., personnel profiles, training paths/training level assignments, curricula) and generates a list of all materials affected by the change(s). Personnel profiles and training paths/level assignment materials can be tracked for use in all other training materials.

Change preparation is accomplished by using the automated impact option which ensures that all occurrences of a noted deficiency are corrected. Alternatively, changes can be made by using the option which allows the operator to prepare a change recommendation for a single deficiency. The review of materials options provide the operator with the ability to review all current materials. Authorized users may, at their level of access, approve a pending change recommendation and incorporate this change into the master curriculum data base. This option also generates an automated impact statement for the operator, so that all persons concerned will know where changes can be expected in the curriculum materials. Figure 5 displays the curriculum products relationships.

Discussion

The objective of the software project was to develop an automated, computer-based system for the (1) analysis and design of instructional materials for all types of Navy training; (2) development, preparation, and production of instructional materials; and (3) systematic support and management of the curriculum development process.

The many steps involved in the instructional design and development process require a set of tracking procedures for project management. This is not unique to the Navy, but applies to many organizations. Like most organizations, the Navy has budgets and time lines to follow in order to produce the training material. Project management requirements may vary from one training development activity to another, but most curriculum developers require basic management and tracking tools for their course development projects. This software package has the proven ability to support and assist in these tracking and management support activities. To take advantage of common course material(s) information, this training information must be added to and be accessible from a data base. Access to paragraphs, topics, sections, and whole parts of already-developed courses would be quite useful to a developer working on a similar course. Time and money savings would be substantial.

In a recent application of this process to a curriculum redesign involving a Sonar Technician course, it was found that 80 hours of subject matter expert time was spent on the project in order to complete the necessary redesign. Since this course had been updated previously, a review of the records was undertaken. The last update took 240 hours of subject matter expert and instructional technologist time to complete. We have found that this automated capability gives us the advantage of producing a typical 40 instructional hour course in 45–66% less time. This results in increased profitability in a very competitive market, and supports Boucher et al.'s (1986) findings of substantial time and cost savings.

As graphic materials become electronic in format, they also must be organized in accessible data bases so that computer-stored graphic images can be available to other curriculum developers at the same training activity and to other training activities through the use of data base management computer programs. Many such software packages are able to support these needs.

The training materials development process involves a detailed audit trail through each of the design and development steps. For instance, there is a detailed methodology which specifies the links from the job tasks, to the objectives, to the presentation points in the lectures, to the testing materials. There is also the government requirement to ensure that changes in one part of the curriculum are accurately and automatically reflected in all other parts. Automation gives us the capability to be very accountable in our product development.

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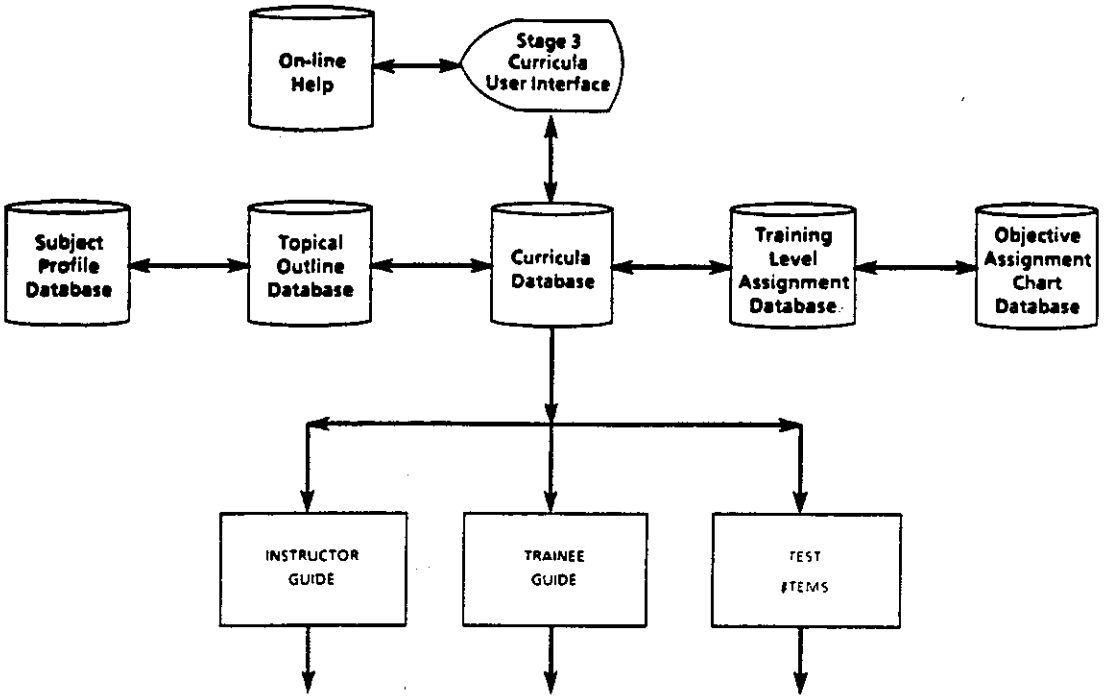
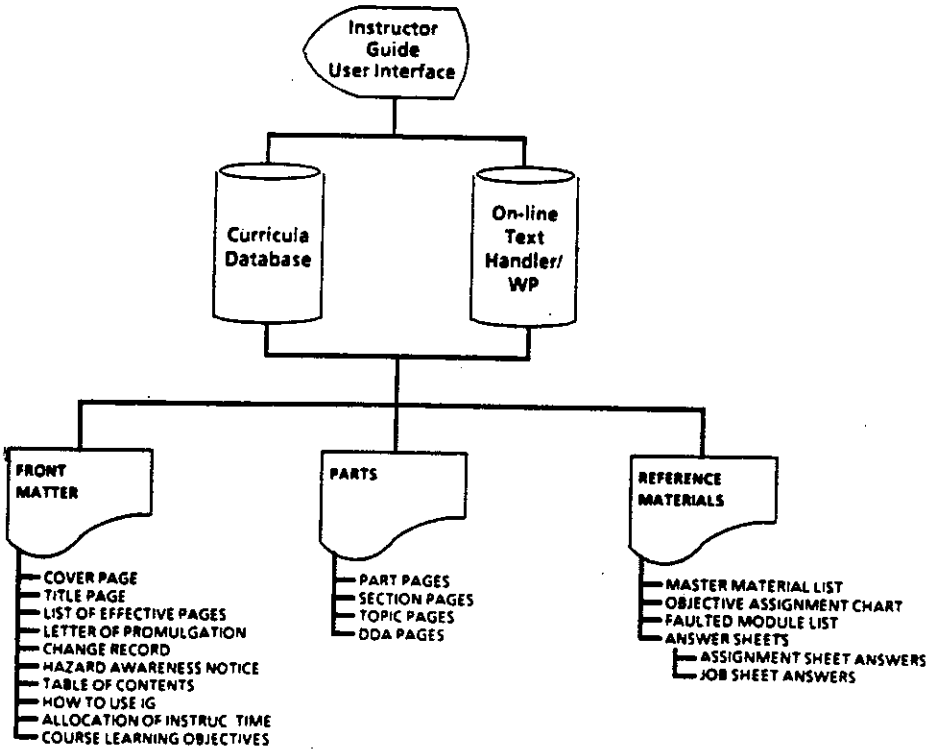
Figure 5. Curriculum products relationships.



Curricula Path Diagram



Curricula-Instructor Guide Diagram

The automated system is intended to better support Navy instructional planners and developers by reducing the time, effort, and expertise needed to produce curriculum materials....

The automated system is intended to better support Navy instructional planners and developers by reducing the time, effort, and expertise needed to produce curriculum materials, thus enabling us to become more competitive as a support contractor. The intent, therefore, is to optimize the process of instructional development and to standardize the products by working toward the following long-range objectives:

- Automate the formatting, production, and quality control standards of the numerous curriculum documents involved in training materials development.
- Provide a more customized software program to further assist in the various phases of curriculum development that require instructional expertise and curriculum development experience.
- Allow graphics editing and generation at work stations linked to laser printers.
- Provide a network environment with access to local and remote data bases so that existing instructional resources—both graphics and text—can be reissued with little or no revision.
- Integrate text and graphics in networked publishing environments.

This software continues to be tested and used in Navy applications. Its services continue to be demonstrated by quality control realized through automation, reduction in manhours of repetitious work, and enhancements of graphics.

Summary

The instructional systems software provides the subject matter expert with a powerful tool to develop a wide spectrum of training materials. Materials are developed with user-friendly menus which step the subject matter expert through the development processes. Materials developed are available for review, modification, and printing as menu options. Printed output is in the format specified by the operator.

The software was initially developed using existing commercial programs to allow Navy-formatted training materials to be developed and maintained in a fully relational data base and to allow for updates as training system development procedures and requirements are modified. The software is installed on an IBM PC compatible hard disk system. File utility options allow all files created with the software to be stored and retrieved from a peripheral storage device (i.e., external hard disk) connected to the hardware system.

The data bases created by the program include personnel profiles, training paths, training level assignments, curricula, and trainee guides. These data bases are linked to provide tracking throughout the training path. This linkage ensures that all training materials are developed and maintained as an integral unit, providing a means of identifying all materials affected by changes to other areas of the training program. These data bases are used for all development and maintenance functions of the program to ensure integrity and avoid unauthorized versions of the material.

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