APPLICATION OF EXPERT SYSTEMS TO FRONT-END ANALYSIS IN TRAINING PROGRAMS

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ABSTRACT

Expert system tools used at Douglas Aircraft Company are presented to aid a subject matter expert in preparing a front-end analysis for instructional systems. Rules are given for selecting tasks for initial training and for refresher training. In addition, another automated tool used for the front-end analysis and selection of acceptable media is discussed. Decisions for selecting tasks for initial and refresher training and for identifying acceptable media are presented as major cost drivers of a program.

The expert system tools, tasks selected for training, and tasks selected for recurrent training were embedded in the copyrighted data base. After testing, they were conventionally programmed and now reside on an IBM mainframe and as personal computer tools. However, media selection is independent of the copyrighted data base because this tool has found additional uses in data bases of other systems with different requirements. These expert system tools are all rule-based and *utilize various expert system shells for their development.*

INTRODUCTION

Instructional technology, as we now know it, had its origin in the 1950s in the work of B. F. Skinner and other behavioral psychologists.[1] Since then, the instructional technology discipline has split into two branches. The first, educational technology, focuses on the design of instructional materials, while the second focuses on training technology, or as it sometimes called, performance engineering. Performance engineering is applied to those human performance problems which can be solved better with training technology than through formal education.

Training technology utilizes small expert systems where applicable. The small expert systems do not try to capture true expertise. Rather, they serve to aid the user in analyzing a small but difficult problem. The expert system provides specific advice on how to solve the problem in a manner which supplies a consistent and accurate answer. The small expert systems used for problem solving have an advantage over the more conventional approaches in that they can be developed with minimal computer or programming knowledge and can be effectively used after a short learning curve.[2] Although some British instructional engineers refer to these small expert systems and similar performance systems as technician systems, it would be preferable to consider them as intelligent instructional job aids.[2] These system building tools will allow experts to record their knowledge *in a manner that provides practical assistance to less skilled* instructional professionals. Criteria for deciding when an on-the-job performance aid is appropriate and when to choose conventional learning using memorization are shown in Table 1.[3]

TABLE 1
CRITERIA FOR DECIDING WHEN A JOB AID IS APPROPRIATE

IF	THEN
RESPONSE SPEED IS VERY IMPORTANT (MORE IMPORTANT THAN ACCURACY) TASK IS FREQUENTLY PERFORMED SMALL ERRORS WILL NOT HAVE LARGE CONSEQUENCES READING INSTRUCTIONS WOULD INTERFERE WITH PERFORMANCE, OR JOB PRESTIGE REQUIRES A MEMORIZED RESPONSE	CHOOSE UNAIDED MEMORY
RESPONSE SPEED IS NOT AS IMPORTANT AS ACCURACY (SMALL ERRORS HAVE LARGE CONSEQUENCES) TASKS ARE INFREQUENTLY PERFORMED READING INSTRUCTIONS WILL NOT INTERFERE WITH PERFORMANCE TASKS INVOLVE MANY STEPS OR A COMPLEX DECISION-MAKING PROCESS	CHOOSE PERFORMANCE AIDS

One such application of system building tools is found in the Douglas automated front-end analysis program used in developing training systems. This program is designed to provide a data base for courseware design and instructional development. The automation of the front-end analysis presently appears at three decision points. First, the analyst must decide which tasks identified in a master task listing require training; second, the analyst must decide which previously selected tasks will require refresher training at a future date to maintain proficiency or which additions to the original task list will require update training. Refresher training is sometimes combined with update training in a recurrent training session. Another decision the analyst must make is in selection of appropriate media for supporting instruction for the learning objective. The media alternative selection model, unlike the models used for selecting tasks for original or recurrent training, is a conventionally prototyped and programmed tool. The small expert system tools may be included in the model as a performance aid in the design of its internal media selection/characterization matrices.

The development of an instructional system for the new Douglas aircraft, the MD-11, was initiated two years ago. A front-end analysis was one of the first tasks in this effort. The program manager decided that subject matter experts (SMEs) would be trained as the analysts. For many of these SMEs, this project served as an introduction to front-end training analysis. Initial indications were that all of the selected SMEs would be able to analyze tasks and develop accurate data on these tasks. However, the instructional decisions were more difficult for the SMEs to make, and they lacked the consistency necessary for credibility. The immediate areas of concern were identification of the tasks that required training, identification of tasks that required refresher training, and allocation of media to tasks as described by their corresponding learning objectives.

Each of these areas will be separately treated, followed by a discussion of the relationships between the various decision tools and their roles in automating a front-end analysis.

EXPERT SYSTEM TOOL FOR IDENTIFYING INITIAL TRAINING TASKS

Selection of training tasks from a master list of tasks performed on the job is difficult and time-consuming. The decision is often arrived at subjectively by the SME analyst, with inaccurate and inconsistent decisions resulting. Aside from reflecting on the credibility of the course content, incorrect decisions waste a company's training funds by providing instruction for tasks that the student already knows or for which no formalized instruction is required. The omission of tasks that should have been taught but were not taught affects the company's product liability. The courseware loses instructor and student credibility, the company risks its reputation for quality, and there may also be legal consequences of improper training.

An expert system was designed to interrogate the selection criteria and "decide" whether or not training is required for a task. The expert system identifies reasons or conditions by which the selection was made, thus providing the SME analyst with a rationale for questioning decisions made by the expert system. The expert system for selecting training tasks at the present time does not consider input errors in identifying and controlling data generated by the SME analysts.

Model Variables and Definitions

The model for training tasks considers six variables:

1. Task criticality, which is a measure of the importance of performing the task in meeting the goal.
2. Task newness, which is the determination of whether or not the student has previous experience in learning how to do the task or in task performance on the job.
3. Personnel hazards which identify tasks that, if improperly performed, can cause injury or death to the performer or others.
4. Equipment hazards which identify tasks that, if improperly performed, can cause minor hardware damage or major damage sufficient to abort the mission.
5. New skills or knowledge required to perform the task.
6. Task frequency, which identifies performances that are frequent enough so that the student will not forget what to do between learning the task and performing that task on the job for the first time.

Since forgetting is inherent in original training as well as refresher training, a review of the factors that influence forgetting may help the reader to understand the parameters of both original and refresher training which are used in our expert system models.

In determining task training frequency, one should consider task length as measured by the number of subtasks and the frequency of performance, or the interval between the completion of the learning and the first performance on the job. The percentage of students whose job performance is above the proficiency level is a measure of skill retention.

Rose et al[4] found that forgetting curves, shown in Figure 1, were influenced by the length of the task and the interval between the original learning of the task and its performance on the job.[4, 5]

Using the percentage of performers above the proficiency level as an index for refresher training, the following working guidelines were considered in the development of the expert system rules:

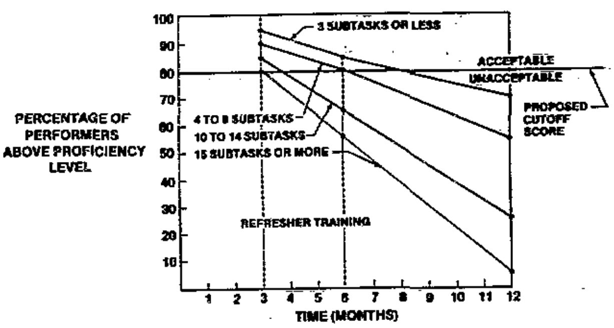

FIGURE 1. LOSS OF PROFICIENCY DURING A ONE-YEAR PERIOD

1. Short, simple tasks consisting of three subtasks or less (procedural steps) do not require refresher training earlier than six months after learning. After six months, job performance aids should suffice for refresher training.

2. More complex tasks consisting of four to nine subtasks do not require refresher training earlier than three months after learning. Between three and six months, either refresher training or job performance aids should be adequate to maintain proficiency. Refresher training is required one year later.

3. Longer tasks consisting of 10 to 14 subtasks may require job performance aids, refresher training, or both three months and six months after learning. Refresher training is required one year later.

4. A task consisting of 15 or more subtasks, the most complex task considered, may require a job performance aid after only three months. Refresher training is required for a longer period of time.

Rules for Selecting Tasks for Training

The expert system tool used in selecting tasks for training is a rule-based system consisting of the following 20 simple rules.

Rule 1 — If an equipment hazard exists, then train.

Rule 2 — If a personnel hazard exists, then train.

Rule 3 — If an equipment hazard does not exist, and the task is not critical, and new skills are required, then train.

Rule 4 — If an equipment hazard does not exist, and the task is not critical, and new knowledge is required, then train.

Rule 5 — If a personnel hazard does not exist, and the task is not critical, and new skills are required, then train.

Rule 6 — If a personnel hazard does not exist, and the task is not critical, and new knowledge is required, then train.

Rule 7 — If an equipment hazard does not exist, and the task is not critical, and new skills are not required, then do not train.

Rule 8 — If an equipment hazard does not exist, and the task is not critical, and new knowledge is not required, then do not train.

Rule 9 — If a personnel hazard does not exist, and the task is not critical, and new skills are not required, then do not train.

Rule 10 — If a personnel hazard does not exist, and the task is not critical, and new knowledge is not required, then do not train.

Rule 11 — If an equipment hazard does not exist, and the task is critical, and the performance frequency is less than three months, then train.

Rule 12 — If a personnel hazard does not exist, and the task is critical, and the performance frequency is less than *three months, then train.*

Rule 13 — If an equipment hazard does not exist, and the task is critical, and the performance frequency is three months or more, and new skills are required, then train.

Rule 14 — If an equipment hazard does not exist, and the task is critical, and the performance frequency is three months or more, and new knowledge is required, then train.

Rule 15 — If a personnel hazard does not exist, and the task is critical, and the performance frequency is three months or more, and new skills are required, then train.

Rule 16 — If a personnel hazard does not exist, and the task is critical, and the performance frequency is three months or more, and new knowledge is required, then train.

Rule 17 — If an equipment hazard does not exist, and the task is critical, and the performance frequency is three months or more, and new skills are not required, then train.

Rule 18 — If an equipment hazard does not exist, and the task is critical, and the performance frequency is three months or more, and new knowledge is not required, then train.

Rule 19 — If a personnel hazard does not exist, and the task is critical, and the performance frequency is three months or more, and new skills are not required, then train.

Rule 20 — If a personnel hazard does not exist, and the task is critical, and the performance frequency is three months or more, and new knowledge is not required, then train.

These rules were entered into an expert systems shell, NEXPERT, Macintosh Version 1.1, and run on a Macintosh IIx with 4 MB of RAM. The program, in C language, was supported by the Macintosh Programmers Workshop, C (20.2) and Pascal compilers and the MacApp Version 2.0, the expandable Macintosh application programming library.

Beta testing is being conducted to correlate test results of subject matter experts *using the tasks for a selection tool* with tasks selected by a group of experts. Preliminary results indicate that there is agreement within each group as well as between groups. Final results will be published when available.

EXPERT SYSTEM TOOL FOR IDENTIFYING REFRESHER (RECURRENT) TRAINING TASKS

Update training and refresher training are both provided on a recurring basis. After the original training has been completed, instruction is added to any new or changed tasks to incorporate these tasks into the learning experience of the student. The course content and media can be updated by subject matter experts using an expert tool to identify tasks for training and for media selection. Identifying tasks for refresher training requires different expertise and a different expert tool, as discussed in the following text.

Long-term retention of knowledge or skill proficiency is influenced by the degree of original learning of the student. During original learning, overtraining in the knowledge or skill may provide a longer period of retention. Overtraining means the training that extends beyond the first successful performance. In certain cases, overtraining is an important alternative instructional strategy for reducing, if not eliminating, refresher training. Overtraining may decrease the cost of total training and still maintain the performer's effectiveness. Therefore, when selecting tasks for refresher training, one should be aware of the alternative strategy of overtraining under certain conditions. For a discussion of the overtraining alternative, see Schendel and Hagman.[6]

The major variables that influence the selection of tasks for refresher training are based on a consensus among our experts. Our experts ranked variables identified in empirical studies and included only the major ones in our model. After testing the existing prototype, the order and perhaps the number of variables considered may be changed. The order of the following variables should be interpreted cautiously because some variables are: (1) so global that they may have several subvariables which are not of equal importance; (2) not completely independent and interact with each other, producing a synergistic effect, or (3) measured using different methods that may not be equivalent.[7]

In selecting the tasks for original training, a characteristic considered was the newness of the task. Task newness determines the extent and depth of instruction. The greatest amount of instruction is needed when the task requires that all new knowledge and skills be taught. The type of task also influences whether or not a task requires refresher training. Continuous or fine control tasks such as tracking have a better mastery retention rate than discrete or procedural tasks.

The complexity of a task is measured by the number of subtasks. The more "steps" in a procedure that must be recalled by a student, the more rapidly it is forgotten. Often, very short periods of nonuse lead to an almost total lack of performance. It is interesting to note that procedural tasks are of the greatest concern in training programs for enlisted personnel in the military.

In general, the longer the period of nonuse, the more the student forgets. However, as discussed previously, the type and complexity of the tasks have an effect on memory. The extent of retention varies with the different skills required for each step of a procedural task. Early research into mental imagery indicates that greater retention is possible if, during a nonuse interval, a "mental rehearsal" of the procedure is practiced.

Instructional strategies also influence the retention of skills and knowledges. However, quantitative measures for various instructional strategies are unreliable. Until better measures are devised, the best statement to follow is: If the acquisition of the knowledge needs to be complete, then computer-assisted instruction leads to better retention than a group-paced lecture. This is particularly true for smart computer-assisted instruction using information referencing. Feedback to the student on individual learning prescriptions as reported in a paper on Information Reference Computer-Assisted Instruction is particularly helpful in student learning and retention.[8] Ultimately, the goal is an intelligent tutoring system using a relational data base which is accessed by the student according to his self-identified needs.

In designing refresher training, there are other factors to consider. When a student enters refresher training, he or she generally retains a high level of factual recognition; for example, he or she may be able to identify panel components or succeed on a multiple choice test. The student also requires only 50 percent of the time to relearn motor skills to the original mastery criterion. However, the time to relearn is greatly affected by individual differences in such variables as innate abilities, prior knowledge, and skills or motivation.[4] Research concerning the variables comprising individual differences is limited, with most information inferred from the means by which the individual originally learned the task.[7]

Table 2 summarizes the key variables of task complexity and performance frequency, measured in terms of the percentage of performers who retained on-the-job proficiency after intervals of nonperformance.[6]

TABLE 2
RELATIONSHIP OF PROFICIENCY TO TASK COMPLEXITY AND TIME

	FREQUENCY ON-THE-JOB*		
	ONCE IN		
TASK LENGTH	3 MO OR LESS	4-6 MO	12 MO OR MORE
0-3 SUBTASKS	95	85	70
4-9 SUBTASKS	90	80	55
10-14 SUBTASKS	85	65	25
15+ SUBTASKS	80	55	05

*PERCENTAGE OF PERFORMERS AT PROFICIENCY AT THAT TIME PERIOD

NOTE: FROM REFERENCE 5.

At this point in our investigation of the expert system tool for identifying tasks for refresher training, Instructional

Systems Development experts, by consensus, set the cutoff score at the 80 percent level; that is, 80 percent of the performers must have mastered the task. The standard for the population "able to perform the task to proficiency" may be changed to 85 percent or 90 percent after more empirical studies have been conducted. For the present, the 80 percent cutoff score appears the most cost-effective. Changes in the conditional statements in the rules — that is, changes in the consequence (right, or action, side of the rule) — would result if the proficiency level changes.

The expert system tool used in the refresher training model is a rule-based system similar to the system used for identifying tasks for original training. The major difference between the rules for identifying tasks for training and tasks for refresher training is that refresher training is expressed as metarules, or a synthesis of more than one simple rule — that is, "if" (condition), "then" (action).

Metarules and Rules for Selecting Tasks for Refresher Training

1. If a task has been selected for original training and is performed at least once every three months, and contains up to three subtasks, and was easy or difficult to learn during original training, and has equipment or procedural cueing, then the task does not require refresher training.

2. If a new task has been selected for training and is performed at least once every three months, and contains up to three subtasks, and was easy or difficult to learn during original training, and has equipment or procedural cueing, *then the task requires no update training.*

3. If a task has been selected for original training or is new, and is performed at least once every three months, and contains up to three subtasks, and was easy or difficult to learn during original training, and has no cueing, then the task requires update or refresher training.

4. If a task has been selected for original training and is performed at least once every three months, and the task contains four to nine subtasks, and was either easy or difficult to learn during original training, and had either equipment cueing or procedural cueing, then the task does not require refresher training.

5. If a task has been selected for original training and is performed at least once every three months, and contains four to nine subtasks, and was easy to learn during original training, and has no cueing, then the task does not require refresher training.

6. If a task has been selected for original training and is performed at least once every three months, and contains four to nine subtasks, and was difficult to learn during original training, and has no cueing, then the task requires refresher training.

7. If a new task has been selected for training and is performed at least once every three months, and contains four to nine subtasks, and was easy or difficult to learn during original training, and had either equipment or procedural cueing, then the task requires update training.

8. If a new task has been selected for training and is performed at least once every three months, and contains four to nine subtasks, and was easy to learn, and has no cueing, then the task requires update training.

9. If a new task has been selected for training and is performed at least once every three months, and contains four to nine subtasks, and was difficult to learn during original training, and has no cueing, then the task requires update or refresher training.

10. If a task has been selected for original training or as a new task for training and is performed at least once every three months, and contains 10 to 14 subtasks, and was difficult to learn during original training, and has equipment cueing, or procedural cueing, or no cueing, then update or refresher training is required.

11. If a task has been selected for original training and is performed at least once every three months, and the task contains 10 to 14 subtasks, and was easy to learn, and has equipment cueing or procedural cueing, then no refresher training is required.

12. If a new task has been selected for training and is performed at least once every three months, and the task contains 10 to 14 subtasks, and was easy to learn, and has equipment cueing, or procedural cueing, or no cueing, then update training is required.

13. If a task has been selected for original training and is performed at least once every three months, and the task contains 10 to 14 subtasks, and was easy to learn, and has neither equipment cueing, nor procedure cueing, or no cueing, then no refresher training is required.

14. If a new task has been selected for training and is performed at least once every three months, and the task contains 10 to 14 subtasks, and was easy to learn, and has equipment cueing or procedural cueing, then update training is required.

15. If a task has been selected for original training or as a new task for training, and is performed at least once every three months, and the task contains 10 to 14 subtasks, and was easy to learn, and has no cueing, then update or refresher training is required.

16. If a task has been selected for original training or as a new task for training and is performed once every three months, and the task contains 15 or more subtasks, and was difficult to learn, and has equipment cueing, or procedural cueing, or no cueing, then update or refresher training is required.

17. If a task has been selected for original training or as a new task for training and is performed at least once every three months or at least once every six months, and the task contains 4 to 9 subtasks, or 10 to 14 subtasks, or 15 or more subtasks, and is difficult to learn

or easy to learn, and has equipment cueing, or procedural cueing, or no cueing, then update or refresher training is required.

18. If a task has been selected for original training or as a new task for training and is performed at least once every 12 months, and the task contains 10 to 14 subtasks or 15 or more subtasks, and is difficult to learn or easy to learn, and has equipment cueing, or procedural cueing, or no cueing, then update or refresher training is required.

19. If a task has been selected for original training or as a new task for training and is performed at least once every six months, and the task contains 15 or more subtasks, and is easy to learn, and has equipment cueing, or procedural cueing, or no cueing, then update or refresher training is required.

20. If a task has been selected for original training or as a new task for training and is performed at least once every 12 months, and the task contains up to three subtasks or four to nine subtasks, and was easy or difficult to learn, and has no cueing, then update or refresher training is required.

21. If a task has been selected for original training or as a new task for training and is performed at least once every 12 months, and the task contains up to three subtasks, and was easy or difficult to learn, and has equipment cueing or procedure cueing, then no refresher training or update training is required.

22. If a task has been selected for original training and is performed at least once every six months, and the task contains four to nine subtasks, and was difficult to learn or easy to learn, and has equipment cueing or procedure cueing, then no refresher training is required.

23. If a new task is selected for training and is performed at least once every six months, and the task contains four to nine subtasks, and was difficult to learn or easy to learn, and has equipment cueing or procedure cueing, then update training is required.

24. If a task has been selected for original training and is performed at least once every six months, and the task contains up to three subtasks, and the task was difficult to learn or was easy to learn, and has equipment cueing or procedure cueing, then no refresher training is required.

25. If a new task is selected for training and is performed at least once every six months, and the task contains up to three subtasks, and was difficult to learn or easy to learn, and has equipment cueing or procedure cueing, then update training is required.

26. If a task has been selected for original training or as a new task for training and is performed at least once every six months, and the task contains up to three subtasks or from four to nine subtasks, and was difficult to learn, and has no cueing, then update or refresher training is required.

27. If a task has been selected for original training and is performed at least once every six months, and the task contains four to nine subtasks, and is difficult to learn during original training, and has equipment cueing or procedural cueing, then the task does not require refresher training.

28. If a new task is selected for training and is performed at least once every six months, and the task contains four to nine subtasks, and is easy to learn or difficult to learn, and has equipment cueing or procedural cueing, then the task requires update training.

29. If a task has been selected for original training or as a new task for training and is performed at least once every six months, and contains four to nine subtasks, and is easy to learn during original training, and has equipment cueing, then the task requires update or refresher training.

The expert system shell, NEXPERT©, a product of Neuron Data, Inc., is used for programming to identify tasks for training and for refresher training. Following the Beta-test for the expert system tool for identifying tasks for training, the refresher training task tool will be tested. Present test plans for the refresher training expert system tool are to use the same basic test design and population as used to identify *tasks for training*.

MEDIA ALLOCATION/LIFE-CYCLE COST PERFORMANCE TOOL

The media allocation/life-cycle cost performance tool is a conventionally programmed, multipurpose performance aid for media analysis and media cost modeling for training systems. Unlike the expert system performance tools which are part of the front-end analysis system, the media allocation/life-cycle cost performance tool is a stand-alone aid.[9]

When the media allocation program is used in support of the mainframe front-end analysis, some data may be manually transferred directly from the front-end analytical data base to the program. Work in progress will enable all front-end input data to be transferred automatically to the program. At this time, the front-end analytical systems are the source of the data entered through the on-line input screens for the media program.

With accurate data input and the appropriate criteria for identifying selection measures, the media allocation program will identify candidate media for both academic type learning objectives and training device, or "hands-on," learning objectives. Summary reports are generated in sufficient detail to allow the media analyst to choose a specific media configuration or to develop alternative media mixes.

Model Variables and Definitions

The training analyst takes the learning objectives from the front-end analysis to the extrinsic media allocation

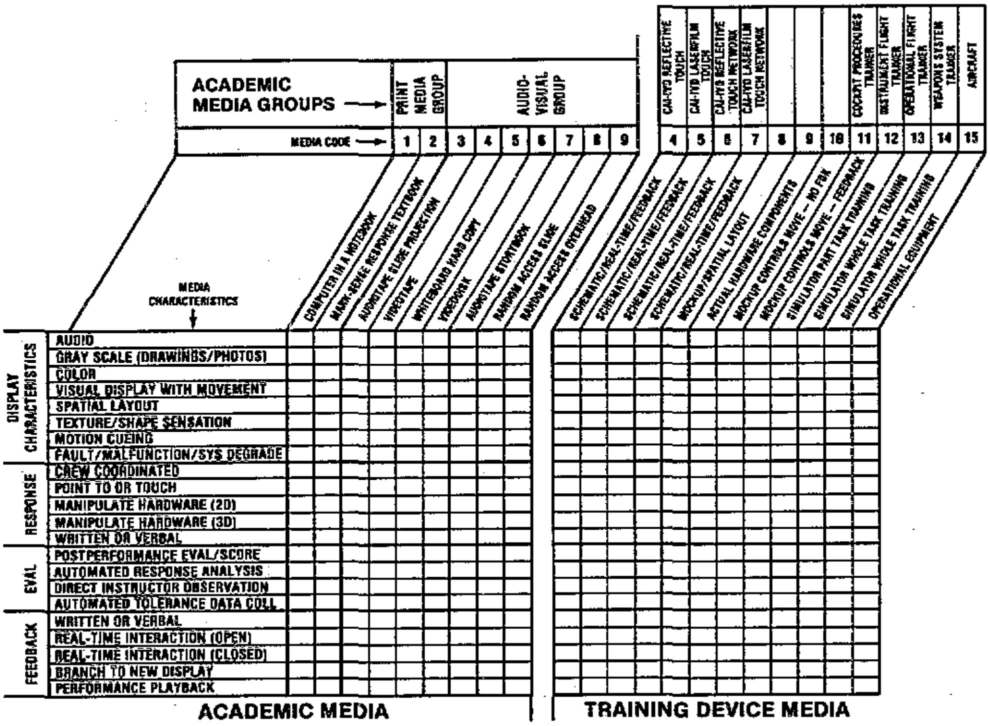

FIGURE 2. A TYPICAL MEDIA CHARACTERISTICS MATRIX

program and continues to analyze them by identifying those media characteristics which meet the display, response, feedback, and evaluation requirements of the learning objective (Figure 2). Each objective is assigned a numerical value (1, 2, or 3) which represents a low, medium, or high probability that the subject matter content presented by the media will change. The learning objectives are grouped into two basic parts, academic (knowledge-based) and training device (skill-based). The media candidates are identified for knowledge-based learning, and potential candidate media are allocated for each knowledge-based learning objective. The media candidates identified for a skill-based learning environment are interrogated through computer routines and primary and secondary media are allocated for each skill-based objective. All learning objectives are described in terms of observable, goal-directed behavior that can be measured by a performance standard.

Academic Media Allocation Process

Allocation of academic media to each learning objective is a process that has the media "competing" for each qualified objective. The first round of competition calls for the medium to be matched by its characteristics to those required by the objective. A typical media characteristics matrix is shown in Figure 3. Selected characteristics have been designated as remember or use type characteristics, and these are used primarily to classify learning objectives identified for knowledge or skill type learning. Once the matching process is complete, the medium is screened according to its capability to accommodate an update test. Candidate media must meet the requirements established by the analyst when he or she has assigned a probability of update (POU) constant for the objective. A high POU will be matched with media that are in this range of capability to accommodate an update. Another matrix that assigns a rank order to each academic medium is based upon the medium's capability to accommodate the update as identified by the POU constant.

USE		REMEMBER	
AIDED	UNAIDED	0	FACT
1	2	3	RULE
4	5	6	CONCEPT
7	8	9	PROCEDURE

FIGURE 3. LEARNING OBJECTIVE CATEGORY MATRIX

The final criterion considers each medium based upon the behavior classification discussed earlier. Ten categories of learning behaviors are considered. The learning behaviors are first grouped by a remember/use criterion where remember learning is associated with knowledge and use is associated with skills. Objectives may be further classified as study session or hands-on. Another part of the classification considers content, such as rule, concept, fact, or procedure. The learning objective category matrix is shown in Figure 3. The 10 categories are each prioritized in their order of preference for each learning objective. Media candidates are allocated based upon a best fit of the characteristics between the medium and the objective.

Similar media are grouped to provide an overview of all candidate media. Media groups are defined by the analyst and prescribed distribution ceilings are established if percentage constraints have been included in the media analysis. The media allocation process identifies a recommended medium and many alternate media.

Training Device Media Allocation Process

Of the three matrices discussed, only the characteristics matrix is used for training devices; i.e., hands-on media allocation. Training device components are numbered in a hierarchical system to assign the various components of the equipment to each learning objective. The component numbering system is limited to the imagination of the analyst, following the conventions established in the program. This unique feature provides a capability beyond the customary media models. It allows for further definition of media device characteristics. An example component hierarchy is shown in Figure 4.

```
1200000       SYSTEMS MANAGEMENT EQUIPMENT
-------       ----------------------------
1210000           COMMUNICATION/NAVIGATION SYSTEMS
1211000            COCKPIT MANAGEMENT PANEL/COMM SYSTEMS
1211100            COCKPIT MANAGEMENT PANEL
1211200            COMM SYSTEMS
1211210             INTERCOM
1211220             IFF
1211230             UHF RADIO
1211240             VHF RADIO
1220000           NAVIGATION SYSTEMS
1221000            AHRS
1222000            VOR/TACAN/ADF
1223000            ILS
1224000            HSI
1230000           ENGINE DISPLAY
1231000            RPM INDICATOR
1232000            EGT
1233000            FUEL FLOW
1240000           FUEL DUMP/FUEL CONTROL/FUEL QUANTITY
1241000            FUEL DUMP
1242000            FUEL CONTROL
1242100             BACKUP SWITCH
1242200             BACKUP INDICATOR
1243000            FUEL QUANTITY
1250000           WARNING/INDICATOR LIGHTS
1251000            CENTRAL WARNING LIGHTS
1252000            ADVISORY LIGHTS
1260000           HYDRAULIC PRESSURE

1300000          WEAPONS DELIVERY CONTROLS
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1310000           ARMAMENT PANEL
1320000           WEAPONS RELEASE
1330000           STORES JETTISON

1400000          MISCELLANEOUS EQUIPMENT/CONTROLS
-------          --------------------------------
1410000           GROUND POWER/ELECTRICAL POWER/EXTERIOR LIGHTS
                   INTERIOR LIGHTS/AUXILIARY COCKPIT LIGHTS

1411000             GROUND POWER/ELECTRICAL POWER
1411100              GROUND POWER
1411200              ELECTRICAL POWER
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FIGURE 4. EXAMPLE COMPONENT HIERARCHY

The device allocation process identifies only two media; a primary medium and a secondary medium. The assignment applies to both available options: (1) the build-a-device option, and (2) the external device option. The latter is more often selected. A detailed media analysis progresses from the build-a-device option to the external device option. In the external device option, objectives are allocated to specific rather than generic devices. Experience has shown that the use of both options in a progressive media analysis yields the best results. A simplified flow diagram (Figure 5) summarizes the training media allocation process for study sessions or academics and Figure 6 summarizes the media allocation process for hands-on media.

Report Generation

Reports may be generated for an academic media analysis, a training device media analysis, or a combination of both. The following fixed reports are available: (1) list of unallocated learning objectives; (2) summary of academic media allocation; (3) academic media distribution by media group; (4) training device media distribution by device type, and (5) summary of training device media allocation. Mainframe utilities allow the analyst to preview the results of a media program run on-line prior to requesting a hard-copy printout.

Media Mix Distribution And Selection

The media analyst searches for the optimum combination of academic and training device media. His or her foremost consideration is that each media mix candidate meets instructional standards. Minimum standards are maintained through careful construction of various media mix alternatives. These options may be identified by simple labels such as Mix 1A, Mix 1C, or Mix 3C. The numeric in the example identifies the academic media mix number while the alpha character identifies the training device mix. A typical media mix table is shown in Table 3. Each approved mix becomes available for cost analysis. The media allocation/cost analysis guides the instructional technology team in making critical decisions[3] on specific media/device configurations by considering both cost-effectiveness and the effectiveness of instruction. Final selection of a media mix is made when the cost analysis is complete.[1]

Media Mix Cost Analysis

A compatible training support requirements cost analysis performance tool is used with the media allocation tool to identify costs associated with the definition, production, and support of the training system. The cost program is capable of projecting costs from 1 to 20 years in the future. Cost data are gathered from a variety of sources and then input into a separate data file that is read upon execution of the program. Reports generated by the program separate dollar costs into major categories: academic courseware development, training device courseware development and update, personnel, facilities, training device/equipment procurement, and maintenance of devices and equipment throughout the life of the system.[10]

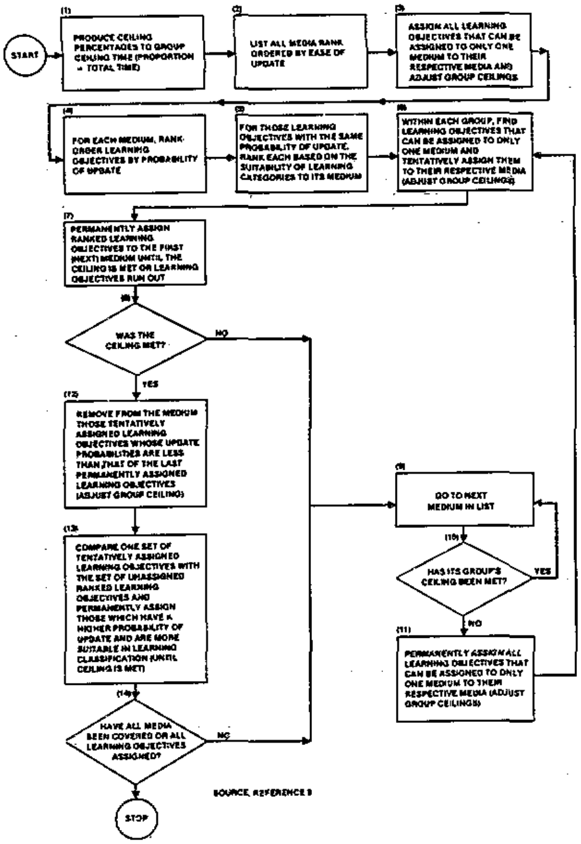
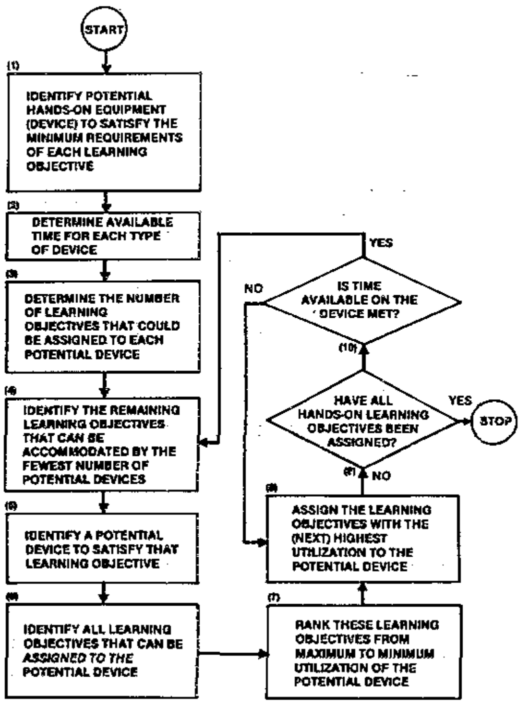


FIGURE 5. STUDY SESSION OR ACADEMICS MEDIA *ALLOCATION*



SOURCE: REFERENCE 9

FIGURE 6. HANDS-ON MEDIA ALLOCATION

TABLE 3
A TYPICAL MEDIA MIX TABLE

ACADEMIC	TRAINING DEVICE
MIX 1 30% PRINT 10% AUDIOVISUAL 20% PROGR LEARNING 30% INTERACTIVE 30% INTEG CBT	MIX A INTEG CBT (PART TASK TRAINER) COCKPIT PROCEDURES TRAINER OPERATIONAL FLIGHT TRAINER AERIAL SITUATION TRAINER T-XX (AIRCRAFT)
MIX 2 50% PRINT 10% AUDIOVISUAL 20% PROG LEARNING 10% INTERACTIVE 10% INTEG CBT	MIX B INTEG CBT (PART TASK TRAINER) OPERATIONAL FLIGHT TRAINER T-XX AIRCRAFT (TRAINER)
MIX 3 10% VISUAL 10% AUDIOVISUAL 10% PROG LEARNING 20% INTERACTIVE 70% INTEG CBT	MIX C COCKPIT PROCEDURES TRAINER OPERATIONAL FLIGHT TRAINER AERIAL SITUATION TRAINER T-XX AIRCRAFT (TRAINER)

The best cost profiles are developed when the training system life-cycle is separated into major cost phases. This practice allows for an operational distribution of dollars into the appropriate year. Cost phasing also allows for replacement of computing equipment and upgrade of other equipment to be identified in the life-cycle cost analysis. No cost analysis model is able to give results any more accurate than the data input to the model. A solid foundation of historic cost data is the secret to a good life-cycle cost analysis. Once historic data are available, the remainder of the life-cycle cost becomes more easily identified using this performance aid.

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The first two job performance aids support an intelligent instructional system development (ISD) task. The third performance aid provides the ISD analyst with a means of selecting alternative acceptable media and ranking these media for each learning objective. The media alternative selection program can also model many different acceptable media mixes for a given set of learning objectives. The media mixes provide an early quick look at the various possible media required for a specific training program.[11]

The Douglas Instructional Technology group is presently Beta-testing all three performance aids. Prior to Beta-testing, the performance aids were evaluated by individual users for practical applications such as front-end analysis. In the case of the media allocation program, the performance aid is used to reevaluate the media selected for in-process projects.

The interest in performance aids is encouraging. Plans are to develop expert system tools for further development of the media allocation program and provide for a microcomputer application of the original mainframe-based program. Expert tools for the internal media allocation program decisions will aid the ISD analyst in tailoring the matrices of the program. Tailoring provides the means by which the generic media allocation program complies with a specific project's training requirements.

There are three decision matrices in the media allocation program that are candidates for further expert tool development: (1) the ability to decide whether courseware can be practically updated; (2) the ability to determine whether each medium will meet global media characteristics; and (3) the ability to determine whether the observable behavior is described by the learning objective.

This paper described performance engineering tools used to develop information for an instructional system. In aiding the ISD analyst to arrive at consistent and reliable decisions for small but difficult problems, the baseline for accurate system-level decisions is provided.

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