ADAPTIVE INSTRUCTIONAL MODELS FOR NAVY TRAINING

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Naval technical training is continuously committed to providing cost-effective training that maximizes individual student attainment of training objectives while simultaneously minimizing the completion time. Further, the full utilization of all instructors, training aids, simulators, and real life resources becomes an important cost consideration. To achieve these goals, instructional training models have been designed and implemented. These training models represent both the process of training and the decision rules that guide students.

The purpose of this paper is to review one class of these models, adaptive instructional models (AIM). In order to fully appreciate AIMs, the full range of training models shall be described. In turn a detailed description of an adaptive instructional model appropriate for technical training shall be delineated. For comparative purposes, this shall be contrasted with the existing Naval CMI Model. Finally, future research and development requirements for AIMs shall be reviewed.

Training Models. Models of instruction can be conveniently arranged in three ordered levels or sets, each subsuming the prior set. These can be labelled conventional, individualized, and adaptive. Within each set, there is a continuum that reflect the degree of responsiveness to the student's performance. The concept of responsiveness is equivalent to the statistical concept of sufficiency, that is, to what degree is the learning data utilized within the instructional decision process. A comparison of these three sets of models shall best illuminate the generic features of AIMs.

A Conventional Model of the non-responsive form is exemplified by a television presentation. While appropriate instructional systems development (ISD) factors like group entry characteristics or task order relationships can be reflected, the instructional process is serial, fixed paced, and insensitive to student learning responses. A Responsive Conventional Model is best illustrated by the lecturer who implements question-answer interactions or discussion sessions. The use of discussion techniques and evaluative feedback guide these conventional models towards adaptiveness. On the other hand, human limitations on memory (how much can an instructor keep in primary memory while making a decision?), language styles, and role expectancies plus the fixed pacing makes the potential of these models constrained at best.

In response to the need to facilitate course flow, non-responsive individualized models, as represented by programmed instruction (PI), came into existence in the 1950's. PI does allow for individual pacing and error correction but remains limited in that all students must pass through the same frames. Responsive individualized models, as represented by 1970 computer-assisted instruction, allows for branching, but usually on a within concept basis. While individualized models tend towards adaptiveness, they limit their attention to the immediate concept learning and do not address issues of incentives, purpose, or full resource utilization.

The Adaptive Instructional Models have four properties that promote the individualization of the training process: adaptiveness, contingency, mediation, and cybernetic. The processes are basically actuarial in nature; that is, they reflect individual, group, and systems data in a predictive structure. This description reflects the design-implementation of the Air Force Advanced Instructional System.

AIM is adaptive, in that the training process is individually tailored to each student. In operational terms, the training decisions are made by continually choosing among instructional alternatives as a function of differential student characteristics. The concept of adaptiveness includes the features of selectiveness since each student is presented with information according to his needs in light of the terminal objectives, sequenced because the materials are presented in an optimal sequence for each student, and paced since the student is provided with a rate index commensurate with his prior performance and his learning characteristics. In addition, adaptiveness should include the concept of individually-prescribed media, amount and type of review, and use of remediational material.

In reference to the second feature, contingency, AIM provides relationships which will consider who is being taught, what is critical in the subject matter, and how the teaching is to be done. This includes strategies by which student characteristics are matched with a catalog of training alternatives under the control of computer-based algorithms so as to prescribe optimal sequences. In addition, contingency will include the concept of individually-prescribed incentives according to performance related incentive schedules, as well as opportunities to branch or re-enter learning sequences according to identified levels of mastery.

The third general characteristic concerns the mediation process, which includes a wide range of media and learning formats configured to optimize the information flow according to specifiable subject-matter maps. In essence, the subject-matter maps are defined in terms of task characteristics and will lead to an optimal matching of training resources in light of task features and student characteristics. Mediation includes the concept of appropriate media matches as well as individual and small group instruction. Where appropriate, the student may also be assigned to individual counseling sessions designed to facilitate the learning process.

An empirical feedback procedure which uses student data from established criterion measures to redefine parameters of the strategies and their embedded decision rules characterizes the cybernetic feature. Each student is continuously monitored by AIM so that his profile identifies his current status as well as his best performance within various instructional strategies. The feedback of success and failures is recorded for individual students but also will be aggregated so as to improve the overall modeling process for new groups of students. This continuous updating of student performance improves the accuracy of both the individual learning prescription and the model's predictions of optimal learning sequences. Thus, AIM provides data which will cybernetically improve the performance of the model itself.

Computer-Managed Instruction (CMI) Model

As a framework, AIM must provide a proper flow so that students may be prescribed learning tasks in an individualized sequence. As presented in Figure 1, this adaptive instructional flow can be characterized by ten steps. The critical steps are concerned with the selection of an appropriate adaptive model and its application in the composition of an instructional prescription.

In reference to Figure 1, the AIM utilizes the following steps in individually guiding the students:

Step 1. The student's learning profile is updated based on immediately prior performance, learning time, and associated data from similar learning tasks.

Step 2. The current task characteristics with their associated behavioral objectives are retrieved. Most importantly, these task characteristics will related propositional statements concerning the type and kind of learning processes involved.

Step 3. All available instructional alternatives for the associated instructional tasks are retrieved. Table 1 presents a list of the type of instructional alternatives which are being considered.

Step 4. Any essential student characteristic data present in the computer data base are retrieved if the data are likely to be utilized within the instructional decision process.

Step 5. An appropriate adaptive decision process based on effectiveness data from the prior application of the model for the task and the student is selected. In essence, an appropriate adaptive model for the task should be chosen.

Step 6. An appropriate instructional strategy is derived from the model. This strategy should provide for selection among instructional alternatives.

Step 7. The specific instructional alternatives are identified and checked as to their availability.

Step 8. An instructional prescription is transmitted to the student.

Step 9. The instruction proceeds.

Step 10. The evaluation of the student learning will supply critical data to the updated student learning profile and effectiveness data for the AIMs.

The flowchart can be successively applied for the task sequence. As illustrated in Steps 5 and 6, the essence of the flowchart concerns the different classes of adaptive models. Each of the models can be characterized both in terms of its purpose and its quantitative characteristics. Perhaps a brief review of the purposes will give some idea of the essential characteristics of each class or type of model.

The primary objective of the Drill-and-Practice Models is to increase the accuracy and speed of student performance on

Step 1

Updated Student Learning Profile

Step 2

[2]Characteristics of Task and Learning Processes

Step 3

[3]Instructional Alternatives

Step 4

[4]Student Data Profile Requirements for Task

Instructional Strategy Decision Rule

Step 5

SELECT DECISION PROCESS

Step 6

a. Drill and Practice

b. Simple Tutorial

c. Complex Tutorial

d. Algorithmic

e. Dynamic Programming

Step 10

Evaluation Process
Adaptive Testing

Step 7

[7]Current schedule of Instructional Resources

Unavailable Schedule

Step 8

[8]Compose Instructional Prescription

Step 9

[9]Implement Instruction

Fig. 1. Adaptive Model(s) Program Flowchart.

TABLE 1. INSTRUCTIONAL ALTERNATIVES FOR ADAPTIVE MODELS

Alternative Method	Advantages
Alternative media presentations	Provides for the selection of appropriate media types at choice points having two or more available media treatments, e.g., film, slide-tape, video tape, text, lecture, computer-interactive problem solving, TV, and skill critique.
Type of interactive instruction	Provides for selection of a training activity that has the appropriate interactive rates and characteristics, e.g., PI, CAI, simulation, performance with equipment, instructor, tutorials, and student-to-student tutorials.
Entrance into a learning hierarchy	For those task sequences that have a generic learning hierarchy, the criteria for each entry point in the hierarchy will be identified and students assigned entry into the hierarchy according to their characteristics and current performance.
Sequence of topics in terms of level of difficulty	Provides for matching student performance characteristic with alternative topic sequences and associated redundancy levels, whether they are summary, normative, or elaborated.
Student and system control pacing	Provides for unique student-based training time limits for an instructional task (student paced) and for system pacing-assignments for computer-interactive training activities.
Amount of practice	For each set required of a student, the number of problems will be uniquely derived according to his performance history.
Incentives	For each student, a set of incentives plus an individualized schedule will be *implemented*.

repetitive tasks. The primary objective of the Simple Tutorial Models is the acquisition of new conceptual behaviors. These behaviors may concern new definitions, dimension of concepts, and relationships among these dimensions. Complex Tutorial Models concern task situations involving two or more concepts, simulation representing the concepts, and/or problem-solving applications of the concepts. The primary objective of Algorithmic Models is to provide a systematic, efficient approximation toward some specific goal. On the other hand, Dynamic Programming Models provide for solutions that minimize learning time and offer the best utilization of resources.

Navy CMI System. The purpose of this section is to briefly describe the Navy CMI System and to reflect on how it might grow into an adaptive model. Growing out of an R and D project, the current system supports 1500+ students daily. From a process viewpoint, the courses are a linear chain of modules that allow for self pacing and a mastery test-remediation cycling. In addition the system predicts rate of success and applies negative incentives (homework, night sessions, negative commentary, etc.) to students who fall behind. Learning Center Supervisors provide tutorial assistance and manage the course.

Given the availability of a computer, there are numerous possible adaptive steps.

1. Apply alternative media (slide/tape, audio lectures, etc.) on an individual predictive basis.
2. Improve the interaction by increasing CRT terminal availability and implementing CAI problem solving.
3. Utilize adaptive testing to both reduce time and allow for individual movement through the task hierarchies.
4. Allow for variable amounts of practice.
5. Apply incentives on an individualized basis.
6. Implement a course counselling procedure.

The merit of an adaptive model is its ability to identify training alternatives for further improvement. Obviously accumulative data analysis is necessary.

Future Research

While many topics could be selected, the resource allocation problem seems paramount at this time. Simply stated, a dynamic scheduler that both maximizes student performance and high cost equipment utilization is required if cost-effectiveness is to be seriously address. Based on similar efforts in the inventory and airline reservation classes, a substantial effort shall be required.

ABOUT THE AUTHOR

DR. DUNCAN N. HANSEN is Professor of Educational Research at Memphis State University. Dr. Hansen's academic background includes a B.A. from the University of Chicago in 1950, a B.S. and M.S. from Wasington University at St.Louis in 1952 and 1953 respectively, and a Ph.D from Stanford University in 1964. As a graduate of Stanford University, Dr. Hansen participated in the development of one of the first CAI Systems. While at Florida State University, he led a multidisciplinary investigation of CAI and CMI under ONR sponsorship. Dr. Hansen is a nationally recognized leader in technologically (media and computers) based training systems, management systems, and evaluational paradigms. He has authored and coauthored numerous books, chapters in books, and articles; and has served as a consultant and speaker in many education- and learning-oriented conferences and programs in Europe as well as the United States.