NESTED SYLLABI IN FLIGHT TRAINING

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INTRODUCTION

"Tailoring" or "individualizing" the training session to meet the unique needs of each student has long been recognized as an objective of a training program. Perhaps most importantly, the technique of individualized training can increase training efficiency by concentrating the training time available on the tasks or behaviors at which the student has not yet developed the required proficiency. Thus, training resources are not needlessly expended on training at tasks at which the student is already proficient. Other benefits are also attributed to the technique. Some of the most interesting are increased motivation and improved quality control. The former is considered to stem primarily from the fact that the student is presented with a challenging task, never a boring one. The latter is really a result of the necessity for objective performance measurement to employ the technique. Thus, considerable benefit has been attributed to the individualized training technique. While better data is needed to verify some of the effects, there can be little doubt that it is in fact a productive training method.

The implementation of the approach is, unfortunately, not always simple and straightforward. Some limited mechanization of it has been attempted. Of course, any good instructor manually accomplishes at least some of the tailoring goals on a case basis. However, overall, only a very limited exploitation of the approach has been achieved, especially in aviation training. A brief look at the four major tasks involved will help explain the lack of implementation of the technique. The tasks involve the development of:

1) task or training objectives
2) objective performance criteria
3) performance measurement
4) detailed training course

The achievement of these four requirements is a sizeable job. Yet considerable progress has been made, especially in techniques for developing the first three. The Exploratory and Advanced Development projects conducted by the Human Factors group at the Naval Training Equipment Center over the recent years have been instrumental in developing and evaluating the tools required. The studies have shown that performance criteria can be isolated. Other studies have developed and tested performance measurement tools. Application of the systems approach to develop training objectives has not only been demonstrated to be effective, but has gained the momentum to carry it throughout the training community. However, it should be pointed out that the results of the typical "systems approach to training" need not necessarily satisfy the particular needs of an individualized training program even though the techniques may be capable of generating the required data. Furthermore, the resultant course need not, and generally will not be oriented to individualized training. In fact, the construction of a training course directly from training objectives data is most easily accomplished using a "lock-step" approach. While some syllabi provide for "self-pacing", few techniques are available to implement individualized training, especially using a simulator, on other than as provided on an individual instructor basis. Although good instructors can accomplish this function, it obviously would be highly desirable to generalize and standardize this capability.

BACKGROUND

The staff of APPLI-MATION, INC., has been involved in advanced training technology, particularly in the aircrew training for many years. Extensive efforts have been involved in the development and demonstration of automated and adaptive training capabilities for operational flight and weapon systems trainers. The systems approach has been extensively utilized and has resulted in the successful technical demonstrations of the basic concepts. These developments required the detailed delineation of performance requirements, the quantitative measurement of performance, the structuring of a detailed course, and the "on-line" sequencing of the course to meet skill objectives at the students learning rate. Papers delivered at previous NTEC conferences have highlighted these efforts. However, it is important to point out that these early studies were for technical feasibility and were not operational prototype developments. With feasibility established, studies are now underway to permit evaluation of the techniques under actual training conditions. APPLI-MATION, INC., under contract to the NTEC is developing an advanced automated individualized simulation instruction system for both basic instrument flight maneuvers and airborne attack (air-to-air). The objective is to demonstrate an individualized training system which efficiently integrates the four basic training elements, the student, the instructor, the training objective, and the simulator.

It became obvious early in the study that training activities, with the exception of those involved in elementary skills, assumed a student knowledge and skill level which formed the base line of the training course. It also became clear that if the supporting or basic training activities utilized the block or lock-step approach and did not have good performance measurement and criteria, then the entering student may not in fact have developed the required prerequisite skills. In fact, our knowledge of individual difference would virtually dictate that a significant variation in entry proficiency would exist. If this were the case,attempts to develop advanced skills would either require extensive resources (simulator time, instructor time, student time) or result in even more costly attrition. Furthermore, and of more importance to our efforts, attempts to individualize or adapt the course could prove futile since the problem involves the student not possessing some of the basic skill required. Therefore, early in the study we began to look at alternative means of implementing individualized training which would accommodate not only different individual learning rates, but also different individual entry skill levels. Simple analyses also pointed out that successful completion of basic training, even if objectively measured, need not necessarily indicate that the student was prepared to integrate these basic skills into more complex behavior. Finally, the ability to integrate knowledge and skills in aviation probably varies significantly from student to student. Thus, for a variety of reasons, it became obvious that an advanced training course could probably not be successfully individualized without consideration of the requisite entry skills.

THE NESTED SYLLABUS

Our initial efforts involved advanced jet instrument flight maneuvers training. While of more interest to the pilot training program than operational readiness training, the results should be generalizable. The first step was to prepare a "specification" of the precision and confidence maneuvers in the syllabus. The specification included a detailed description of each maneuver including the procedures and performance criteria involved. Difficulty variables were also identified. Next a detailed analysis of each maneuver was undertaken to develop performance measurement alternatives and to develop the avenues required for individualization of the course. The most fruitful approach to both objectives involved "segmenting" each maneuver into subsegments which contained meaningful parameters for measurement. The criteria developed was simply that the selected performance measures be equally relevant throughout the segment. Thus, for example, a simple Vertical S-1 manuever which is a double sequence of standard rate climbs and descents was divided into eleven segments.

1) straight & level entry
2) transition to 1000 fpm descent
3) 1000 fpm descent
4) transition to climb
5) 1000 fpm climb
6) transition to descent
7) 1000 fpm descent
8) transition to climb
9) 1000 fpm climb

10) transition to straight & level
11) straight & level flight

While other segmentation schemes were explored and many are possible, the above breakdown proved to be straightforward and productive. It also proved later on to facilitate the "nested" syllabi approach. Performance measures for each of the segments were easily established. The measures were grouped into three separate scores and were called:

1) Procedures Score
2) Skill Score
3) Maneuver Score

The procedures score reflected the student's knowledge of the maneuver and the proper sequence of actions required to perform it. The skill score samples the student's actual control input and reflects both his control efficiency or smoothness as well as aircraft trim. The maneuver score samples system performance and measures the error in terms of key parameters for the maneuver. Error was measured with reference to the criteria developed in the specification. Thus, performance data was available to detect that the student:

1) knew what to do
2) knew how to do it
3) had achieved criterion performance

These are also the essential data to individualizing the course.

The problem of developing a detailed syllabus and the logic to implement individualization initially posed a more difficult problem. For example, suppose the student could not fly the basic pattern under optimal conditions. Does the syllabus then "freeze" in effect and present the student with the same maneuver over and over again? Or alternatively, does the syllabus send the student back to a previous maneuver, which he has already learned? Obviously neither solution is attractive. In both cases, the student may never learn the maneuver or acquire the skill sought. In the first case he may well learn incorrect behavior by practicing it. Further analysis made it clear that the answer needed had in effect been provided in the results of the segmentation and performance measurement technique. Together they permit identification of the segment(s) in which the student is experiencing difficulty. Since the segments themselves are literally basic skill elements, it is a relatively simple matter to develop a "mini" course to train the missing skills. In most cases the "mini" course was found in previously completed training courses. Thus, for example, the "mini" course for the Vertical S-1 pattern included:

1) Straight & level flight
2) Basic transitions
3) Constant rate descent
4) Constant rate climb

These maneuvers are in fact part of the basic training program which the student had already completed.

It was thus possible to construct a highly individualized or adaptive syllabus for each maneuver in which skill deficiencies could be identified and an appropriate sub-syllabus called upon to present the required training. (This is, of course, very similar to the branching technique utilized in computer-aided instruction.) It achieves the goals originally established to individualize training and optimize the utilization of resources since the student's problems can be identified rapidly and a remedial syllabus developed.

The "nested" syllabi approach is really only a means of identifying the elementary skills involved and of structuring a branching syllabus for the student based on his performance. Using the concept of three types of performance measures which reflect procedural knowledge, control input, and task, it is relatively straight forward to determine what type of assistance the student requires to achieve the proficiency sought.

While the example used, that of the Vertical S-1 pattern, is relatively simple, the approach was used on all the confidence and precision maneuvers from turn pattern to Split "S's", from vertical patterns to penetrations. It is currently being applied to weapon delivery tasks. Although the segmentation and performance measures are not always as easily exposed, so far the approach has proved successful.

ABOUT THE AUTHOR

DR. JOHN P. CHARLES is Vice President of Appli-Mation and Director of the San Diego office. He holds a B.A. degree in Psychology from the University of Minnesota. After attending the University of Edinburgh for 1 year, he received his M.S. and Ph.D. degrees from Northwestern University in Experimental Psychology. Past experience includes being project manager of exploratory and advanced development projects at Appli-Mation; 20 years with the Navy as an Aviation Psychologist in weapons systems RDT&E, and 5 years in industry, primarily in training, research, and management of advanced training projects.