CONF-8410142--27

CONF-8410142--27

DE85 002559

Development of Methods for Nuclear Power Plant Personnel Qualifications and Training*

C. C. Jorgensen, R. J. Carter
Oak Ridge National Laboratory

Presentation Made At:

12th Water Reactor Safety Information Meeting
National Bureau of Standards
Washington, D. C.

October 22-26, 1984

MASTER

*Research sponsored by the U. S. Nuclear Regulatory Commission under Interagency Agreement 40-550-75 with Martin Marietta Energy Systems, Inc. under Contract No. DE-AC05-84OR21400 with the U. S. Department of Energy.

Development of Methods for Nuclear Power Plant Personnel Qualifications and Training*

C. C. Jorgensen and R. J. Carter
Oak Ridge National Laboratory

ABSTRACT

The Nuclear Regulatory Commission (NRC) has proposed that additions and revisions should be made to Title 10 of the "Code of Federal Regulations," Parts 50 and 55, and to Regulatory Guides 1.8 and 1.149. Oak Ridge National Laboratory (ORNL) is developing methods and some aspects of the technical basis for the implementation and assessment of training programs, personnel qualifications, and simulation facilities to be designed in accordance with the proposed rule changes. The paper describes the three methodologies which were developed during the FY-1984 research. The three methodologies are: (1) a task sort procedure (TSORT); (2) a simulation facility evaluation methodology; and (3) a task analysis profiling system (TAPS).

The task sort procedure was developed to determine the training strategy which should be applied to a given task. It accomplishes this by sorting tasks into nine categories, each of which is defined along ten dimensions. TSORT provides rank-ordered preferences for task allocation between and within categories and has the ability to estimate a dollar loss incurred through failure to train on a task. The simulation facility evaluation methodology is being developed to certify simulation facilities for use in the simulator-based portion of the licensing examination. It is to be utilized during two phases of the life-cycle, initial simulator testing and recurrent evaluation. The initial testing phase is aimed at ensuring that the simulator provides an accurate representation of the reference plant, while recurrent evaluation is aimed at ensuring that the simulator continues to accurately represent the reference plant throughout the life of the simulator. The task analysis profiling system has been designed to support training research. It draws on artificial intelligence concepts of pattern matching to provide an automated task analysis of normal English descriptions of job behaviors. TAPS development consisted of creating a precise method for the definition of skills, knowledge, abilities, and attitudes (SKAA), and generating SKAA taxonomic elements. It systematically outputs skills, knowledge, attitudes, and abilities, and information associated with them.

---

*Research sponsored by the U. S. Nuclear Regulatory Commission under Interagency Agreement 40-550-75 with Martin Marietta Energy Systems, Inc. under Contract No. DE-AC05-840R21400 with the U. S. Department of Energy.

Introduction

The Nuclear Regulatory Commission (NRC) has proposed that additions and revisions should be made to Title 10 of the "Code of Federal Regulations," Parts 50 (Training and Qualifications) and 55 (Operating Tests), and to Regulatory Guides 1.8, "Personnel Qualifications and Training for Nuclear Power Plants," and 1.149, "Nuclear Power Plant Simulation Facilities for Use in Operator License Examinations (proposed title change)." The revised training rules would require each nuclear power plant licensee and applicant for an operating license to establish and implement training programs that are derived from a systems approach to training (SAT) for civilian nuclear power plant (NPP) operators, supervisors, technicians, and other appropriate operating personnel. SAT is an orderly, iterative process in which analysis of the job to be performed provides needed information for key decisions about training. Changes to the qualification rules would make it necessary for NPP licensees to follow specific guidance on qualifications or to base qualification determinations on findings from a systematic analysis of prerequisite qualifications and job performance requirements. NRC rules on the operating test would require that it be administered in a plant walk-through, and in a simulation facility which could be the plant, a plant-referenced simulator, or another simulation device, alone or in combination. The simulation facility is to be evaluated, as to its appropriateness for the conduct of the operating test, by the facility licensee for each nuclear power unit.

The Human Factors and Safeguards Branch, Division of Risk Analysis and Operations, Office of Nuclear Regulatory Research (HFSB/DRAO/RES) is supporting Oak Ridge National Laboratory (ORNL) to develop methods and some aspects of the technical basis for the implementation and assessment of training programs, personnel qualifications, and simulation facilities to be designed in accordance with the proposed rule changes. This paper will describe the three methodologies which were developed during the FY-1984 research. Earlier efforts in the program are documented in Haas, Selby, Hanley, and Mercer (1983)[1] and Selby and Hensley (1984)[2]. The three methodologies reported here are: (1) a task analysis profiling system (TAPS); (2) a task sort procedure (TSORT); and (3) a simulation facility evaluation methodology. TAPS will be covered in detail, but the other two methodologies will be treated in only a cursory fashion since work on TSORT was presented at a previous Water Reactor Safety Information Meeting (Jorgensen, Haas, Selby, and Lowry, 1983),[3] and the simulation facility evaluation methodology is to be field tested and further refined during the current fiscal year.

A Task Sort Procedure

Background

During the implementation of a systems approach to training, a variety of analyses must be performed which require the subjective expertise of a training developer. One major analysis is the determination of where (i.e., in what setting, training category, etc.) individual job tasks should be trained and how they should be ranked relative to different instructional aids and approaches. Depending on the skill of the personnel making the decisions, the resulting allocation of tasks to training strategies may or may not be made properly. In SAT, the kinds of courseware developed, the media and methods used, and the types of student evaluations performed are directly influenced by the general training strategy. There is thus a "ripple effect" from poor decisions which have been made early in the process. For the NRC, faced with evaluating many different training programs, it thus becomes important to have an objective basis to determine whether industry selections are reasonable within the SAT framework.

Method Description

TSORT was developed to determine which training strategy should be applied to a given task. It accomplishes this by sorting tasks into nine categories: qualification, certification, and refresher training, candidate for more or less training, potential simulator or formal training task, and candidate for on-the-job training or for elimination from training. Each category is defined along ten dimensions:

1) skill acquisition difficulty
2) skill performance difficulty
3) immediate performance need
4) safety consequences
5) previous nuclear experience
6) normal operation performance
7) emergency operation performance
8) plant delay tolerance
9) regulatory requirement
10) economic consequences

TSORT provides rank-ordered preferences for task allocation between and within categories. The ability to estimate a dollar loss incurred through failure to train on a task is included. A realistic economic model was beyond the scope of the work, but could readily be incorporated. The sort procedure is programmed for an IBM personal computer, menu-driven, and fully interactive for both data entry and analyses.

A Simulation Facility Evaluation Methodology

Background

It has long been recognized that simulators provide great potential for training and testing people on many types of tasks, both in nuclear power generation and other technical training endeavors. Of particular relevance to NPP training/testing, simulators provide a mechanism for training operators how to effectively respond to off-normal conditions. Because of this reliance on simulators for training/testing important tasks, there is an increased danger associated with the simulator being responsible for improper training. If the simulator does not behave in the same manner as the actual power plant, then the operator may be mistrained.

Industry organizations and the NRC recognize this potential problem and have taken steps to ensure that simulator training is effective. They have developed guidelines which define the type of malfunction to be simulated and the quality of simulation required. However, very little guidance is available to determine the acceptability of the simulation.

Method Description

The simulation facility evaluation methodology is being developed to certify simulation facilities for use in the simulator-based portion of the licensing examination. It is to be utilized during two phases of the life-cycle, initial simulator evaluation and recurrent evaluation. Initial evaluation is to be performed when a simulator is acquired, in the case of new simulators, and as soon as is practical for existing simulators. This phase of evaluation is aimed at ensuring that the simulator provides an accurate representation of the reference plant. There are two components of initial simulator evaluation: fidelity assessment and a direct determination of the simulator's adequacy for operator testing. Recurrent evaluation is aimed at ensuring that the simulator continues to accurately represent the reference plant throughout the life of the simulator. It involves three components: monitoring reference plant changes, monitoring the simulator's hardware, and examining the data from actual plant transients as they occur.

A Task Analysis Profiling System

Background

Task analysis is generally a highly subjective process that draws on observations of job performers' behaviors and combines them with an analyst's expert knowledge of systems to produce a functionally useful set of skills, knowledge, abilities, and attitudes (SKAA). The procedure often winds up being an art rather than a science and, as a result, is subject to a variety of shortfalls characteristic of highly subjective procedures.

Because task analysis is used for a variety of research purposes including courseware development, entry level skill identification, performance standards development, and personnel selection, large variations in task analysis quality can be very costly in time and resources. Unanticipated costs often occur as a result of repeated site visits to extract missed information, correct erroneous assumptions, or modify incorrect courseware materials. The end result is growing pressure for a faster, more economical method to support training research.

The task analysis profiling system has been designed to remedy these problems. It draws on artificial intelligence concepts of pattern matching to provide an automated task analysis of normal English descriptions of job behaviors.

Method Development

SKAA Definition. To support the automation of task analysis, a much more precise method for the definition of SKAAs had to be created. For example, a defintion of a human ability such as "perceptual speed" has generally relied upon text descriptions and the opinion of a task analyst such as the following:

> "The ability to compare sensory patterns quickly in order to determine identity or similarity."

Although appearing easy to use, such a general definition can lead to a great deal of disagreement over what constitutes a perceptual speed instance. For example, it may be understood that perceptual speed is a visual ability combined with a cognitive activity of recognition or recall. It is not clear, however, if the "sensory patterns" could also refer to other senses, e.g., auditory recognition of Morse code strings, or tactual recognition by a pilot of changes in g-forces. Thus, from the standpoint of an automated tool to identify perceptual speed, a more precise method of definition is needed. Mallamad, Levin, and Fleishman (1980)[4] recognized the same problem and proceduralized some ability definitions through a series of question/answer flow charts that eventually led to the identification of individual abilities. Unfortunately, such systems and efforts to automate them (e.g., Rossmeissel, Tillman, and Best, 1982),[5] place a tremendous resource demand upon a user since each task must be scanned for each individual ability through a separate question/answer path. To apply such an approach to field analysis of SKAAs would quickly produce massive resource demands on the analyst that would outweigh the benefits of the faster, albeit "noisier" subjective approach.

TAPS has taken another approach in that it recognizes from the onset that resource demands on the user are a critical component in the ultimate implementability of a training research tool. The key to the success of the approach lies in its ability to define SKAAs in a flexible manner capable of accepting many different potential sentence variations of the same underlying idea. Thus, "rapidly spotting a change in a temperature gauge" or "detecting a panel meter deviation in less than ten seconds" must both be recognized as an instance of perceptual speed by the definitional rule.

TAPS gains this flexibility through an approach analogous to choosing dinner items from a Chinese menu. In a typical Chinese dinner, an acceptable "meal" is defined as picking one item from column A, one from column B, and one from column C:

		A	B	C
		Item 1	Item 1	Item 1
		Item 2	Item 2	Item 2
"meal"	=	Item 3		Item 3
		Item 4		

If item A4 was fried rice, item B1 was pepper steak, and item C2 was lychee, "meal" would be [fried rice, pepper steak, and lychee]; on the other hand, another perfectly acceptable instance of meal could have been [chicken chow mein, white rice, and sherbert] which would represent a different path through the columns. A similar logic may be applied to defining SKAAs. For example, another way to define perceptual speed could be:

	A	B	C
	Sees	In Less Than	Visual Acuity Test
	Hears	Before	Auditory Reaction Time Test
"perceptual speed" =	Spots	In Under	
	Observes		
	Notices		

where one acceptable instance of perceptual speed is [spots in less than].

If, as is the case in task analysis, the process is actually the reverse and one is presented with an instance which may represent perceptual speed embedded in other information such as:

"I must <u>hear</u> the change in charging pump frequency <u>in less than</u> 10 seconds"

then perceptual speed would be detected in the sentence by using a pattern recognition technique to spot the underlined word combinations and recognize that they correspond to an acceptable path through columns A and B. To go further, however, once perceptual speed is identified, the ability name in turn can function as a pattern that points to an acceptable performance test such as the "auditory reaction time test" in column C.

To accomplish the pattern matches it was helpful to develop rule processing procedures in a computer language suited to manipulation of sentence strings. Because of its ease of use and highly readable code, a simplified version of the LISP language called LOGO was used to initially code the procedures.

<u>SKAA Taxonomy Development</u>. Because readily usable SKAA lists did not exist in Chinese menu definition forms, they had to be generated. Existing taxonomies were surveyed and evaluated as to their usability. It soon became apparent that evaluative criteria for inclusion or exclusion had to be developed and in some cases (for example, cognitive skills) entirely new elements needed to be produced. To facilitate this process a model of skilled human performance was generated. The transformation of existing taxonomic elements into menu forms was accomplished in two steps. First, all available definitions were compiled for taxonomic items along with an analysis of key word patterns which occurred in the examples presented as definition instances. Second, key word patterns were subjected to a computerized thesaurus to find as many equivalent terms as possible. The resulting lists were then screened for applicability and entered into a structured data base. The result was a large set of menu definitions. Since the primary focus of TAPS was to quickly identify tests associated with entry level requirements of NPP operators, lists of usable measurement tests were generated for each ability and rank ordered by factor loadings. TAPS code was written so as to automatically reference these lists whenever a task analysis identified a particular ability as present. In order to illustrate the full potential of the technique, other types of lists were also generated for SKAAs. These lists allow the automated printing of applications, principles, potential safety risks, and even generate customized advice which could be used by an NRC training evaluator or industry training developer. Lists were developed for every taxonomic item; however, a rigorous compendium of human factors information was not attempted within the scope of this effort.

Method Features

Figure 1 illustrates some of an actual output for a sample sentence that illustrates TAPS capabilities. At the top of the figure is the original sentence which shows errors in capitalization, punctuation, and includes technical abbreviations. The second sentence is the result of the first analysis step in which TAPS cleans up obvious errors and expands the abbreviations to their full length. Thus, HPCI becomes high pressure coolant injection, capitalization is normalized, and punctuation is removed. Although the example uses a single sentence, TAPS is not text limited, and works just as efficiently on paragraphs or even multiple pages of typed descriptions.

TAPS systematically outputs skills and the information associated with them, knowledge, then attitudes, and finally abilities. The skill detected in Fig. 1 illustrates the ability of the program to serve as an automated source of guidance to a training developer by listing human factors insights associated with skill categories. "Knowledge" illustrates another capability of the program. After a general knowledge category such as "regulatory guides" was detected, the program retains specific information about the particular instance of regulatory guidance that was found. It then inserts the information into a sentence frame so as to produce customized textual material specific to the task being analyzed. The advice can be as detailed or general as desired, but only very simple principles are used in the present TAPS version. The detection of attitudes illustrates the capability of TAPS to use indirect clues. Since attitudes generally have to be inferred, TAPS recognized that the HPCI was a safety-related system and that the sentence was referring to maintenance behavior. Consequently, an individual's attitude toward "personal responsibility" could have a significant safety impact if maintenance was done unsupervised or in a slipshod fashion. Finally, the "deductive reasoning" ability illustrates that TAPS could be used to produce customized tests in real time.

Conclusions

As the result of efforts by both industry and NRC to assess and improve operator training and qualifications, the U. S. nuclear industry is moving to adaptation of SAT, and the NRC is in parallel moving to adapt the SAT approach in their evaluation of training and qualifications. The research summarized in this paper is intended to provide methods and a technical basis for NRC's evaluation. A framework for an SAT-based evaluation process has been developed and current efforts are underway to develop the specific methods and tools to implement the process.

The original typed task was:

Based on aBnOrmAl soNic PrOBE readings, iNfeR from NrC buLletins on CorrOSion thaT. HPci, safety Limits reQuire circuit bREaker MAiNteNAnce!

The TAPS expanded task used for computer analysis was:

based on abnormal sonic probe readings infer from nuclear regulatory commission bulletins on corrosion that high pressure coolant injection safety limits require circuit breaker maintenance

Skill detected: diagnosis

*** some important principles are: ***

Be particularly careful of this task if it involves maintenance, diagnostic skills can have wide individual differences.

Knowledge requirement for: reg. guides

Relation of nuclear regulatory commission bulletins to plant operations. Literacy level for proper reading of nuclear regulatory commission bulletins.

Attitude detected: personal responsibility

*** points to consider and possible impacts are: ***

This task probably involves unsupervised action, careless individuals may not be suited for it.

Be alert for emotional situations that could impact safety such as marital problems.

Ability detected: deductive reasoning

*** some acceptable tests are: ***

Complex deduction test #181

Logical reasoning test #168

Figure 1. A sample excerpt from a TAPS sentence analysis.

References

1. P. M. Haas, D. L. Selby, M. J. Hanley, and R. T. Mercer, "Evaluation of Training Programs and Entry Level Qualifications for Nuclear Power Plant Control Room Personnel Based on the Systems Approach to Training," NUREG/CR-3414, ORNL/TM-8848 (September 1983).

2. D. L. Selby, and W. T. Hensley, "A Ranking Scheme for Making Decisions on the Relative Training Importance of Potential Nuclear Power Plant Malfunctions," NUREG/CR-3523, ORNL/TM-8950 (January 1984).

3. C. C. Jorgensen, P. M. Haas, D. L. Selby, and J. C. Lowry, "Nuclear Power Plant Personnel Entry Level Qualifications and Training," 11th Water Reactor Safety Information Meeting, National Bureau of Standards, Washington, D. C. (October 1983).

4. S. Mallamad, J. Levin, and E. A. Fleishman, "Identifying Ability Requirements by Decision Flow Diagrams," Human Factors 22(1), 57-68 (1980).

5. P. Rossmeisel, R. K. Tillman, and P. Best, "Job Assessment Software System for Analysis of Weapon Systems Requirements," U. S. Army Research Institute for the Behavioral and Social Sciences, draft technical report (October 1982).