Guidelines for Evaluating The Use of Commercially Available Web-Based Training

**Applied Research Conducted for the
United States Federal Aviation Administration
National Training Academy to
Determine the Effectiveness
Of Commercially Available Training
To Teach System Maintenance Concepts**

by

Dr. Richard H. Vranesh
Chief Instructional Scientist
Affiliated Computer Systems

For Virtual Educa 2001-Enfoque Ibero Americano **May 13, 2001**

Resume

I have been an instructional scientist working for the Federal Aviation Administration (FAA) for the past 10 years. For the FAA, I have researched the use of distance learning and web-based training for air traffic and airway facilities personnel. Currently, I am working on the development and acquisition of an integrated training simulation system for the enroute controller that permits completing simulated scenarios on a suite of equipment that mirrors that used at the EnRoute Air Traffic Control Centers.

I have a doctorate in education from the Catholic University of America. I have taught simulation at Georgetown University and am President and Founder of the local chapter of the Association for Educational Communications and Technology.

Introduction

Airway Facilities (AF) personnel maintain the computer equipment used by the Air Traffic Controllers in the 20 En Route Air Traffic Control Centers (ARTCCs) in the United States. Since the equipment used to control air traffic is used in an operational environment and is considered vital to the mission of the Federal Aviation Administration, the AF maintenance personnel must be certified on each major system and subsystem before attempting any corrective maintenance actions.

AF personnel certification is a four-phased process that involves the completion of theory of operation training, completion of on-the-job training, demonstration of performance proficiency, and an evaluation by management that the technician has followed all applicable procedures and completed all required documentation. OJT and performance proficiency are equipment specific and involve hands-on demonstrations of national procedures and local directives. Theory of operation training is generic to the type of equipment being purchased and its operational software. Oftentimes for theory of operation training and testing, a wide variety of off-the-shelf training courses are available especially for software operating system and networking monitoring.

The FAA continues to buy and field increasingly more complex and sophisticated systems to handle an ever-increasing volume of air traffic. The controller must be able to handle an ever-increasing work level, the Agency is constantly experimenting with intelligent software to assist controllers to more efficiently and effectively do their jobs. This software is capable of interactively performing multi-dimensional calculations of air space to probe for air space conflicts and provide solution strategies to potential aircraft conflicts. Such complex and custom-made software uses a wide variety of operating systems, network configurations, and sophisticated storage devices to function at such demanding levels.

To cut down on training time and money and the amount of effort required to operate, maintain, and troubleshoot sophisticated equipment, off-the-shelf equipment and training courses are increasingly being used to save on the effort involved in new development and to avoid creating customized courses for common software operating systems and tools such as Unix, AIX, etc. The FAA has found that the easiest and most effective way to deliver such course is through the web or to rely on web-based courseware.

To shorten the amount of classroom training, lesson the cost of development for training for new systems, and to permit the completion of prerequisite training that is assumed to have been completed prior to the introduction of new systems training , the FAA is exploring the possibility of integrating web-based courseware in generic software and off-the-shelf hardware systems into custom-made training that is purchased by the FAA and developed and delivered by the vendor with the new system.

The questions that is now being researched by the FAA training community is what standards should be used to measure for theory operations web-based courseware on generic software and commercial off-the-shelf (COTS) vendor training to determine if it should be integrated into the current curriculum.

Purpose

The purpose of this paper is to present a set of guidelines for choosing theory-based COTS, web-based for integration or replacement of the curriculum for new systems training at the FAA.

Theory of operation training teaches system signal flow, input and output, and the order of events in the new system. In complex systems, theory of operation training also teaches the relationship of subsystems and the connective of subsystem interfaces.

In order to properly prepare AF technicians, theory of operation training is provided to prepare trainees for completion of a theory of operations examination. The theory of operations examination is given to "confirm that the individual possess satisfactory knowledge of system/subsystem/equipment, theory-of-operation, or the integration of components that comprise a new system.[1]

Most of the theory of operation examination comprises knowledge of concepts. To determine whether the method used and depth of the concepts covered were sufficient for FAA use, this paper examined a methodology of judging both the depth of concept presentation and the method by which it was taught. The assumption is that since the guidelines examine the conditions of learning used by the COTS courseware, they should teach the new concepts effectively. Those courses that are judged favorably by both sets of standards are deemed worthy for replacement of integration into the existing FAA course via web-based or other distance learning medium.

Methodology

The Conceptual Learning and Development Model (1974) provided a theoretical base for this present research. This model, developed by Klausmeier, Ghatala, and Frayer[2] is concerned with the attainment of concepts at four successively higher levels and with the uses of concepts when attained at each level in understanding principles, understanding taxonomic relations, and in problem solving. These are the concrete, the identity, the classificatory, and the formal levels.

Concept attainment at the concrete level is inferred when the learner has (1) attended to the perceptible features of an object, (2) discriminated the object from others in the environment, and (3) remembered the discriminated object. Attainment of a concept at the identity level is inferred when, in addition to the prior operations at the concrete level, the learner has (4) generalized that the object when experienced in different contexts or different modalities is the same object. Concept attainment at the classificatory level is inferred when the learner, in addition to the prior

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[1] Federal Aviation Administration, Airway Facilities maintenance Personnel Certification Program, FA Order 3400.3G, Washington, D.C.: U.S. Department of Transportation, 1998, p.11.
[2] Klausmeier, H., Ghatala, E., and Frayer, D. *ConceptualLearning and Development: A Cognitive View*. New York, Academic Press, 1974.

operations at the identity level, has (5) generalized that two or more examples are equivalent (i.e., belong to the same class of objects). Attainment of a concept at the formal level is inferred when the learner, in addition to the prior operations at the classificatory level, has (6) discriminated the defining attributes of an object from the irrelevant attributes and can name or label both the concept and its attributes.

Method of Concept Presentation

Klausmeier and Feldman (1973)[3] have further isolated three factors which have been empirically demonstrated to promote concept attainment. These are: (1) Presentation of a concept definition pointing out critical attributes, (2) the systematic presentation of examples and nonexamples, and (3) emphasis on instance presentation. If these three elements are present in the training material or presentation, test scores have indicated superior performance results.

Concept definitions have been shown by Frayer (1970) [4]to significantly reduce the number of examples provided by the instructional material. The presentation of examples and nonexamples of a concept has proven to help eliminate errors due to overgeneralization (identifying nonexamples as examples), overgeneralizations (identifying examples and nonexamples) and misconceptions (identifying nonexamples and examples and examples as nonexamples) by Klausmeier and Frayer (1974).[5]

Joyce and Weil (1996)[6] have developed a teaching model based on these three factors in teaching concept attainment. Their model has three phases and each phase is based on one of Klausmeier and Feldman's factors. It includes:

- ♦ Phase I - Teacher presents labeled examples and student compare attributes in positive and negative examples.
- ♦ Phase II - Students categorize additional unlabeled examples and teacher confirms hypotheses, names concept, and restates the definition.
- ♦ Phase III - Student describe thoughts and discuss the role of hypotheses and attributes and discuss concept definitions.

Joyce and Weils call these models information processing approaches because they are more linked to concepts and principles from cognitive psychology. Many of the methods are being used to teach conceptual attainment and other mental processing skills such as inquiry training and intellectual development.

What is apparent in both of these approaches is that they advocate the teaching of a systematic approach to concept attainment. The importance of learning this systematic process is that it is maximally transferable to a variety of learning situations. In fact, Schunn and Anderson (2001)[7] cite these same skills as part of the fundamental components of scientific reasoning. Their list includes the following:

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[3] Klausmeier, H.J. and Feldman, K.V., *Effects of a Definition and Varying the Number of Examples and Nonexamples on Concept Attainment*, **Journal of Educational Psychology**, 1975, 67, 174-178.
[4] Frayer, D.A., *Effects of number of instances and emphasis of relevant attribute values on mastery of geometric concepts by fourth and sixth grade children.* Madison: Wisconsin Research and Development Center for Cognitive Learning Technical Report, 1970, p. 116.
[5] Klausmeier, H. & Frayer, D. *Conceptual Learning and Development: A Cognitive View*, New York: Academic Press, 1974.
[6] Joyce, B, & Weil, M., *Models of Teaching*, Boston, MA: Allyn & Bacon, 1996.
[7] Schunn, C.D. & Anderson, J.A., *The Generality/Specificity of Experience in Scientific Reasoning*. Fairfax, VA: George Mason University (in press).

- Observation,
- Finding patterns and generalizations, and
- Forming and assessing conclusions

What these authors advocate is teaching not how to find or prove specific scientific premises but rather how to use the processes that lead to developing, testing, and assessing scientific conclusions. This learning, they argue, is more transferable and generalizable to a wider variety of situations. It thus becomes a type of "metacognitive" knowledge that can be used to apply different processes, relate them to domain specific knowledge, and to find out why they are used.

The most valuable concepts to learn are those that can be applied to detect problems on the job, to develop approaches to solving them by applying principles developed for fuzing and conjoining such concepts, and by deriving conclusions based on testing out a variety of approaches. Concept application is a product of pattern recognition and abstract reasoning aimed at developing novel solutions to well-known problems. These guidelines are being developed to evaluate the concepts being taught to ensure that the method used is sufficiently robust and of sufficient depth to enable the learner to understand, proceduralize, and apply the concepts and principles being taught.

The criteria to be used to judge the adequacy of the delivery method for complimentary courseware then is the ability of this courseware to teach metacognitive knowledge that can be used for technicians to spot equipment and system performance problems, develop theories as to the cause of these problems by detecting and comparing patterns, and to form conclusions on how to solve them.

Depth of Content Presentation

The tool to evaluate courseware that can be incorporated into the existing curricula contains a set of guidelines for judging the ability to the courseware to complement or subsume certain blocks of instruction or serve as prerequisite to it. These guidelines need to detect whether the knowledge provided by the courseware can lead or support the acquisition of metacognitive knowledge that is widely adaptable to situations that will be faced by the technician as part of his/her problem solving tasks. Additionally, these guidelines also include a method for judging the depth of the concept presentation.
To determine this depth, these guidelines will also examine the number of examples provided, the range of variable attributes provided by the examples, and the adequacy and applicability of the definitions provided for the concepts that are presented in the instruction.

Markle and Tiemann (1969)[8] suggested that the number of examples required in learning concepts should be decided according to the number of critical and variable attributes of the given concept, and that practice in identifying examples and non-examples is necessary for full mastery of the concept. The guidelines proposed here count the number of critical variables and ensure a match with the number of examples and counter-examples. Clark (1971)[9] concluded that for the greatest ease of concept attainment, the optimal number of examples that can be presented simultaneously is four.

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[8] Markle, S.M. & Tiemann, P.W., *Really Understanding Concepts*, Champaign, Illinois: University of Illinois Press, 1969.
[9] Clark, D.C., *Teaching Concepts in the Classroom: A Set of Prescriptions Derived from Experimental Research,* **Journal of Educaitonal Psychology Monograph**, 1971, 62. 253-278.

Regarding evaluating the range of variables, Tennyson and Park (1980)[10] showed that providing examples having a wide range of variable attributes of a concept will allow a student to learn generalization behavior across rational sets. Further, Henderson, Davis, and Clooney (1975)[11] further specified this range to include examples that assist in concept classification, concept comparison, and concept contrasting. The guidelines will seek to determine if these types of examples are included in the range.

The term teaching "move" was defined by Henderson, Davis, and Cooney (1975)[12] as a "pattern of language usage-defining, giving examples, asserting, classifying, comparing, or contrasting." The moves are used by the teacher or courseware developer to facilitate the acquisition of concepts. Two main moves are examined by Henderson, these are exemplification and characterization. Exemplification includes the provision of examples, nonexamples, and counterexamples. Characterization includes definition, sufficient condition, and comparison and contrasts. The use and amount of these "moves" will be examined in the guidelines to determine the predicted effectiveness of the instruction.

Concept definitions must also be specific and understandable to provide useful instruction. A study by Feldman and Klausmeier (1975)[13] showed that a concept definition best facilitates concept attainment when stated in terms of critical attributes of the concept. The Evaluation guidelines contain counts of critical attributes that are likely to be relevant for the concept and to the extent that it communicates the proper values and relationships to the learner.

Results

Using these guidelines of concept attainment and quantifying the results provides an evaluative instrument for measuring the effectiveness of incorporation of existing COTS courseware into an existing training curriculum that teaches theory and concept of system operation for AF maintenance personnel.

Although it is difficult to find any commercially developed courses that meet all of these criteria, application of these guidelines can be used to discriminate among competing alternatives. Finally, the results can be used to make decisions regarding the need for and use of prerequisite courses and course material.

[10] Tennyson, R.D. & Park, O, *The Teaching of Concepts: A review of Instructional Design Research Literature*, **Review of Educational Research**, 1980, 50, 55-70.
[11] Henderson, K.B., Davis, E.J., and Cooney, T.J., *Dynamics of Teaching Secondary School Mathematics,* Boston: Houghton, Mifflin, 1975, p 130-136.
[12] Henderson, K.B., Cooney, T.J., and Davis, E.J. *Dynamics of Teaching Secondary School Mathematics*, Boston: Houghton, Mifflin, 1975.
[13] Ibid, Klausmeir and Feldman, 1975.

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