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A COMPUTERIZED INSTRUCTIONAL DEVELOPMENT AID FOR DECISION TASKS

Joseph Saleh
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Prepared For:

Naval Training Equipment Center
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PERCEPTRONICS

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1. OVERVIEW

This report briefly describes an instructional guideline generation system developed during the present one-year contract for NTEC (Analysis of Requirements and Methodology for Decision Training in Operational Systems, Contract No. N61339-77-C-0005). The directions of improvement for the system will be identified in this report, and the development of a computerized instructional development aid for decision tasks will be suggested as a means for improving the system in identified directions. Such an aiding system will be overviewed and a simulated instructional guideline generation session produced by the aiding system will be presented.

2. INSTRUCTIONAL GUIDELINE GENERATION SYSTEM

As part of the present one-year project for NTEC, a system for the generation of instructional guidelines was developed. The system provides a procedure to generate essential information to be incorporated in the production of instructional materials for any decision task subject to training in any specific instructional enviornment. Such information includes:

(1) Identification of decision tasks in the form of objective hierarchies.

(2) Classification of decision tasks.

(3) Identification of task-specific and basic instructional contents.

(4) Selection of the most effective instructional method.

(5) Selection of the most effective instructional media.

Although the project has been initially aimed at developing a systematic procedure for providing instructional guidelines for decision tasks encountered in LAMPS ASW operation, a task-independent methodology was developed to underlie the design in order to make application of the system to other task domains subject to minimal modification effort. Such a methodology allows incorporation of general purpose decision training components into task specific decision training programs. This incorporation provides trainees with the basic skills required for task-specific decision making within a new domain. Furthermore, since the characteristics of decision tasks within any specific domain are subject

to change with time, the methodology will allow development of more effective training programs even in the case where there is no possibility of transfering the trainees to other task domains.

The instructional guideline generation system is presented in Figure 2-1. The system contains two basic modules: Decision Task Classification Preprocessor and Decision Training Guideline Generator. The Decision Task Identification Component precedes the Decision Task Classification Preprocessor module which is composed of two sub-components: Decision Type Recognition and Decision Task Classification. The Decision Training Guideline Generator module contains five sub-components: Instructional Guideline Generation, Cognitive Level Weighting, Instructional Method Selection, Method/Media Relevancy Detection, and Instructional Media Selection. The description of the eight components and their interactions as well as the input/output of the system is described in the remainder of this chapter. In what follows, attention must be paid to the fact that the implicit procedure defined by the system is being performed (operated) by an instructional technologist.

Decision Task Identification receives any training task presented in the objective hierarchies and works as a filter which separates decision tasks from non-decision tasks. The specification of this component follows the definition of a decision task:

(1) The objective of a decision task is to select an alternative from a specified set of alternatives.

(2) This selection may require the formulation of alternatives (problem structuring).

(3) There is a lack of completely specified criteria for either alternative formulation or alternative selection.

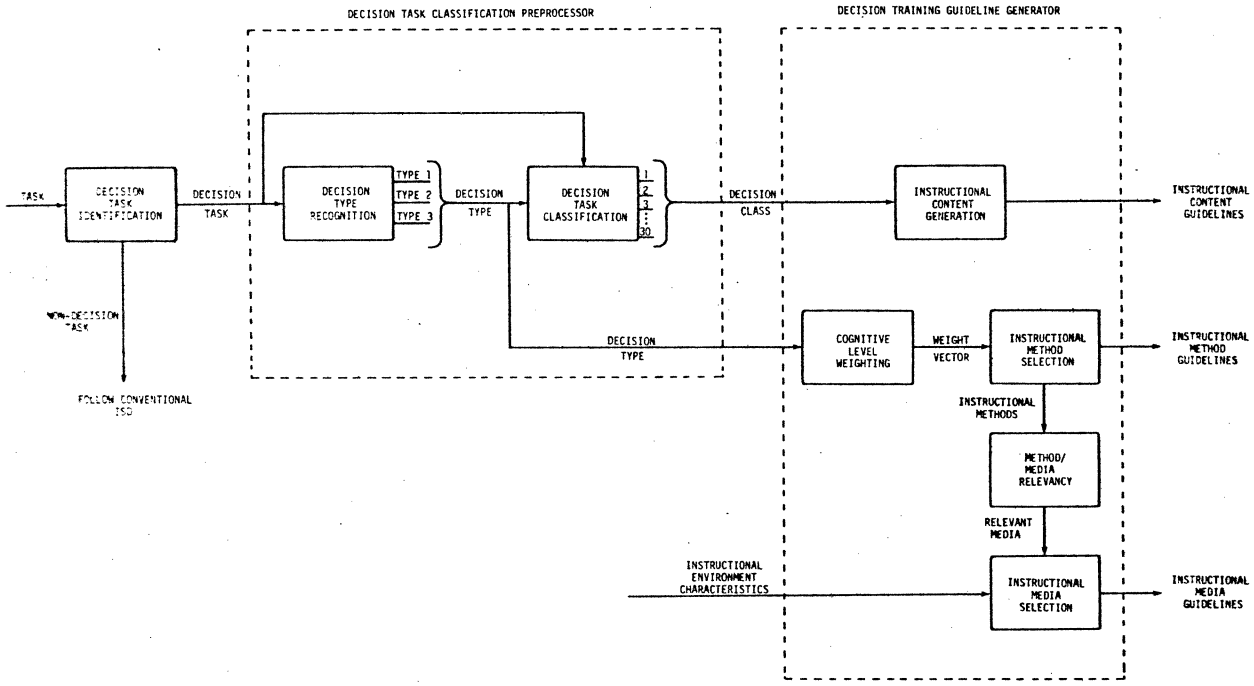

FIGURE 2-1
DECISION TRAINING GUIDELINE GENERATION SYSTEM

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The output of the component is the identification of the input task either as a decision task, which causes the task to enter the Decision Type Recognitive and Decision Task Classification components, or as a non-decision task, which results the initiation of a conventional ISD procedure.

Decision Type Recognition receives a decision task and identifies it as Type 1, Type 2, or Type 3. Type 1 represents decision tasks with processes requiring only problem structuring; Type 2 includes all decision tasks concerning only action selection; Type 3 is composed of all decision tasks which require both problem structuring and action selection. Since the processes involved in problem structuring are of different cognitive complexity than the ones involved in action selection, the training process for the tasks belonging to different decision types must be conducted differently. The information concerning the type of the decision task enters Decision Task Classification and Cognitive Level Weighting components.

Decision Task Classification is based on a procedure similar to that of discriminant analysis. To distinguish between classes of decision tasks, a collection of discriminating variables is selected that measures characteristics on which the classes are expected to differ, that is, training content requirements. A set of variables was designed to provide satisfactory discrimination for decision tasks with known class membership. The classes have been identified, and the classification of any new decision task with unknown membership can be accomplished. Thirty different classes constitute the set of possible classes relevant to decision training (Table 2-1). Since Type 3 decision tasks requires processes involved in both Type 1 and Type 2, the class of any Type 3 decision task can be presented by a combination of the classes identified for the corresponding Type 1 and Type 2 decision tasks, as indicated in Figure 2-2.

TABLE 2-1

DECISION TASK CLASSES

CLASS NUMBER	DECISION TYPE	DECISION CLASS	ATTRIBUTE
1	1	SWRS	Single attribute, sell defined, time relaxed, static
2	1	SWRD	Single attribute, well defined, time relaxed, dynamic
3	1	SWPS	Single attribute, sell defined, time pressure, static
4	1	SWPD	Single attribute, well defined, time pressure, dynamic
5	1	SARS	Single attribute, ambiguous, relaxed, static
6	1	SARD	Single attribute, ambiguous, relaxed, dynamic
7	1	SAPS	Single attribute, ambiguous, pressure, static
8	1	SAPD	Single attribute, ambiguous, pressure, dynamic
9	1	MWRS	Multiattribute, well defined, time relaxed, static
10	1	MWRD	Multiattribute, well defined, time relaxed, dynamic
11	1	MWPS	Multiattribute, well defined, time pressure, static
12	1	MWPD	Multiattribute, well defined, time pressure, dynamic
13	1	MARS	Multiattribute, ambiguous, time relaxed, static
14	1	MARD	Multiattribute, ambiguous, time relaxed, dynamic
15	1	MAPS	Multiattribute, ambiguous, time pressure, static
16	1	MAPD	Multiattribute, ambiguous, time pressure, dynamic

TABLE 2-1 (Continued)

DECISION TASK CLASSES

CLASS NUMBER	DECISION TYPE	DECISION CLASS	ATTRIBUTE
17	2	RSEU	Time relaxed, subjective expected utility
18	2	PSUE	Time pressure, subjective expected utility
19	2	RMMN	Time relaxed, Maxi-min utility
20	2	PMMN	Time pressure, Maxi-min utility
21	2	RMMS	Time relaxed, Maxi-max utility
22	2	PMMX	Time pressure, Maxi-max utility
23	2	RMMR	Time relaxed, Mini-max regret
24	2	PMMR	Time pressure, Mini-max regret
25	2	RLEX	Time relaxed, Lexicography
26	2	PLEX	Time pressure, Lexicography
27	2	RHUR	Time relaxed, Hurwicz
28	2	PHUR	Time pressure, Hurwicz
29	2	RSAT	Time relaxed, satisfying
30	2	PSAT	Time pressure, satisfying

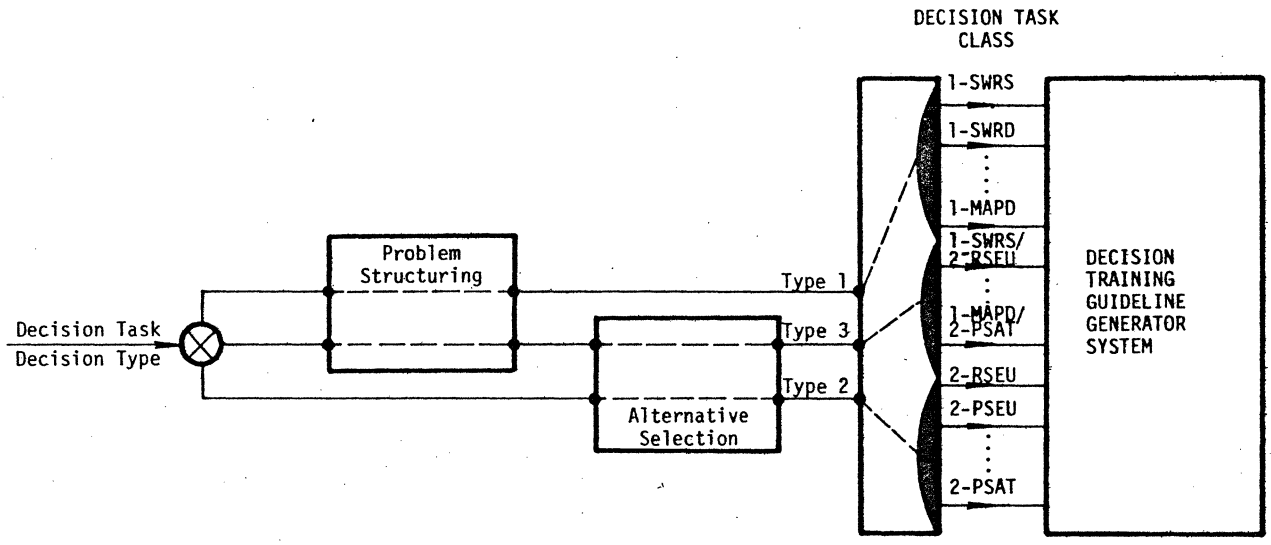

FIGURE 2-2
DECISION TASK CLASSIFICATION

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The decision task and the information concerning its type enters Decision Task Classification component. The output of the component represents the class of the decision task which is sent to Instructional Content Generation component.

Instruction Content Generation receives the information about the class of the decision task and generates the required instructional contents. Since a set of basic instructional contents is associated with each class, the process involved is a simple table look-up. The basic instructional content appears as part of the system's output which together with the task-specific information presented in decision trees, constitute required instructional content for the decision training program.

Cognitive Level Weighting receives the decision type and selects a cognitive level weight vector. The idea of cognitive level weight vector was initiated by the fact that the training objectives for different tasks with unequal cognitive complexity can be accomplished differently depending on the instructional method employed. Such dependency between cognitive complexity and instructional method suggested a detailed analysis of cognitive levels involved in performance of each decision behavior. The result of the analysis was the identification of a cognitive level weight vector associated with each decision type (Table 2-2). Each vector presents the degree of importance of the six cognitive levels with respect to the corresponding decision type. The six cognitive levels include: knowledge, comprehension, application, analysis, synthesis, and evaluation. Since a weight vector is assigned to each decision type, the process involved is a simple table look-up. The selected cognitive level weight vector is sent to Instructional Method Selection component.

Instructional Method Selection receives the cognitive level weight vector, incorporates it with the data in method/attribute matrix, and

TABLE 2-2

COGNITIVE LEVEL WEIGHT MATRIX

Decision Type \ Cognitive Level	Knowledge	Comprehension	Application	Analysis	Synthesis	Evaluation
Type 1	ε	0.1	0.2	0.5	0.2	ε
Type 2	0.09	0.11	0.51	0.17	0.06	0.06
Type 3	0.04	0.11	0.36	0.33	0.13	0.03

ε: very small weight, can be approximated by zero

results in the most effective instructional method. The method/attribute matrix represents the judgmental evaluation of the degree of effectiveness of fourteen major instructional methods with respect to the six cognitive levels (Table 2-3). The judgmental data is provided by a training specialist and a psychologist. A weighted average procedure is used to caluclate a degree of effectiveness for each instructional method with respect to the decision task. The method with the highest degree of effectiveness is selected as the most effective instructional method and appears as part of the system's output.

Method/Media Relevancy Detection receives the selected instructional method and, using method/media relevancy matrix, identifies the media relevant to the selected method. Since some instructional media are not applicable to a training environment employing a specific instructional method, a study of the relevancy of each of the twelve instructional media with respect to each instructional method was performed. The result of the study dichotomized the relevant and irrelevant media for each instructional method. These results appear in the method/media relevancy matrix, Table 2-4. The relevant instructional media are identified by a reference to the method/media relevancy matrix, and the information is sent to the Instructional Media Selection component.

Instructional Media Selection receives the relevant media and, using media/attribute matrix and the weights of different attributes with respect to the training environment, selects the most effective media. The degree of effectiveness of each instructional media with respect to different attributes was judgmentally assessed by a training specialist. The results of this assessment appears in Table 2-5. The weight vector which identifies the degree of importance of different attributes of the instructional method with respect to the specific training environment, is provided by the system user instructional technologist. A weighted

TABLE 2-3

METHOD/ATTRIBUTE MATRIX

METHOD \ ATTRIBUTES	Knowledge	Comprehension	Application	Analysis	Synthesis	Evaluation	Cost (Low)	Time (Short)
Drill/Practice/Review	10	5	1	1	1	1	10	6
Lecture	7	7	3	3	3	1	8	6
Discussion-Individual Tutorial	7	10	9	10	9	8	2	6
Discussion-Group	4	9	7	8	6	7	5	3
Programmed Instruction	8	8	5	4	2	1	5	8
Games	3	3	8	7	5	4	4	3
Simulation	2	3	10	8	8	7	2	3
Projects-Individual	4	8	8	9	9	7	5	2
Projects-Group	3	8	7	8	6	6	5	4
Laboratory	4	6	10	9	5	8	2	4
Apprenticeship	5	6	9	6	5	6	2	2
Demonstration Visual Aid/Film	5	7	2	3	3	1	5	6
Individual Investigation	6	8	8	9	9	9	5	1
Text-Readings	8	7	3	4	3	2	10	7

TABLE 2-4

METHOD/MEDIA RELEVANCY MATRIX

METHOD \ MEDIA	Oral Presentation (Lecture)	Textbook	Workbook Problem sets	Pictures, Slides, Transparancies	Audiotape	Motion Picture	TV/VTR	Programmed Text	CAI	Part-time Trainer	Simulator	Natural Object
Drill/Practice/ Review	1	1	1	1	1	1	1	1	1	1	1	1
Lecture	1	0	0	0	1	1	1	0	0	0	0	0
Discussion-Individual Tutorial	1	0	0	0	0	0	0	1	1	0	0	0
Discussion-Group	1	0	0	0	0	0	0	0	0	0	0	0
Programmed Instruction	0	0	1	1	1	1	1	1	1	1	1	0
Games	0	1	1	1	1	1	1	1	1	1	1	0
Simulation	0	0	0	1	1	1	1	0	1	1	1	1
Projects-Individual	0	0	0	0	0	0	0	0	0	0	0	1
Projects-Group	0	0	0	0	0	0	0	0	0	0	0	1
Laboratory	0	0	1	1	1	1	1	1	1	1	1	1
Apprenticeship	0	0	0	0	0	0	0	0	0	0	0	1
Demonstration	0	0	0	1	0	1	1	0	0	1	1	1
Individual Investigation (Research)	0	0	0	0	0	0	0	0	0	0	0	1
Text-Reading	0	1	0	1	0	0	0	0	0	0	0	0

TABLE 2-5

MEDIA/ATTRIBUTE MATRIX

MEDIA \ ATTRIBUTES	Learner Paced (Control)	Self Instructional	Motion/Skill	Situational Detail (fidelity)	Control over Time (motion)	Flexible Sequencing	Repeatable	Context Creation	Allows Testing/ Evaluation	Cost (Low)	Simplicity of Use, Maintenance
Lecture (oral presentation/chalk board)	1	1	1	1	1	7	1	2	7	8	8
Textbook	10	9	5	3	1	10	10	1	7	10	10
Workbook, Problem Sets	10	9	5	3	1	10	10	1	10	10	10
Pictures, Slides, Transparencies	10	7	5	10	1	10	10	5	5	7	5
Audiotapes	5	9	1	7	10	1	10	4	5	8	5
Motion Pictures	3	9	10	10	10	1	10	7	5	5	4
Television/Videotape Recording	3	9	10	9	10	2	8	7	5	3	3
Programmed Text	10	10	5	3	1	3	10	1	10	10	10
CAI	10	10	5	3	1	6	10	1	10	3	4
Part-task Trainer	10	7	10	7	10	7	10	7	10	4	4
Simulator	10	9	10	8	10	7	10	8	10	1	2
Natural Objects	3	10	10	10	1	7	5	10	2	1	1

average procedure is used to calculate the degree of effectiveness of each relevant instructional media with respect to the decision task. The media with the highest degree of effectiveness is selected as the most effective instructional media and appears as part of the system's output.

3. PROCEDURE FOR INSTRUCTIONAL GUIDELINE GENERATION

The process of instructional guideline generation for decision tasks is compatible with conventional Instructional System Development (ISD). This process can be considered as a module, within a structured ISD program, for recognition and classification of decision tasks as well as selection of the most effective instructional methods, media, and contents for those tasks. The process of instructional guideline generation (i.e., use of the system) can be defined as a systematic execution of a series of steps:

(1) Define objective hierarchies for the training tasks. As in the case of any ISD program, the process of instructional guideline generation starts with identification of objective hierarchies for the training tasks.

(2) Recognize Decision Tasks. The objective hierarchies are processed by the decision task identification scheme to recognize the decision tasks involved in the training.

(3) Identify type and class of the decision task. Using the method described as Decision Task Classification Preprocessor the type and the class of each decision task are identified.

(4) Select the Instructional Contents. The instructional content corresponding to different attributes of the class of decision tasks are combined to construct the basic instructional contents. The basic instructional content includes: general definition, amplification, rules, pitfalls and limitations, interactions with other decision elements, and prerequisits for each instructional content section. In addition to basic instructional content, the decision tree, representing each decision task, is constructed to provide the required task-specific information for instructional content.

(5) Identify Cognitive Level Weights. The cognitive level weights vector associated with the decision type is identified by a simple table look-up procedure.

(6) Select the Most Effective Instructional Method. A linear evaluation procedure is performed by a summation over the results of the multiplication of elements of the cognitive level weights vector by corresponding elements of each vector associated with different methods in the method/attribute relevancy matrix. This procedure provides an effective value assessment for each instructional method. The method with the highest effectiveness value is selected as the most effective instructional method for training the decision task under consideration.

(7) Identify the Instructional Media Incompatible with the Selected Method. The vector associated with the selected instructional method in the method/media relevancy matrix is identified by a simple table look-up. Those instructional media corresponding to zero-value entries in the vector are considered as the ones incompatible with the selected method.

(8) Select the Most Effective Instructional Media. The degrees of importance of attributes, associated with each media, with respect to the training environment is defined in a weight vector. Then, a linear evaluation procedure, similar to the one used in item 6, is performed to select the most effective instructional media. A summation is performed on the results of the multiplication of elements of the weight vector by corresponding elements of each vector associated with different media in the media/attribute matrix.

The result of this summation will define the degree of effectiveness of the media if the media is compatible with the selected method. In the cases where the media is not compatible, the degree of effectiveness will be zero. The media with the highest degree of effectiveness will be selected as the most effective instructional method to be used with the selected instructional method in the specific instructional environment.

4. DIMENSIONS FOR IMPROVEMENT

The instructional guideline generation system provides a systematic procedure for incorporating a great deal of data into the process of selecting different components of a decision training program. These data are of great importance to any instructional system development and, theoretically, should all be considered in the development of any program. However, in practice, the lack of a systematic procedure for incorporating these data caused the instructional technologists to ignore a great portion of the data during the design process. The procedure of instructional guideline generation, developed in this project, provides systematic means for the management of data and its effective utilization in the process of instructional system development. However, a more effective utilization of the instructional guideline generation system requires more detailed look into three problems:

(1) elicitation of more accurate judgmental data.

(2) generation of a control structure to guide the user in executing different steps of the system.

(3) development of a computational aid for calculations required in the system.

A computerized instructional guideline generation system can result in substantial improvements in all three dimensions.

5. COMPUTERIZED INSTRUCTIONAL DEVELOPMENT AID

The effectiveness of the instructional guideline generation system can be enhanced by improvement of the system in the three dimensions identified in the previous chapter. Computerization of the instructional guideline generation system can result in substantial improvements in all three dimensions. The result will be a computerized system to aid the process of instructional development.

The aiding system follows the design described in Chapter 2. It has the potential of working in two different modes: (1) development mode and (2) application mode. Development mode will provide access to judgmental data, stored in the system, in order to modify them by an adaptive procedure. The accuracy of each data element will be assessed by analysis of the guidelines generated for decision tasks used as a test case. The inaccurate data will be modified to adapt the system's output to a desirable response. Application mode represents a man/machine interactive session through which the information concerning the characteristics of the training environment, as well as the input decision task, are elicited from the user instructional technologist and, based on that information, the instructional guidelines for the decision task are generated. During interactive sessions, the user will be guided by the sequence and content of a series of questions designed to elicit the required information. Furthermore, all necessary calculations will be performed automatically by the system. Such a system simplifies the process of instructional guideline generation into a series of judgmental evaluations of elementary attributes. While the process is highly simplified for the user, the system automatically incorporates all the information acquired from the user into the process which results in the most effective instructional method and media as well as the required instructional contents.

6. SIMULATED INSTRUCTIONAL DEVELOPMENT SESSION

A prototype application mode session of the computerized instructional development aid is simulated in the folloiwng pages. The user responses have been underlined.

Describe the characteristics of the instructional environment by assigning an important weight (between zero and one) to each of the following attributes.

1. Learner paced control on the instructional media.
   AT(1) = .7

2. Instructional media to be self instructional.
   AT(2) = .8

3. Motion of the instructional media.
   AT(3) = .3

4. Fidelity of the instructional media in terms of situational details.
   AT(4) = .8

5. Learner control over the instruction speed (motion).
   AT(5) = .6

6. Flexibility of the media for instructional sequencing.
   AT(6) = .4

7. Instruction readability.
   AT(7) = .3

8. Context creation.
   AT(8) = .8

9. Convenience for development of testing and evaluation.
   AT(9) = .6

10. Low cost of instruction.
    AT(10) = .3

11. Simplicity of use and maintenance.
    AT(11) = .9

Here is the attribute list with the weights you assigned.

1. WEIGHT = 0.70: Learner paced control on the instructional media.
2. WEIGHT = 0.80: Instructional media to be self instructional.
3. WEIGHT = 0.30: Motion of the instructional media.
4. WEIGHT = 0.80: Fidelity of the instructional media in terms of situation
5. WEIGHT = 0.60: Learner control over the instruction speed (motion).
6. WEIGHT = 0.40: Flexibility of the media for instructional sequencing
7. WEIGHT = 0.30: Instruction readability.
8. WEIGHT = 0.80: Context creation.
9. WEIGHT = 0.60: Convenience for development of testing and evaluation.
10. WEIGHT = 0.30: Low cost of instruction.
11. WEIGHT = 0.90: Simplicity of use and maintenance.

Options are	Type
1. Weights are satisfactory.	q
2. Change weight of an attribute.	c
3. Display complete list.	d

OPTION = c
Attribute number = 10

10. WEIGHT = 0.30: Low cost of instruction.
New Weight - .5

OPTION = q

Here is the attribute list with the weights you assigned

1. WEIGHT = 0.70: Learner paced control on the instructional media.
2. WEIGHT = 0.80: Instructional media to be self instructional.
3. WEIGHT = 0.30: Motion of the instructional media.
4. WEIGHT = 0.80: Fidelity of the instructional media in terms of situation.
5. WEIGHT = 0.60: Learner control over the instruction speed (motion).
6. WEIGHT = 0.40: Flexibility of the media for instructional sequencing.
7. WEIGHT = 0.30: Instruction readibility.
8. WEIGHT = 0.80: Context creation.
9. WEIGHT = 0.60: Convenience for development of testing and evaluation.
10. WEIGHT = 0.50: Low cost of instruction.
11. WEIGHT - 0.90: Simplicity of use and maintenance.

Throughout this consultation session the above importance weights will be considered to represent the elements of the instructional environment. To present a new environment cancel the current session and start a new one.

Press RETURN when ready to continue.

Introduce the new instructional task by its instructional objective.

Enter description: press the ESC key then RETURN.

Classify the Contact as U.S. Ship, Enemy Ship or Natural Object.

Do you want to change or correct the description? Type yes/no. No

What is the time pressure on course representation?
Specify it by a time pressure factor between zero and one.

Factor = .3

Does the objective of the task include selection of an alternative from a set of alternatives? Yes

Is the set of alternatives given? Yes

Is there a completely specified procedure for the alternative selection? No

Once the alternatives are given, is there any critical time pressure on the operator for fast alternative selection? Yes

Which of the following decision rules is the most suitable one for the task?

1. Subjective Expected Utility (SEU)
2. Mini-max loss (MMX)
3. Mini-min loss (MMN)
4. Mini-max regret (MMR)
5. Lexicography (LEX)
6. Hurwicz (HUR)
7. Satisficing (SAT)

Enter a number between 1 and 7? 2

INSTRUCTIONAL GUIDELINES

Instructional objective: classify the contact as U.S. Ship, Enemy Ship or Natural Object.

The task to be taught is a decision task.

Decision Type: Type 2

Decision Class: 2-PMMX

Instructional Content Must Include the Following Items:
Collecting subjective utilities under time pressures. Translating outcomes into utilities. Aggregating utilities. Relation of loss and utility concept of minimizing maximum loss. Effect of time pressure on quality. Concept of payoff tables.

The Best Three Suggested Instructional Methods are:

1. Discussion-Individual Tutorial for which the best three instructional media are:

    1. Programmed Text
    2. CAI
    3. Lecture (oral presentation/chalkboard)

2. Individual Investiation (Research) for which the best three instructional media are:

    1. Natural Objects
    2. Textbook
    3. Workbook, problem sets

3. Projects - Individual for which the best three instructional media are:

    1. Natural bojects
    2. Textbook
    3. Workbook, problem sets

Press RETURN when ready to continue.