DOCUMENT RESUME

ED 353 960 IR 015 920

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TITLE	The Application of Formal Design Theories to the Production of Videodisc/CBI Instructional Systems.
PUB DATE	90
NOTE	25p.
PUB TYPE	Viewpoints (Opinion/Position Papers, Essays, etc.) (120) -- Reports - Desc iptive (141)
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	*Computer Assisted Instruction; Expert Systems; *Instructional Design; Instructional Development; *Instructional Systems; *Interactive Video; Media Selection; Models; Needs Assessment; Systems Approach; Task Analysis; *Videodisks

ABSTRACT

This paper describes a new instructional development model, the INTERACT model, for use in instructional design of interactive instruction, especially interactive computer-delivered instruction such as intelligent tutors and videodisc-based computer-based instruction (CBI). The model is derived largely from current practice in instruct. :al development and from work in intelligent tutors, and was motivated by the current need for intelligent CBI authoring systems. The model involves a few novel assumptions, including: (1) in practice, projects do not usually begin with a task or needs analysis, but with goals usually derived from corporate assumptions about the existing problems and solutions; and (2) media selection should not be driven solely by the behavioral objectives, but by the nature of the learning experience. Six figures illustrate the INTERACT model and various concepts presented in the paper. (Contains 5 references.) (Author/ALF)

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THE APPLICATION OF FORMAL DESIGN THEORIES TO THE PRODUCTION OF VIDEODISC/CBI INSTRUCTIONAL SYSTEMS

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ABSTRACT

This paper describes a new model, the INTERACT Model, for use in instructional design of interactive instruction, especially interactive computer-delivered instruction such as intelligent tutors and video discs. It is derived largely from current practice in instructional development and from work in intelligent tutors, and was motivated by the current need for intelligent CBI authoring systems.

This paper presents a new instructional development model and discusses its application to the design of interactive instruction, such as the design of computerized instruction, intelligent tutors and videodisc-based CBI. The model cannot be presented in its entirety in this paper, and so certain critical components of the model will be discussed. Finally, the model has not yet matured, and there are still important design questions the model does not address. This presentation will end with a discussion of some of these needed developments.

This model, called the Interact Model, involves a few novel assumptions. First, several instructional development models begin with either a task or a needs analysis. In practice, however, projects do not usually begin with these steps, but with some pre-existing goals. These goals usually derive from corporate assumptions about what problems exist and what solutions are worth considering. These assumptions lead to some expectations for the project, and these expectations lead to the goals for the needs or task analysis, if there is one at all. More often than not, they lead to the direct establishment of the development project.

The INTERACT Model recognizes the above sequence of actions as often being critical to the determination of the training program, and so, unlike most models, includes these steps within the model. Following these steps, a formal needs analysis should normally be conducted. If a complete needs analysis is not required, goal verification and validation steps are important. Therefore, the INTERACT Model recognizes that there are several ways in which initial project definition may be established. This is reflected by the multiple starting points in Figure 1.

A second assumption is that media selection should not be driven solely by the behavioral objectives, as it is in many models. Instead, in the INTERACT Model, media selection is driven by the nature of the learning experience through which the objectives are to be achieved. We argue that the teaching/learning activities are more closely deterministic of particular media than are the specified learning outcomes of these activities.

Other assumptions will become evident as the model is presented. The model is shown in Figure 1. This figure shows that the first step in the model is to determine the type of project, if any, that is needed, and to establish initial goals, purposes or aims for the project. Once the nature of the required accomplishment has been established, the nature of the teaching/learning experience is determined. Then the necessity for a task or content analysis is determined and the appropriate instructional design approach is selected.

Once these decisions have been made, the task or content analysis and macro-design activities are carried out. The results of these activities are a map of the teaching/learning activities and all the knowledge and performance items that must be mastered. Now is the time for media selection. Once it is known what is to be taught and/or learned, in what sequence and through what types of activities, it is fairly easy to determine what media will serve what purpose at what point in the instruction.

This is the point at which, among other things, the content and activities to include in the CBI and videodisc are identified. Once the content of the interactive portion of the lesson has been determined, the micro-design can be produced. The micro-design sequences the instructional interactions, determines their contents, describes the linkage between interactions, and specifies the nature of the interactivity.

The literature contains a great richness of methods and supporting research for some of the steps described above. The INTERACT Model takes advantage of this previously published work, and concerns itself with problems of selection among existing methods or models. Two of these steps are of particular interest to the design of videodisc-based CBI instruction: the selection of instructional methods and the selection of methods for the design of instruction.

Much work has been done in the development of formal models of instructional methods. Called Models of Teaching, these models serve as schematic diagrams for the instructional activities, specifying their sequence through a course, lesson, module or curriculum. A teaching model can be defined as an "... overall conceptual and procedural framework which serves to organize the classroom environment, direct activities and facilitate the

achievement of specific goals. Within this framework, specific strategies and teaching activities can be organized. Examples that might be familiar are Ausubel's Advance Organizer Model, Precision Teaching, or the Developmental Model derived from Piaget's work." (Dills, 1990).

These Models of Teaching have been developed independently by many different people, operating from different perspectives, working with different subject-matters, and with different goals in mind. The results of these efforts are available for our use. A great many of these models have been gathered together in the book, Models of Teaching, by Joyce and Weil. Many others have also been created.

The determination of the nature of the teaching/learning experience in the INTERACT Model becomes, in most cases, the selection of an appropriate formal Model of Teaching. Many factors go into this selection, but models can be selected largely in terms of their formal structures and characteristics.

First, a model must be selected which can achieve the goals that must be met. Second, each model also nurtures, or indirectly fosters, certain other objectives in addition to those it directly achieves, much in the way that a hidden curriculum teaches indirectly. It must be determined whether or not these nurturants, or indirectly nurtured objectives, are acceptable to the program and compatible with the institutional environment within which the instruction will take place.

The required support structures and social structures must be implemented, or the model won't function properly. Finally, the time for preparing the materials and training the instructors in the use of the model must be available.

If no model can be found that is satisfactory, one must be created. But it would be a very unusual situation in which this became necessary.

The task of selecting an appropriate Teaching Model is difficult. An expert systems computer program, called Teaching Models, has been constructed to make this process easier and simpler, especially for the inexperienced designer.

Each Model of Teaching has its own syntax, or phasing. This is a description of the steps of the model and their sequence. For example, the Role-Playing Model of Chesler and Fox, as described by Joyce and Weil (1986)1, has nine phases. These range from Phase one, Warm Up the Group, through such phases as Set the Stage (3), Enact (5), Re-enact(7) and finally, phase nine, share the experience and generalize.

The phases of each model are used by the INTERACT Model to determine the types of knowledges and skills that must be obtained, and this information is used in turn to select the type of task, content or job analyses activities that will be required.

The Teaching Model syntax is also used, along with the project goals, as the input to the selection of an instructional design method. Again, a great deal of work has gone into the development of many different instructional design models. Each of these has been developed from a different perspective, with different kinds of instructional outcomes in mind.

Several of these models have been described in the book Instructional-Design Theories and Models, edited by Charles Reigeluth. Other models are also described in the literature.

The INTERACT Model calls for matching the perspective of a formal Instructional Design Model to the perspective of the chosen Model of Teaching. The types of outcomes the Design Model addresses must also be matched to the types of outcomes the project and the Teaching Model are intended to produce.

Again, if no adequate formal Instructional Design Model can be found, one must be produced. But usually an existing model proves satisfactory.

Discovering the best model to use in a given project is difficult, however. Again, an expert system is currently being constructed to simplify this problem.

Once the appropriate formal models have been selected, they are utilized as appropriate to analyze and synthesize the data, resulting in the production of the macro-design. This is the top-level blueprint of the instructional activities, objectives, materials, and evaluation devices and procedures. Now media selection can be carried out, including making the decision as to whether or not videodiscs and CBI programs will be integrated into the instructional system, and if so, what elements of instruction are to be included in them.

Once the content of the CBI/videodisc segments has been determined, the micro-design for them can be produced. A major problem is encountered here; no formal instructional design model yet exists for use in the design of interactive instruction. Some work has been accomplished in this direction by people working with intelligent tutoring systems. But there still remains no model for structuring interactions between learners and the instruction, for determining the frequency or the optimal mode of the interactions, or for selecting the types of materials to be interacted with and at what points in the instructional sequence. Variations in these

factors for learners with different cognitive styles, different kinds of motivation, in different subject-matters and with different objectives can only be dealt with through hueristics and the intuitions of experienced designers at the present time.

For want of a model to use in designing interactive instruction, or even an adequate psychological definition of interaction, most designers resort to the use of hueristics and intuition. The results are usually acceptable, especially if the designer is experienced. But a formal model is needed if the range of quality is to be narrowed, and if the design costs are to be significantly reduced.

The INTERACT Model includes a formal design model for interactive instruction. This formal model is still under development, and does not yet address some of the questions one would want addressed by such a model. It has already reached a stage of development at which it can be useful, however, and so it will be presented here.

Typically, the design of interactive instruction consists in designing a linear sequence of linked interactive activities, called a path, and then creating loops, alternative paths and multiple intersections among these paths. Students can transfer from one path to another at intersections. An excellent treatment of this design approach at its best can be found in Richard Schwier's book, Interactive Video (Educational Technology Publications, 1987).

The INTERACT Model, however, takes a different approach to producing the same types of objects. In this approach, each instructional action, or Interact, is designed independently of any path it may ultimately become a part of. Along with each Interact is designed the Interface Mechanism that leads to and from that event, and that determines the interactive nature, or environment, of the Interact.

The resulting structure of the Interact is shown here (Figure 3). As can be seen, the final design for each Interact consists of a Content Atom and a Linkage Mechanism for that Atom. Each Content Atom consists, in turn, of Display Elements and an Expository Web. The Expository Web determines how the Display Elements will appear, perform, and so on, and is fixed by the instructional author. How the Linkage Mechanism will arrange and augment that atom in an Interact, however, is re-determined by the instructional program every time the atom is used.

The size of the Interact is determined by the internal logic and the instructional or psychological requirements of the Interact itself. No formal algorithm has yet been developed to determine these matters, and one still must fall back upon intuition and experience and aesthetics.

A good technique to use, though, is one taken from the production of television: paragraphing (verbal, visual, textual, conceptual, auditory, etc.). Each Interact should express a complete thought, a cognitive icon. To determine if the proposed icon is a single complete thought, write a behavioral objective for the Interact. If the Interact is short and concise, the objective may seem trivial at this level. This is partly because we don't normally write objectives at this low a level in the curriculum, and partly because, if it is a single thought, it probably is a trivial objective. But if the proposed icon is not a single thought, break it up by writing two or more even more trivial objectives, and use each one to define a separate icon.

Once it has been determined that the Interact is a single idea, describe the idea in great detail, both in terms of its content and its structure. Its structure, by the way, normally ought to be in an expository mode. This is true even if the lesson is to be in some other mode, such as an inquiry mode or an inductive mode.

The full description of the idea is written, and those parts of the idea that are suitable are assigned to the videodisc. The rest of the icon will be placed in the computer as text, graphics, digitized photographs and so on.

Since the display items are stored in different places, they should be conceived as being distinct from the structure, or Expository Web, that holds these displays in proper relationship to each other. This Web is actually the logical representation of that portion of the computer program that controls the display of the Content Atom.

An important point to note here is that students do not interact with the Content Atom. The Content Atom is an expository icon which is displayed to the student. It is much like a slice taken out of a linearly-presented video or CBI lesson, and has no interaction capability. All interaction occurs before and/or following the presentation of the Content Atom, and involves only the Linkage Mechanisms.

Content Atoms may be designed at this point for all the Interacts, or each Interact may be fully designed before going on to the next Event. This is a project management decision, and doesn't impact upon the instruction. One should note, though, that these Interacts are not to be conceived as elements in a linear flow, but as elements in a mosaic of the Instructional Events Field. This field, as shown here, is the network of Interacts; it holds the Web of Interaction. We have not yet created this field in the design process described so far; its creation is described below. But the concept of this field is necessary to an understanding of the nature of the arrangement of Interacts in the instructional path followed by a given student. Even though every student of necessity follows a linear path through instruction, that path is created by or for the student as the path is traversed; it does not pre-exist in the computer program, at least in the most interactive variety of instruction.

Once a Content Atom has been fully designed, several questions must be answered concerning the interactive aspects of the Interact. How does one arrive at this particular event? How many and which place within the Interact network may one come to this place from? Where may one go to from here? While here, what commands can the user exercise? What questions or responses to stimuli must (may) the student make? What data will be recorded about the student's responses?

The answers to these questions are used to design the interaction control and monitoring mechanism of the Interact. This mechanism, called in the INTERACT Model the Linkage Mechanism, determines all aspects of the Interact from two perspectives, that of the computer and that of the learner.

First, it determines the essence of the Interact from the standpoint of the computer, in that it tells the computer when the Interact may be fetched from memory or disc, when to retire the Interact from active memory, what data to record, and what interface options to activate.

Second, the Linkage Mechanism also determines what the nature of the Interact is for the learner, phenomenologically speaking. It determines what displays will be activated and when; it controls the video displays; it asks the students questions and determines what responses and commands the student may activate.

A linkage Mechanism has three components. One is the Command Interface to the computer CPU, memory and other internal components. The second component is the User Interaction Interface. This interface contains the values for the variables in the computer interface program. In addition to these interfaces, a central part of the Linkage Mechanism contains the information describing and controlling the display of the Expository Web and its Display Elements.

Once the Content Atoms and the Linkage Mechanisms have been designed, they may be ordered, although the ordering process may or may not result in a fixed sequence, depending upon the degree of learner control and other flexible features one wishes to allow for. The result of this ordering is the Web of Interaction.

The nature of this Web depends upon how the authors intend the Interacts to be used. This Web can be ordered using the same techniques used to structure a hypertext or hypercard network. With maximal learner control over a highly interactive lesson involving many independently-designed Interacts, the easiest and possibly the instructionally best way is not to create a Web of Interaction at all, but to give the student a list of the Interacts and allow him or her to construct their own individualized Web.

Alternatively, depending upon the Model of Teaching and the Instructional Design Model chosen, a very tight and complicated Web of Interaction may be desired, based upon variables such as the learner's cognitive styles and other learner variables. This is particularly true in Intelligent Tutoring in which a very detailed and sophisticated Student Model is used. Performance variables, content variables and knowledge structure variables may also be used here.

Here again, the INTERACT Model in its present state of development lets us down. No better method is available for structuring tight, complex Webs of Interaction than can be provided by hypercard design techniques or by the heuristic or intuitive approaches commonly in use.

Once the Web of Interaction has been created, the micro-design is complete. It remains only to produce the computer programs, graphics, videodiscs and other materials to be used in instruction. Once the micro-design has been completed, the INTERACT Model currently differs little from other models in use today. The instruction is piloted, revised, installed, supported and maintained.

Much of the interactive design aspect of the INTERACT Model have derived from current and recent work in intelligent tutoring (Wenger, 1987) and in attempts to design intelligent authoring systems for use in authoring intelligent videodisc-based CBI instruction. It is expected that much of the future development of the system will also be conducted in this environment.

Two things need to happen in the future. The INTERACT Model needs to be elaborated and field tested, so that currently-unanswered questions can be answered by the model. In other words, the present model still draws upon intuition, heuristics and personal experience for answers on how to design the videodisc and other interactive courseware at several points. It needs to be brought closer to being an algorithm.

The above statement is not meant to be a position in the argument concerning whether or not human designers follow algorithms in their own best work, or if instructional development as a human activity is itself algorithmic. But we do mean to suggest that we believe instructional development can be modelled by an algorithmic structure, at least to the extent that the model can be followed by a computer and eventually such algorithms can result in instruction as effective as the best that humans can produce. It follows from this that we are also arguing that algorithms can successfully represent non-algorithmic activities.

And the use of the model needs to be simplified. Completion of the two expert systems discussed earlier will assist in achieving this goal. But sooner or later, an authoring system, preferably an intelligent authoring system, will be needed to aid in such tasks as constructing the Linkage Mechanisms and describing the Web of Interaction. Some work has already been conducted by the authors at a Syracuse company called IntelliSys, which specializes in artificial intelligence, training and simulation, and at Case Center, a computer research institution associated with Syracuse University.

Hopefully, by pursuing the further development of the INTERACT Model and its implementation through expert systems and intelligent authoring languages, the problem of the systematic design of interact' e instruction eventually will be adequately dealt with.

Until this has occurred, the design of videodisc-based interactive instruction will remain an art form, and intelligent tutoring and intelligent CBI will remain experimental. While we are waiting for the ideal interactive design algorithm, it is hoped that the model for interactive design described here will help designers produce better interactive designs than they could do using intuition and conventional methods alone.

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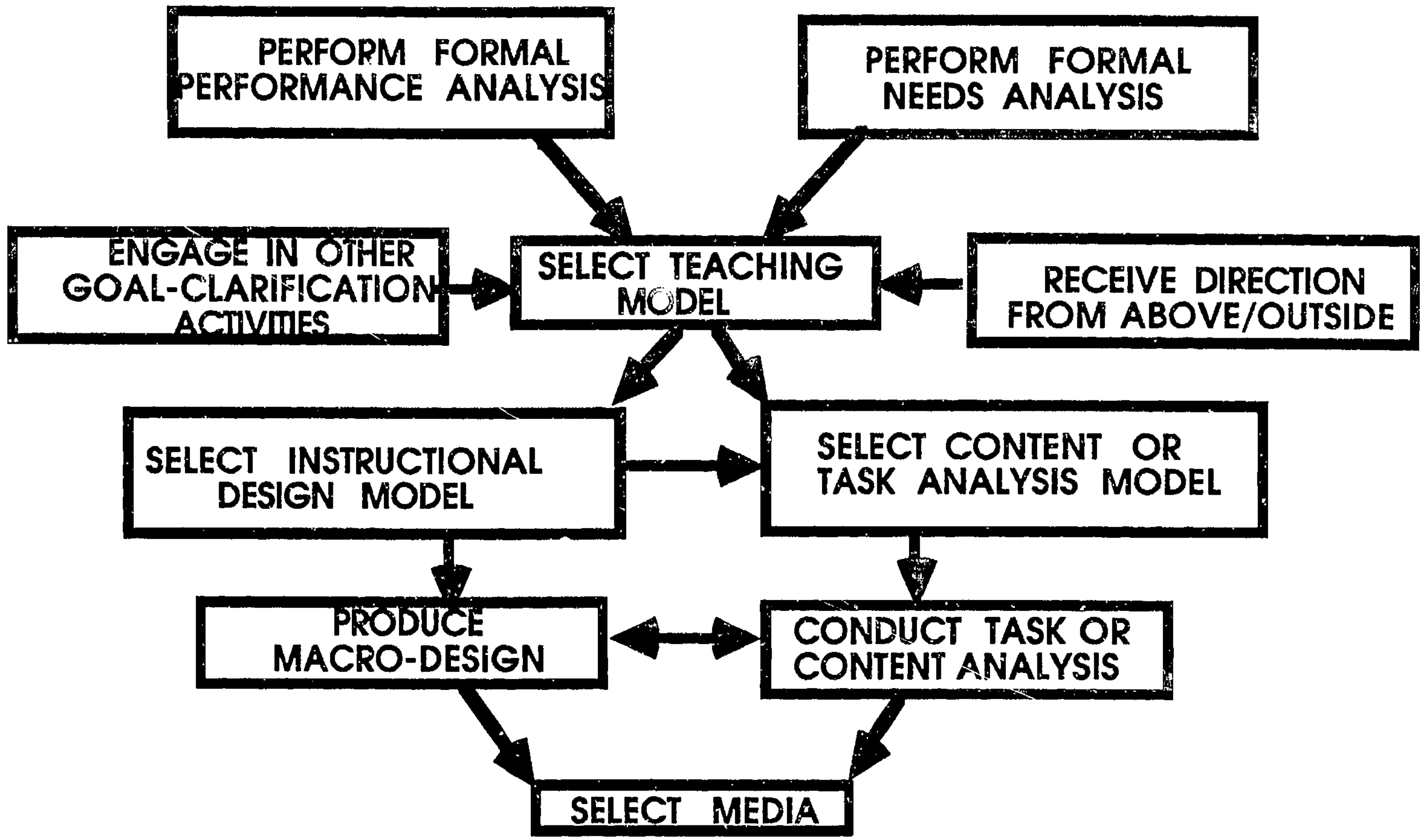

FIGURE 1
INTERACT MODEL

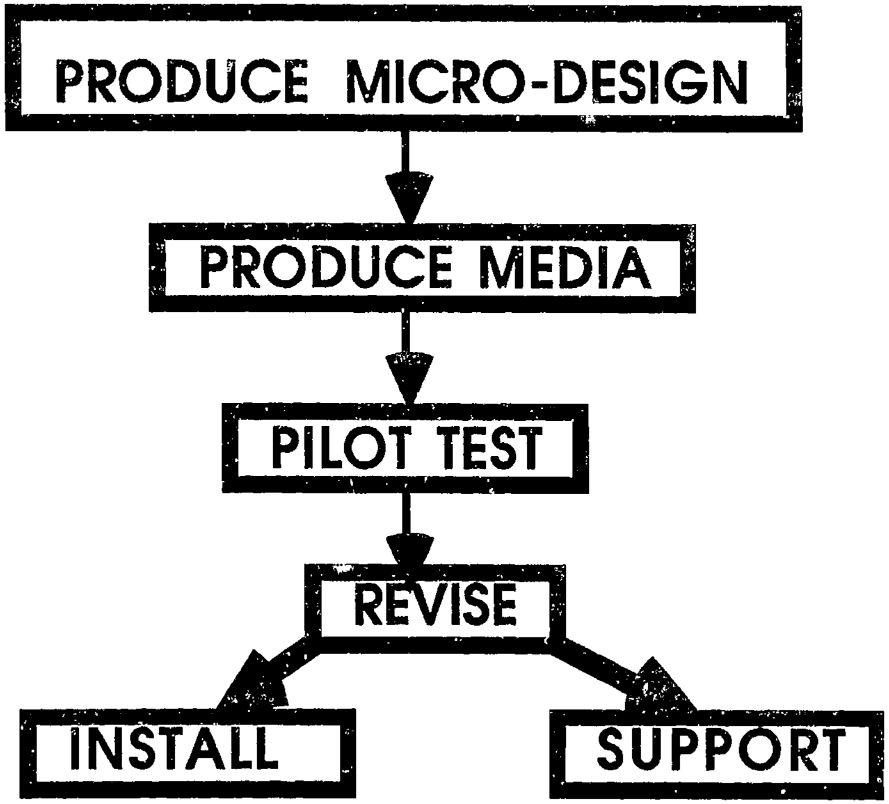

FIGURE 2
INTERACT MODEL

FIGURE 3 INSTRUCTIONAL EVENTS

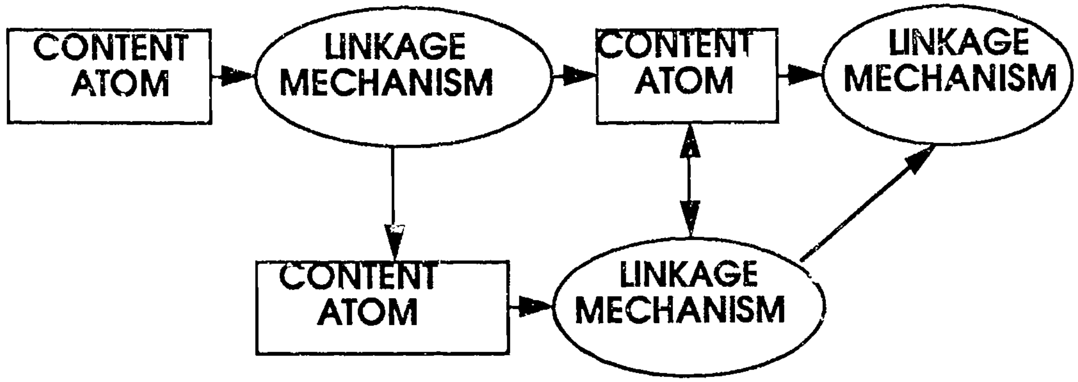

FIGURE 4

INSTRUCTIONAL INTERACTS LINKED INTO A PATH

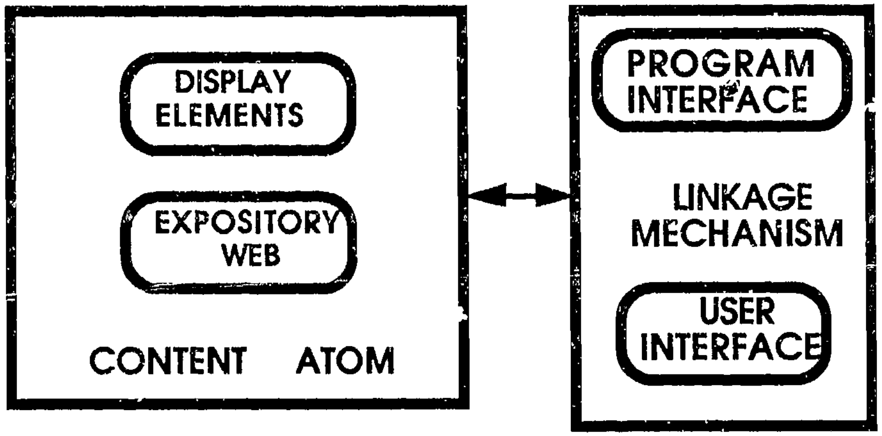

FIGURE 5

AN INSTRUCTIONAL INTERACT

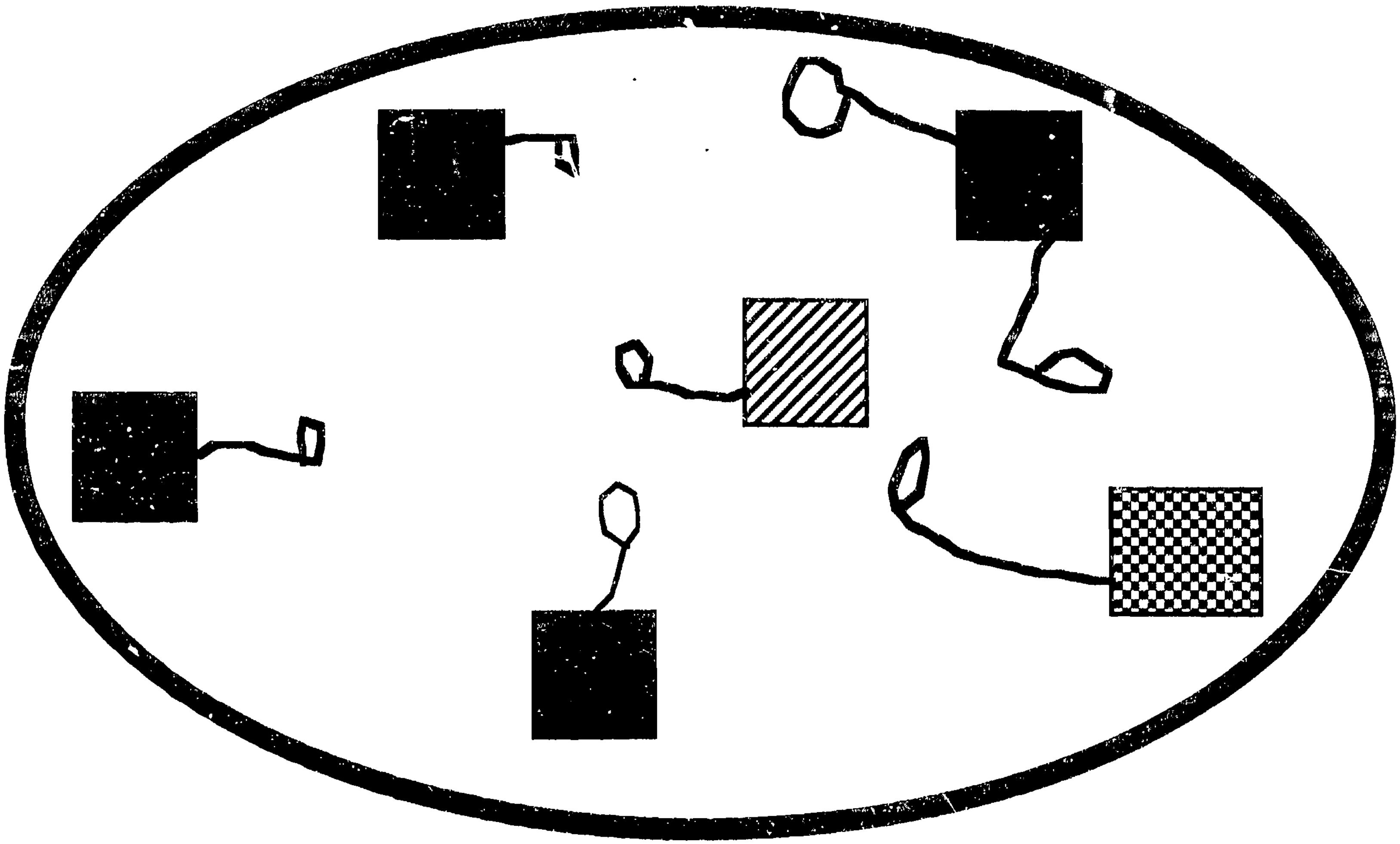

FIGURE 6
WEB OF INTERACTION
CONTAINING INSTRUCTIONAL EVENTS