PROCEEDINGS
Volume 1

Asia Pacific Information Technology in Training and Education Conference and Exhibition
28 June – 2 July 1994
Brisbane, Australia

Supporters


Australian Council for Computers in Education


Australian Computer Society

Australian Society for Computers in Learning in Tertiary Education

Japan Society for Computer Assisted Instruction


International Federation for Information Processing


South East Asian Regional Computer Confederation

Information Technology for Training and Education


Malaysian Council for Computers in Education

apitite 94

CONTENTS

Keynote papers

ACEC conference papers

apitite 94

Poster presentation abstracts

ITTE conference papers

ASCILITE conference papers

apitite 94

AUTOMATED INSTRUCTIONAL DESIGN AND DEVELOPMENT

M. David Merrill and ID$_2$ Research Group

Department of Instructional Technology

Utah State University

Introduction

What are the problems?

- Trained instructional developers are in short supply.
- ISD, especially for computer-based multi-media interactive instruction, is too labor intensive usually requiring more than 200 hours of development for a single hour of instruction.
- ISD is not adequate for computer-based multi-media interactive instructional development. It provides little guidance for interaction and it does not specify an adequate syntax for knowledge representation

What is the challenge?

- Reduce the development to delivery ratio by at least an order of magnitude -- from 200:1 to 20:1.
- Provide tools which empower subject matter experts to do effective computer-based multi-media interactive instructional development without requiring them to have extensive training in instructional design or authoring systems.

What is a possible solution?

Develop an intelligent instructional design environment with the following important features:

- It includes a built-in instructional design advisor.
- It provides guided knowledge acquisition (subject matter analysis).
- It automates much of the instructional development.
- It allows the user to override prescribed solutions.

This paper will describe and demonstrate the attempts of the Utah State University Department of Instructional Technology ID$_2$ research group to develop ID Expert™, an intelligent computer-based multi-media instructional development system.

Instructional transactions with built-in instructional design

The Gagné assumption

There are different kinds of knowledge and skill and each type of knowledge and skill requires unique conditions for learning. (Gagné 1985).

Learned performance is a function of engaging the learner in instructional interactions (conditions) which are appropriate for a given type of knowledge.

An instructional transaction shell is a computer program which encapsulates the conditions for a given type of knowledge or skill. An instructional transaction shell can be used over and over to teach different topics and even different subject matter domains providing the type of knowledge being taught is the same.

The computer program assumption

A computer program is an algorithm plus data. An algorithm is a procedure for performing some symbol manipulation task. Data are the symbols which are manipulated. Computer programs gain their power by being reusable, that is, the same program can be used over and over with different data.

It is assumed that an instructional transaction shell, a computer program which encapsulates the conditions for a given type of knowledge, is an algorithm. It is assumed that the subject matter (knowledge) to be taught can be decoupled from the strategy required to teach this knowledge. It is assumed that the subject matter to be taught are the symbols to be manipulated and represent the data part of the computer program. Therefore, a given instructional transaction shell (computer algorithm) can be used over and over to teach different knowledge (data).

What is a transaction?

An instructional transaction is a mutual, dynamic, real-time give-and-take between an instructional system and a student in which there is an exchange of information. An instructional transaction can be enabled by an instructional algorithm which is a pattern of learner interactions which promotes acquisition of a particular kind of knowledge or skill. An instructional transaction shell is a computer program which promotes a particular set of learner interactions which can be reused for different content topics providing these topics require the same kind of knowledge. An instructional transaction supports different kinds of instructional interactions including presentation, exploration, practice, and assessment.

Characteristics of an Identify transaction

We have described a number of classes of instructional transactions including identify, execute, interpret, classify, generalize, judge, decide, and transfer (Merrill, Jones & Li, 1992). We describe here some of the characteristics of an identify transaction.

An identify or naming transaction is modeled on paired associate learning from learning psychology. It enables the learner to acquire the ability to name, locate and describe parts of an entity. It encapsulates the following learning principles:

The learner is presented one member of a pair (A, B) and asked to locate, recognize or recall the other member of the pair. Adequate learning has not occurred until when given A the learner can provide B, or when given B the learner can provide A for every pair in the learning task.

Adequate learning has not occurred until the learner can identify a member of a pair when the pairs are presented in random order.

Adequate learning is facilitated when the pairs to be learned are chunked (grouped together) into meaningful groups each of which include only a few pairs.

Demonstration of an Identify transaction

Several multi-media interactive lessons illustrating the identify transaction will be demonstrated via ID Expert. The parts of the instruction which are built-into ID Expert will be discriminated from those aspects of the lesson which must be supplied by the designer. It will be demonstrated that the system is able to engage the student in presentation, exploration, and practice interactions using the same knowledge objects. The user was not required to specify any details of the interactions which were automatically created by ID Expert.

A knowledge base -- uncoupled subject matter

Knowledge representation

We previously stated the assumption that subject matter can be decoupled from instructional strategy and that knowledge (subject matter content) is the data to be manipulated by an instructional algorithm (instructional transaction).

It is also assumed that knowledge and skill from different subject matter domains can be represented with a common syntax or knowledge structure and that this knowledge structure can be detached from the instructional transactions required to teach this knowledge to a learner. It is further assumed that resources (multi-media representations including text, graphics, video, and audio) can be detached from the knowledge that they portray. We have previously described an *elaborated frame network* knowledge representation system (Jones, Li & Merrill, 1990).

Learned performance is a function of engaging the learner with an appropriate type of knowledge structure and appropriate representations of the knowledge or skill to be acquired.

Entity knowledge

In an elaborated frame network three types of knowledge objects are identified: entities, activities, and processes. An identify instructional transaction is appropriate for teaching the parts, location of the parts, and descriptions of the parts of an entity. An entity knowledge object is a device, object, person, creature, place or symbol. An entity knowledge object consists of several slots (knowledge elements) including a manifestation, a name, a location, a description and a demonstration. Each of these knowledge elements are represented by multi-media resources. A manifestation is usually represented by a graphic which illustrates the entity or part of an entity. Some entities may be manifested by other forms of multi-media representation including audio, video, and text. The name is usually represented by a text string or an audio name. The description is also represented by text or an audio description. The demonstration can be any multi-media representation including text, graphic, audio, or video.

A given knowledge object can have more than one manifestation or demonstration. The same knowledge object can be attached to different multi-media representations.

Demonstration of ID Expert - linking in new knowledge

ID Expert™ enables the user/subject matter expert to couple and uncouple knowledge from a given transaction by the click of a button. We will demonstrate how knowledge, which exists in the knowledge base, can be easily linked into an existing transaction and how knowledge can be uncoupled from an existing lesson. The knowledge exists in a knowledge base separate from the instruction and can therefore be coupled and uncoupled and reused without any additional development effort.

Demonstration of ID Expert - creating new knowledge

ID Expert™ enables the user/subject matter expert to easily create a new knowledge object independent from the transaction(s) which will use this knowledge object. ID Expert enables the user to link one or several resource configurations to the knowledge object. We will demonstrate the creation of a new knowledge object using ID Expert. The system includes the capability to call up multi-media editors to select, create or edi : resources for attachment to a knowledge object. Knowledge objects are created once and can then be reused as often as necessary. Once created the knowledge object can be linked to a transaction without any requirement to modify the existing transaction shell. The same knowled ge object can be used in different transactions. Because an knowledge object can have multiple resource configurations its appearance to the student may be completely different when it is reused in another transaction.

Automated instructional design -- parametized interactions

Parameters

Instructional transactions can carry out their responsibilities (interactions with the students) in a number of different ways. Instructional transactions are controlled by a set of parameters which determine how they carry out their interac tions. Changing the value of an instructional parameter changes the way that this instructional transaction interacts with the student. Parameter values can be changed by the user of the system or the system can automatically change the parameter values based on built-in rules for effective instruction.

The way a particular instructional transaction carries out its responsibilities is a function of the characteristics of the learners being served, the subject matter domain (knowledge) being taught, and the instructional environment in which the instruction is occurring. An instructional designer must adjust the parameters of an instructional transaction to best accommodate particular learners, learning tasks, and learning environments. An intelligent system, given information about learners, learning tasks, and learning environments can use its internal rules to automatically adjust the parameters of an instructional transaction to best accommodate particular learners, learning tasks, or learning environments.

Demonstration of instructional parameters

ID Expert™ is controlled by instructional parameters. We will demonstrate that parameters can be changed at the click of a button. We will demonstrate the reconfiguration of the resulting instruction when parameters are changed.

Demonstration of automatic configuration based on audience characteristics

ID Expert™ has built-in transaction configuration rules. We will demonstrate that when the user changes a learner characteristic (such as motivation or experience) by the click of a button that the transactions are automatically reconfigured to be more appropriate for learners with these new characteristics. We will also demonstrate that the user can override the automatic configuration by the click of a button.

Demonstration of reconfiguration based on predefined parameters

ID Expert™ enables the user to save course configurations. This means that a user can adjust the parameters and save as many course configurations as desired. The course can then be reconfigured by the touch of a button. With existing systems it is usually necessary to have

multiple versions of the course for different audiences. The required development time for multiple courses is very costly. With ID Expert such reconfiguration is available at the touch of a button. We will demonstrate the ability of ID Expert to reconfigure itself based on user defined configurations.

Automated instructional design -- interaction selection and sequence

A transaction manager

Learning goals or objectives are usually seen as a fundamental task of ISD. However, if knowledge is specified using a known knowledge structure (such as an elaborated frame network) then an intelligent system can contain rules for automatically generating the goals which are possible for a given body of subject matter knowledge. If the learning structure contains interconnections between knowledge objects and these interconnections are for known relationships, then an intelligent system can contain rules for automatically generating lesson and segment sequences appropriate for the knowledge to be taught.

A transaction manager has two responsibilities: first, to assign and sequence knowledge objects to lessons and segments; and second, to assign parameter values to configure the transactions and interactions to best meet the needs of particular learners, learning tasks, and learning environments.

Automated objectives

When the type of knowledge object and the elements of the knowledge object are known, then the system also knows what instructional objectives are possible. Statements of these objectives can be generated by the system and the user can select from the possible objectives those which are appropriate for a given course or lesson.

For example, if the knowledge object is a process, then the following objectives represent the range of skill that a student can acquire with regard to this process.

- recognize and name the events of the process.
- recognize a correct demonstration of each event in the process
- predict which events of the process will or will not occur under different conditions.
- predict which events of the process will or will not occur under different faulted conditions.

If appropriate knowledge has not yet been specified it is possible for an intelligent system to generate a list of possible objectives. When the user selects the desired objectives from the possible objectives then the system can guide the user to specify the knowledge objects and knowledge elements that are required to instruct these objectives.

Automatic selection and sequence of lessons

If the knowledge base contains appropriate elaboration of knowledge objects, then algorithms can be applied to select and sequence appropriate segments for a lesson and appropriate transactions for a segment. An elaborated frame network includes specified elaborations of knowledge objects. Every process owns event components; every activity owns step components; and every entity owns part components. Every process is owned by an entity and is defined as changing the properties of an entity. Every activity is owned by an entity and the

execution of the activity changes a property of this entity. The elaborated frame network specifies these association links, and the properties involved. The internal rules of the system defines a segment to teach a process which includes the following transactions: a transaction to enable the learner to identify the parts of the entity involved in the process; a transaction to enable the learner to enact each of the activities owned by the entity; a transaction to enable the learner to interpret the events of the process.

Automatic selection and sequence of strategies

Built-in strategy rules enable the system to configure the transactions selected by assigning appropriate values to the transaction parameters. Some of these parameters include the following: *transaction level* ranging from providing information about the process, a demonstration of the process, to allowing the learner to manipulate property values and see effects in a simulation of the process. *Transaction sequence* including an integrated presentation -- the presentation for each transaction is completed prior to exploration, prior to practice, prior to assessment; a segregated presentation -- each transaction is completed prior to the enactment of the next transaction; and learner control of transaction sequence --the name of each transaction is available on a learn-about menu that enables the learner to enact the transactions in any order. Interaction sequence includes a standard sequence -- presentation, practice, assessment; a remedial sequence -- assessment or practice first followed by presentation or exploration of content not at the criterion level; and learner control -- the interaction modes are available to the learner on a learn-by menu. Built-in rules automatically configure each of these strategy parameters, however, the parameters can be accessed by the user to override the built-in rules when the resulting instruction is judged by the user to be inappropriate.

Summary

This paper identifies some of the requirements for an intelligent computer-based multi-media interactive instructional development and delivery system. We have illustrated the following:

Instructional design principles can be built-into intelligent design/development tools for use by subject matter experts.

Intelligent instructional development tools can significantly reduce the development delivery ratio.

Intelligent instructional development tools can empower subject matter experts for better instructional design of multi-media computer-based interactive instruction.
