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Design and Formative Evaluation of a Prototype Hypermedia Program on Development of Hypermedia.

Laura Helena Porras-Hernández

A Thesis

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ABSTRACT

Design and Formative Evaluation of a Prototype Hypermedia Program on Development of Hypermedia.

Laura Helena Porras-Hernández

The design and formative evaluation of a hypermedia environment to be used as an instructional and research tool in Educational Technology at Concordia University are described. The content of the program is the design and production process of hypermedia for different purposes: (a) education and training, and (b) presentations. A prototype of the module on hypermedia for education and training was developed for the Macintosh environment. A description of the theoretical bases for the instructional and visual design of this module is included, as well as a multifaceted formative evaluation plan for the different stages of the design and production of a prototype for this module. Results from the evaluation of the storyboard by subject matter experts and a focus group, as well as improvements made to the prototype are presented. The prototype was evaluated by subject matter experts and end-users in terms of instructional design, visual design, learning impact (short-term and long-term retention), and satisfaction. Differences between experienced learners versus novices for the variable of learning impact are included. Suggestions for improvement and possible issues for further research using this system are discussed.

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Finally, I would like to dedicate this project to my parents, my brother and my sister, whose support and understanding have always helped me to achieve my goals.

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Introduction

The history of the introduction of new technologies to educational settings shows that as general public access to developing tools increases, the educational quality of the product decreases or it is simply overlooked by other disciplines (e.g., esthetic presentation) (Blum-Cohen, 1983). Although there are many causes for such problems two main factors can be identified.

First, a multidisciplinary development team approach is not used in the development of such materials. Professionals in the educational field do not get involved in the conception and production phases. Therefore, many of the materials developed for instructional purposes lack a solid grounding in educational and learning theories.

Second, there might be a lack of concern about the quality of the product that is being developed. Unfortunately, the lack of control over computer products for education is reflected in the production of programmes that do not enhance learning, do not accomplish the objectives for which they were developed (Marconi-Menéndez, 1989), or simply do not function properly (Feng,1990).

Another fact shown by history is that once new technologies are implemented, issues concerning education and learning are raised (Marchionini, 1990). Thus the characteristics of the new technologies and their claimed possibilities for enhancing learning determine a new spectrum of options for research, as well as an opportunity to implement evaluation strategies that can focus on the special characteristics of such media.

Antecedents and Problem Context

In the educational technology field, this decade has been characterized by the introduction of new technologies consisting of instructional environments that offer learners the opportunity to access information in different media formats via computer control. Furthermore, this multimedia access has been made interactive and the structure and functionality of hypertext has been incorporated to allow the user free navigation to different pieces of information, thus giving birth to the term Hypermedia. The special characteristics of this medium (i.e., the non-sequential access to information, the possibility of presenting it in different formats, and the greater amount of control and number of options offered to the learner), represent a challenge

for instructional designers who will have to follow a production process different from traditional CBT or CAI, in particular, in order to avoid the chaos that can result from too much learner control (Marchionini, 1988).

Bearing in mind the problems described above, the development of an effective and high quality tool that could both introduce Educational Technology students at Concordia University to the production process for hypermedia materials and at the same time serve as a research instrument for issues raised by this technology, was considered. Such a tool should make the user aware of the possibilities and limitations of hypermedia. Therefore, an immersion technique in a hypermedia environment was chosen to guide the user in the process of designing and producing hypermedia materials for different purposes: education and training, presentations and reference. Each of these purposes represents a module in the system

The programme is currently being developed by a multidisciplinary team. This team is formed by two undergraduate students from the Computer Science Department, three students from the Educational Technology master's programme, a graphic designer and educational technologist with experience in production of multimedia materials, and a project supervisor who is a faculty member of the Educational Technology Department, who has experience in managing multimedia projects.

Two educational technology students (the author included) are responsible for the instructional design and storyboarding of the module on hypermedia for education and training It is the design and evaluation of a prototype corresponding to this module, that is reported in the present study. The other educational technology student and the graphic designer have undertaken the same tasks for the module on presentations. The graphic designer also plays the role of design consultant for the team, providing feedback on the aesthetics for both modules.

Even though tasks are clearly defined, the design and production aspects of this particular project differ from traditional CBT and CAI development. A true multidisciplinary approach is being used, in the sense that all members participate at all stages of the process. They meet once a week and at the same time the storyboarding is being developed, production is occurring currently, program functionality is being tested by programmers and feedback is being received from the graphic designer. In this way, what is possible and advisable to do is immediately identified and included in the

storyboard There is a multidirectional communication process and the whole team takes part in the decision-making process.

Some of the specific characteristics of the programme are listed below

1) It is a problem-based environment that allows the learner to reflect, make decisions and go through the conception and production processes of hypermedia materials in a hypermedia environment

2) The user learns about the advantages and limitations that this particular technology encompasses by experiencing what it is like to work in such an environment.

3) The system is based on "anchored" learning It allows the learner to select a topic or scenario where hypermedia can be implemented and then subsequently work and interact with the program within the framework of this scenario. This is consistent with some of the principles associated with the notion of situated cognition, in which the learner builds up new knowledge associated to meaningful contexts (Clancey, 1992).

4) The system provides different degrees of learner control in the separate modules. The one on hypermedia for presentations allows the learner more freedom for creation than the other. In the module on tutorials, the learner will make her decisions based on interaction with knowledge bases already included in the system.

5) Different types of interaction are available throughout the decision-making process.

6) The learner is provided with help and hint facilities to assist in making her choices.

7) A set of special features that allow collaboration between the system and the student are provided. (e.g., working areas, icons representing important information, local help, navigation maps, glossary and reference sections).

8) Navigation patterns and the time spent by each student in each portion of the program, are recorded by the system

Purpose of the Study

The purpose of this study is to ensure the quality of the module on hypermedia for education described above, both at the validation (goal accomplishment) level and at the verification level (technical functioning) The impact of its content structure, visual design and learner control

possibilities on learning and satisfaction will be evaluated. Since it is a product that is still in a development phase, a formative evaluation can yield important data that should be taken into consideration during the final design of this module, as well as later, at the development phase of the whole system. Therefore, a multifaceted evaluation plan consisting of several stages has been designed. In fact, this type of approach has been suggested in the literature (Marchionini, 1990). The plan can be divided into two main phases: before implementing the prototype and after implementing it. The stages for each of these phases will be explained later in the procedure section of this thesis.

Premises and Limitations

Since the scope of this project does not cover the production of the whole system until its final state, but a prototype of one module only, it is assumed that the evaluation of this section is an initial phase in the quality control of the final product. Therefore, it is expected that other studies will continue with the evaluation process, deriving their plans and goals from the results and suggestions provided in this initial phase. If compared with other models of formative evaluation, it will be seen that the present evaluation is only a part of the whole process. However, it is assumed that a thorough evaluation at the beginning of the production phase will provide valuable information that may increase the success of the final product.

History and Characteristics of Hypermedia

In order to allow a better understanding of the instructional design of the module under study, a literature review on the history of hypermedia and the characteristics particular to hypermedia environments is presented.

History of Hypermedia

As suggested by Reeves, (1993) before any decisions on evaluation of multimedia materials are made, the first question to ask--in this particular case--is what is meant by hypermedia.

The term Hypermedia has been lately used to distinguish a particular category of applications from related systems that are associated with its origins. Several authors have drawn attention to the distinctions among these related terms (Nielsen, 1990a; and Ambron & Hooper,1990). Hypermedia differs from the general idea of multimedia presentations, in that the latter--which is also associated with the coordinated use of different media to present information--does not necessarily have to be interactive or computer mediated. A second term associated with hypermedia is hypertext; which in spite of the organization of information in meaningful linked nodes, does only involve text. Another term associated with hypermedia is interactive multimedia, which certainly includes interaction but does not necessarily involve the organization and access to linked information, as is the case with hypermedia.

As a matter of fact, the history of hypermedia is rooted in the just mentioned terms. The possibility of presenting information using a coordinated variety of media goes back to the times of lantern presentations (Galbreath, 1992). However, the possibility of having it stored in a big database with established links among various elements was predicted by Bush (1945) in his Memex machine.

In 1963 Douglas Engelbart from the Stanford Research Institute (Jonassen, 1989) published a paper concerning the possibility of augmenting human intelligence (especially symbol manipulation and mental structuring) and five years later developed the prototype of a system that allowed access to selected information from a database that included video and text. This information had a hierarchical structure, but it could also be linked in a non-hierarchical way.

Another significant figure in the history of hypermedia is Theodor Nelson (cited in Jonassen, 1989), who coined the term "hypertext" to designate a personal way of structuring information so that it makes sense to the user. He was also the one who established the basic methods of structuring hypertext.

As more advances in software and hardware allowed the development of these kinds of systems in personal computers, more people have been working on them and on their application to learning. At present a few names associated with hypermedia are: Jonassen, who has done research on the cognitive implications of using hypermedia; Nielsen who has done research on human factors and interaction in hypermedia environments; and Marchionini, who has done research on searching strategies.

Now that a very brief review of the history of hypermedia has been presented and that the term has been distinguished from related concepts, it would be useful to analyze the special characteristics that this kind of technology encompasses.

Characteristics Particular to Hypermedia Environments

Park, (1991) provides an explanation of the characteristics and functional features of hypermedia and contrasts it with other systems. He identifies three main characteristics: (a) it takes advantage of database structure, (b) it is a psychological representation of knowledge, and (c) it is a technical method for supporting interaction.

Hanfling (1989) identifies three basic characteristics of hypermedia, which he pairs with a related area of knowledge that supports it: (a) it simulates human cognitive processes by linking ideas (related to cognitive science), (b) users learn how to control the computer (microworlds), and (c) it can simulate an intelligent system (intelligent tutoring systems).

Marchionini (1990) also, mentions three main characteristics which he pairs with research issues that should be investigated for this technology: (a) access to information in different formats (access and searching strategies) (b) an enabling instead of directive environment (learner control), and (c) facilitation of interaction (collaboration).

Jonassen (1990) identifies the following characteristics of Hypermedia: (a) organizational structure formed of links and nodes related in meaningful

ways, (b) interactivity and dynamic control allowing different paths and collaboration, and (c) an authoring environment

From what has been discussed it can be concluded that the main characteristics of hypermedia are:

(a) it allows the learner access to information in different formats, giving her control of the form of presentation

(b) it establishes connections among those pieces of information, allowing the learner to browse along different paths and structure the sequence according to her own needs and preferences.

(c) it is an interactive environment mediated by the computer in which collaboration between human and system, or among humans and system, is established.

(d) it can be used as an authoring environment for computer mediated instruction.

As will be discussed next, these special characteristics determine some specific procedures for the design and formative evaluation of hypermedia products, and they also have implications for research issues to be considered.

Design and Production.

Having presented the context, the rationale and the general characteristics of the system under study, as well as the main features of hypermedia systems, the instructional design, visual design and production of the module are discussed in this section.

Instructional Design

Considering the non-linear access to information characteristic of hypermedia, most of the reports concerning design for this medium concentrate on the problem of structuring and presenting information (Jonassen, 1986; Marchionini, 1988, Spiro, 1991). The few reports on instructional design models for hypermedia development are general and do not provide prescriptive guidelines; therefore the approach used for this study was an eclectic one.

A combination of the twelve point system/strategy specification profile used by Romiszowski (1988) and the seven components of Morariu's (1988) model for hypermedia design was used as a guide for the design process. Nevertheless, other instructional design theories were utilized in decisions made at more specific levels.

Purpose. In accordance with the general objective of the system, the purpose of this module is to allow the user to experience the process of design and development of a hypermedia product for educational purposes. In accomplishing this goal, the role of the system is to serve as a tutor, guiding the user in the decisions she has to make at each step of the process.

User characteristics. The end-users are students from the Master's program in Educational Technology at Concordia University. Students in this program come from different domains and therefore may or may not have experience with computers or instructional design. However, it is assumed that they have little or no knowledge of the tools and technologies particular to hypermedia production, and that they are interested in the design and development of instructional materials.

Considering the learners' different levels of experience, and given the results of studies on the differences between experts' and novices' knowledge

structures (Perkins & Solomon, 1989, and Duffield 1991), hypermedia -- due to its flexible access to pieces of content -- an adequate medium for presenting information to this kind of learner.

A major issue to consider when designing the module was to ensure flexibility, thus allowing the user to explore in depth the topics that were new for her, and skip the ones that she already knew. Support for understanding technical terms was provided by a glossary and a list of relevant references. Both features are accessible at any point in the program.

Other issues to consider were language level and pre-requisite knowledge. Vocabulary used at superficial levels of the program is simple and straightforward, more technical terms are introduced at deeper, more detailed levels. In order to make sure that the user has the pre-requisite knowledge necessary to access deeper information, certain entry points were identified at the upper levels of the structure, thus restricting access to hierarchically related information.

Content. The content of the module was determined through a literature review conducted by the two instructional designers responsible of the module. Considering that the module addresses a procedural type of knowledge, the main phases of the process were identified, as suggested by Dick and Carey (1991). The next step, following Jonassen's model (1986), was to identify the key concepts for each phase, categorize them, and establish the relationships among them (See figure 1).

One of the main problems in evaluating hypermedia systems, where the learner is in control of the sequence of instruction, is that each learner covers different content (MacLellan, 1993). The module was organized in different layers or levels (See figure 2). The first levels are entry points to any deeper content and they represent the nodes that are accessed when the program is used in a linear way. Therefore, they constitute the minimal content to be covered by the user. Bearing this in mind, a specific instructional goal comprising these superficial layers was determined for each of the phases:

Figure 1 . Detailed Content Structure

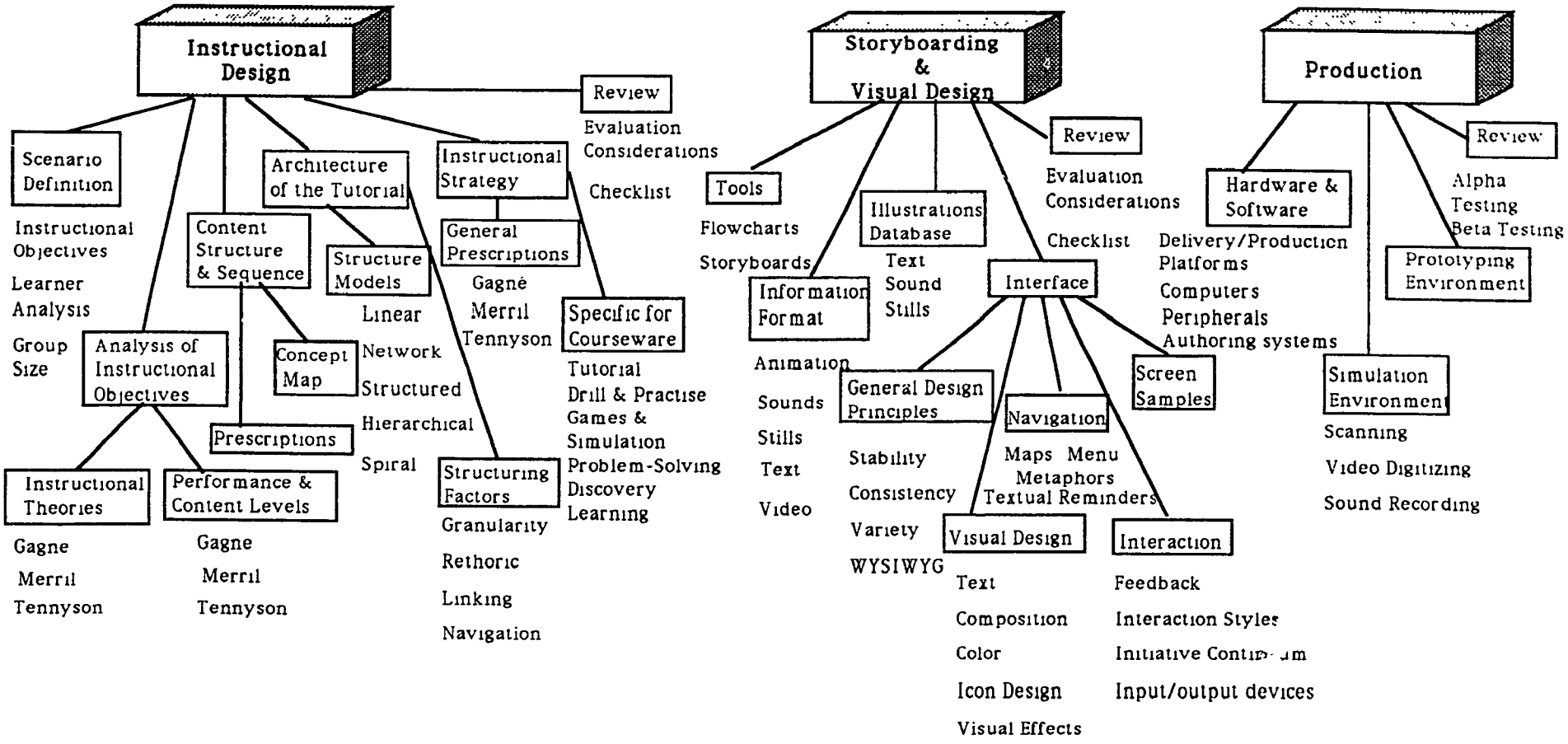
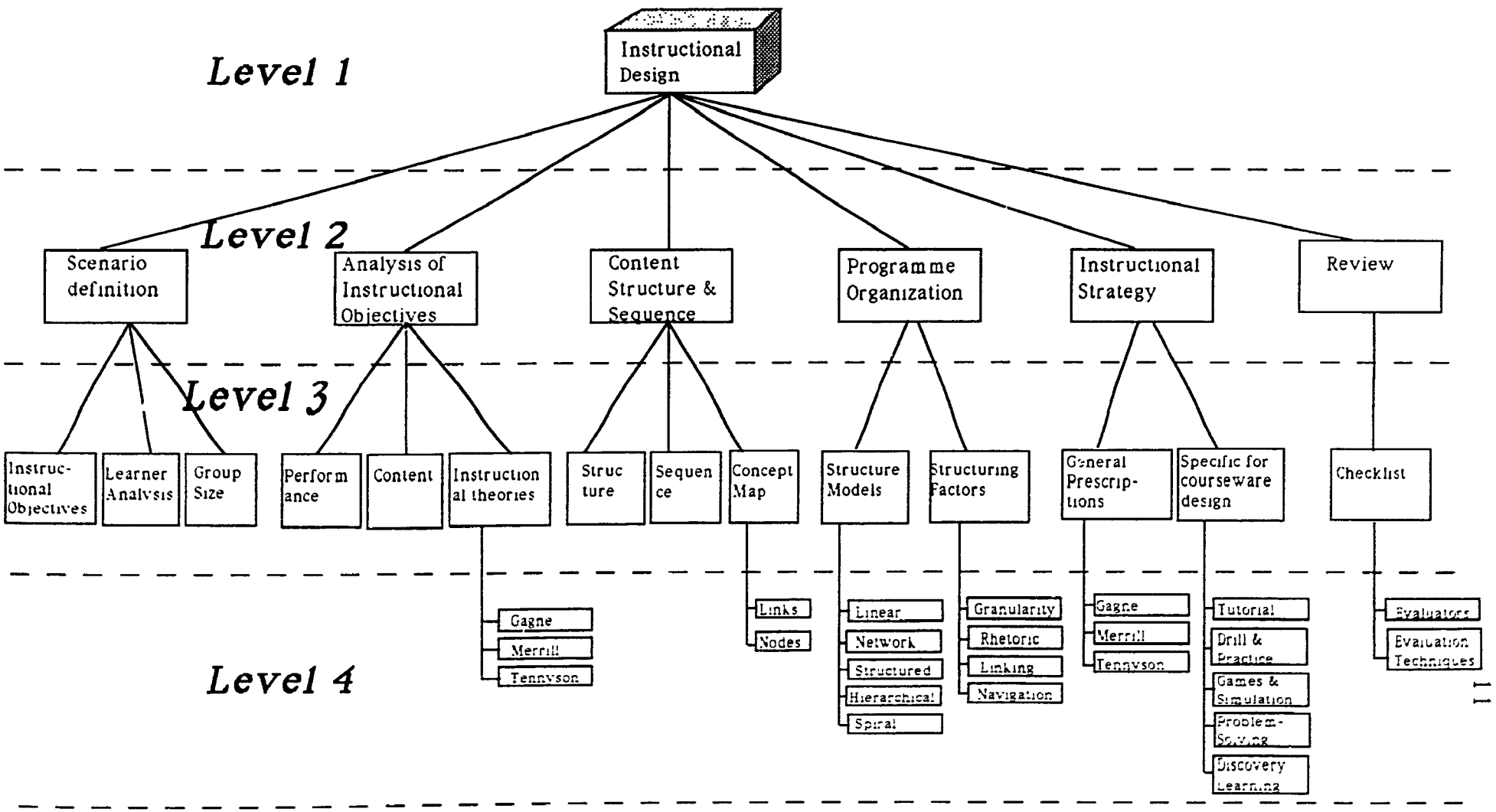


Figure 2. Example of Levels of Content Organization



(a) At the end of the Instructional Design portion of the module, the learner will be able to define the strategy, content structure and appropriate architecture of her product according to a chosen instructional objective. Decisions are based on instructional design theories.

(b) By the end of the Storyboarding and Visual Design phase, the learner will be able to identify the key principles for functional and aesthetic design as well as the best format for illustrating the content. For this purpose the learner will have access to the theory behind these issues; moreover, she will be able to apply the principles by selecting illustrations in different formats from a database.

(c) The Production phase is intended to give the learner the opportunity to:

(1) be aware of the hardware and software available for hypermedia production.

(2) experience simulations of image scanning, sound recording and video digitizing in the Macintosh environment.

(3) develop a simple prototype (twenty screens maximum) where she can edit text, images and sounds and specify links among cards.

At the end of each phase a checklist is provided to make the learner aware of the need to conduct formative evaluation of intermediate products -- instructional design, storyboard, prototype -- as well as testing and summative evaluation of the final product.

Instructional strategy and mode of use. In accordance with the purpose of the model, the performance objectives and the learner characteristics, the instructional strategy is that of a tutorial that guides the user along the phases involved in the process of design and production of an instructional hypermedia application. The user takes an active role and is able to act at three different levels: (a) decision-making, (b) exploration, and (c) simulation.

The whole system is based on "anchored learning". Researchers using this approach have emphasized the importance of choosing interesting, and rich anchors (Young, 1993, The Cognition and Technology Group, 1990, and Bransford, 1989). In the case of this system, rather then providing one anchor, the user is able to select variables to define a learning situation. She works with the situation throughout the whole process, making the necessary

decisions for the design and production of an instructional hypermedia product. Information and feedback to support those decisions are provided by the system. Even though no evaluation of knowledge is embedded in the program, any decision made can be self-evaluated and changed by the user

Theory behind each particular step can be explored by the user, who has access to a database of information that can help her in making an adequate choice.

Considering the hardware requirements, some production skills are developed through simulations (e.g., video grabbing, scanning, and audio digitizing). Other skills, where only software is required, can be practised by branching to the actual applications. Examples of these are text and graphic manipulation. Access to a database of scanned images, sounds, animation and text, which can be cut and pasted, completes this process Thus, the learner is able to author a small project in a very simple environment provided by the system. The fact that at any level the user is engaged in creating an artifact according to her interest ensures a constant interactive process (Thompson & Jorgensen, 1989).

The ease of use of the program is supported by on-line and off line features, which ought to be helpful for novice hypermedia users (Marchionini, 1988). A local help is available to provide technical instructions in case a user does not know what to do on a particular screen. A glossary of terms and related references can be accessed at any point in the program A navigational map displaying the nodes of the program can be accessed from any topic corresponding to the first level of the map, and an electronic trace and bookmark allows the user to terminate a session and then, subsequently, resume from the point where she left off. Off-line materials include a short documentation package to facilitate the use of the program (See appendix F)

Structure. Although, at a first glance, the content seems to be hierarchically structured, due to the relationships between some concepts and previous knowledge, it is not a pure hierarchical organization Branching from the main linear sequence in a vertical direction to access this additional content, the user progressively elaborates her decisions

Node size. The content map presented in figure 1 represents the nodes of the program; however, each node may correspond to more than one card in

the program. This is a valid strategy in cases where examples and supporting explanations are provided (Jonassen, 1986). Nevertheless, none of them includes more than three cards. This is an important design feature intended to prevent the user from getting lost in the content (Marchionini, 1988, Locatis et al, 1988).

Links between nodes. One of the major problems in hypermedia is deciding when and where to provide links, ensuring flexibility, yet not leaving the user in full control of the sequence (Locatis et al, 1988). The criteria used to establish links in the module were the strength of the relationship between concepts, the need for freeing the user's working memory (e.g., providing access to previous choices and suggestions) (Lajoie, 1990), rhetoric in the presentation of information, and pre-requisite knowledge. According to these criteria, links were established, as well as some restrictions to access some nodes.

Network representation. The user is provided with a dynamic model of the network (see screen examples provided in appendix G) that identifies the topic she is in and provides access to other nodes at the entry points determined according to the criteria described above. This network is accessible from any topic at the second level of the map, and is supported by a static representation on paper which is given to the user as part of the program's documentation package.

Navigation. The user is able to follow the process in a linear way or directly jump to any of the phases she is interested in via the navigational map. Other options for accessing detailed contents are provided by hypertext or sensitive areas in illustrations. This additional information is displayed in different ways according to its complexity and its source -- either hypertext or sensitive areas:

(a) balloons for small pieces of information associated with illustrations.

(b) overlay windows when only verbal information is associated with hypertext.

(c) full screen windows when verbal information plus illustrations are provided. These screens have the same interface characteristics as those encountered at the main level.

All the navigational styles provide variety for stimulus change necessary to gain and retain students' attention (Gagne & Briggs, 1985) as well as to involve the student in different interaction styles with the content (Miller, 1988).

A support for navigation is provided on-line in the form of local help that provides instructions to interact with the program in particular screens Another way of facilitating navigation is by implementing automatic branches at some points. An example of this is the checklist, where the user evaluates her choices by marking whether they need to be modified or not. If a decision is to be changed, the program branches the user to the particular screen where the choice was made; the new decision is made and the user is sent back to the checklist.

Intelligent information is provided in the form of feedback according to the user's choices in relation to her own learning scenario For example, if having chosen children as her target audience the user chooses a very complex illustration for one of the screens of her prototype, the system will indicate the reasons why that choice is inappropriate, and will suggest to her that she should change it. As discussed before, knowledge is not evaluated, and it is left to the user's discretion whether to alter her choice or not according to the feedback received.

Media needs. Considering the interactivity needed for the content and strategies described, hypermedia was selected as the most appropriate medium. Besides the possibility of adapting to users with diverse levels of experience on the topics, its integration of information presented in different formats allows the user to experience hypermedia both as user and as designer.

The program comprises information presented in the form of text and graphics at the main level; audio and text for the help facility; and animation, motion video, and scanned images for deeper levels and examples All of these elements are integrated in one delivery platform.

Authoring needs. The authoring needs for the final system will be the same as the ones used in the case of the prototype. The prototype was developed on a Macintosh Quadra 700 using SuperCard v.1.6 as the authoring tool. The hardware platform was selected for development as well as for delivery because the available memory allows rapid and easy manipulation of

images, sound and animation SuperCard was selected because of its capability to use color and build sensitive areas with different shapes, its facilities to build windows, keep a trace of students' paths and integrate external applications. Supporting applications for authoring were also used. Scanned images were processed through Photoshop. Video frames were captured using a VideoToaster on the Amiga Platform, transferred to IBM format and then finally converted to Macintosh files. MacroMind Director and Quicktime were used for playing back some animation and video sequences. Finally Hypersound and SoundEdit were used for the recording of audio.

Regarding the delivery system, a fast Macintosh computer --ideally a Quadra 700, like the one used for production as a minimum -- with a color screen, a mouse and a keyboard is needed. No external peripherals are necessary, since simulations for external hardware are provided within the system.

In terms of software, the final product will be a stand-alone program. However, the prototype requires SuperCard v1.6 and MacroMind Player as support software to run. The prototype consists of one controller stack, a glossary stack, and seven animations. All of them can be stored in compressed form on five $3^{1/2}$" high density diskettes.

Evaluation approach. The prototype was tested by the members of the development team and a formative evaluation plan was developed to ensure its quality. This plan is discussed in more detail in the methods chapter (see figure 3, page 31). It included an evaluation of the storyboard for the whole module (information which was used to improve the prototype) and an evaluation of the prototype by end-users and subject matter experts. The variables considered were: knowledge, learner satisfaction, instructional design, visual design, and technical design. Information obtained through this evaluation will serve to improve the development of the final system, which will again be evaluated through formative and summative methods, once it is produced

Characteristics particular to the module. Besides these peculiar characteristics of the instructional design process, there are some features particular to the module itself. It is different from an authoring environment for educational materials (Lam & Chang, 1992) in that it is a tutorial dealing

with how to design and produce a hypermedia program using the most appropriate tools, whatever they might be in each particular case It is also different from expert systems that provide prescriptions concerning instructional design (Merrill, 1987; Pirolli & Russell, 1990; Wilson, & Jonassen, 1990/91) in that the tutorial is specifically for hypermedia design and in that it goes beyond the design phase to encompass the production stage and even embed considerations for formative evaluation.

Visual Design

The selected topic for the prototype was the Instructional Design phase of this module (See figure 1). The style of the program is very direct and intends to create a comfortable working and exploratory environment Considering the importance of a consistent and transparent interface design, the visual design of the screens are based on three basic areas: (a) a conversation box, (b) a working area, and (c) a navigational area (see screen examples in appendix G).

The conversation box is an area where information about the content, links for hypertext and operating instructions are presented Considering that colour can be a useful tool to facilitate the distinction among elements (Faiola & DeBloois, 1988), these three types of information are colour coded. Content information is presented in black, while hypertext is presented in a pink colour to give the idea of a Hotpoint, as opposed to the blue cold colour used for operating instructions.

The working area is the most extensive of all. It is a space where the user is able to interact with the content by making choices, exploring theory, and running simulations or animations. In accordance with findings regarding the importance of graphic interfaces and direct manipulation for the design of learning environments (Hutchins, Hollan and Norman, 1986), it includes objects with 3-D effects to give the sensation of space and invite the student to manipulate them. Such manipulations help the student attribute meaning to the interaction, thus facilitating retention and knowledge construction (Vacherand-Revel & Bessiere, 1992).

This working area disappears in some hypertext screens and overlay windows at deeper levels, where information is provided only. However, since it has been proven that the semantic content of visually presented information is accessed more rapidly than text by inexperienced learners

(Pezdek, cited in Mayes, 1992), this design is consistent for all screens at the main level, which represents the minimal content all users will access.

The navigational area presents all the buttons to navigate through the program and to access special functions. The icons were specially designed for the program. Wherever the meaning of a graphical representation was not clear words were used to facilitate comprehension. The navigational buttons are represented by arrows which give the user the idea of where she can go next in the map structure. This strategy follows the spatio-temporal model suggested by Vacherand-Revel and Bessière (1992) that allows the user to orient herself and act as an active agent in the program. Space orientation is also supported by transition effects from screen to screen according to the dimension in which the learner moves in the map.

Production

The definition and sketching of the content for the whole project, including the second module in the program (i.e., hypermedia for presentations) was completed in two months. The product was a map of the content nodes and their links, thus defining the structure and sequence of contents. As described before, the production team met once a week to present the work done and to discuss the feasibility of what was being planned. A rapid prototyping approach was used in the sense that many production tasks were being performed even before the storyboard was finished (Tripp and Bilchemeyer, 1990). Programmers tested required functions and developed some screens for evaluation during this phase.

The production of the storyboard for the three sections of the module on hypermedia for education and training was developed in one month of full time work by the two instructional designers, the author included. The author was responsible for developing 75% of the first section, 15% of the second section and the entire third section.

The first chapter of that module was selected to be developed as a prototype of the whole program. The facilities from the Education Department at Concordia University were used for production, thus reducing production costs. The availability of different platforms facilitated the use of already existing material that was identified and collected from libraries, as well as materials developed by other students in the department, which, with their permission, was digitized and incorporated into the program. This phase was

completed in a month of full time work by the two programmers and the author. Alpha testing was conducted by the programmers and instructional designers during a two-week period, resulting in the necessary technical adjustments. Two more weeks were dedicated to reviewing minor visual and rhetorical details by the instructional designers and the project manager. A formative evaluation of the product with subject matter experts and students was then conducted by the author.

The next chapter discusses some evaluation issues for hypermedia systems, followed by the evaluation method used in this particular study.

Formative Evaluation of Instructional Software

The present chapter discusses some models and techniques for the formative evaluation of instructional software and presents some research issues concerning hypermedia systems.

Need for the Formative Evaluation of Instructional Software

The benefits of formative evaluation in the production of materials for instruction are not new. Their value was recognized at the beginning of the century when film productions were used for educational purposes. Lashley and Watson (in Cambre, 1981) conducted a formative evaluation study in 1921, field testing a sex hygiene film with different groups and with subject matter experts. This study demonstrated the need for quality control in educational productions. According to Cambre, the authors asserted the value of this kind of approach for reducing production costs, assisting designers to produce more effective products, and allowing school administrators to choose good educational materials.

In the evaluation of products, the same problems have been faced by the production of programmes for various kinds of media. Even though numerous studies proving the benefits of pilot testing have been conducted, the same story seems to be recurring. Baggaley(1986) discusses how formative evaluation can provide accurate and timely information to television producers to modify productions before spending their budget on something that will not have the expected effects. For computers Owston (unpublished) has proven the importance of field testing software before it is put on the market, in order to have better quality products. The problem of having lots of bad quality software in the market has been addressed by Marconi-Menéndez (1989) who, after evaluating mathematics software produced for the blind and partially impaired, found that they did not help the student accomplish what they were supposed to accomplish She suggests the use of formative evaluation to ensure quality.

One of the benefits of formative evaluation that goes beyond the specific needs of designers, teachers and students is the possibility of building databases that can serve for other designers to review what has been produced and evaluated and to consider this in their own productions. Examples of this are databases containing evaluative information on software maintained by

organizations such as MicroSift, The Educational Products Information Exchange, and the Council of Ministers of Education in Canada (Duchastel, 1987).

Formative Evaluation Models

Different models have been developed for the formative evaluation of educational materials. Some of them will be discussed briefly, since there is not one model that could be identified as ideal, and models, methods and evaluation techniques have to be adapted according to the goals of the evaluation process (Knussen, 1992).

Ragsdale (1982) reviews three common models for evaluation:

(1) The discrepancy model is based on the differences that exist between expected standards and actual performance. It consists of five steps that are implemented during different phases of the development and trial of the material: programme description, implementation, achievement of enabling objectives, achievement of terminal objectives, and comparison of the experimental programme with an alternative.

(2) Stake's model is based on the degree of congruence between three important elements: antecedents, transactions and outcomes.

(3) The TICCIT model for courseware evaluation consists of five stages: (i) experts' review for content accuracy and excellence, instructional psychology and message design. (ii) Debugging: trying the product with skilled and critical students. (iii) Field trials with at least 20 students for text displays and lesson segments. (iv) Field trial with at least 20 students at the actual implementation site. (v) Field tests at different schools.

Dick and Carey (1990) divide the process of formative evaluation into three phases: (1) One-to-one evaluation, which has the benefit of letting the designers know the flaws of their product, thus facilitating changes. (2) Small group evaluations that allow designers to see if the changes made after the one-to-one evaluation were appropriate or not (3) Field tests, which allow the designers to see how the product works in the actual setting for which it is intended and make any necessary changes to harmonize the product with real situations.

A similar proposition, applied specifically to software evaluation, has been made by Reiser and Dick (1990) and the model itself has been evaluated. Gill and Dick (1992) found that the teachers considered the model very useful

to evaluate the materials they were developing; however, it was time consuming and a solution was to eliminate the small group evaluation.

Schwarz and Lewis (1989) suggest an evaluation system for educational software consisting of three stages. The teacher reviews the documentation first, then reviews the application and finally the students try and evaluate the software. They collect their data in the form of a checklist that has proven to be consistent for both categories of end users --teachers and students.

Formative Evaluation Techniques

Several reviews of evaluation techniques comparing their characteristics, advantages and disadvantages, have been conducted. One of them is presented by Duchastel (1987) (see table 1).

Table 1.

Evaluation Techniques Discussed by Duchastel (1987)

Technique	Characteristics	Advantages	Disadvantages
Product Review	Done by anyone familiar with educational software. Contrast with previously seen instructional packages Provides feedback to producer	Time saving	Subjective
Checklist	Rating of a product along various dimensions	Systematic measure Several evaluators can use it	Limited Needs predefined standards
User observation	Observation of students interacting with software	Reactions are recorded Effectiveness and efficiency of learning can be measured	Time consuming Needs a large sample to overcome individual differences

Another comparative review of the different evaluation techniques has been presented by Knussen et al. (1991) (See Table 2). She stresses the importance of selecting the technique according to the evaluation goals, the kinds of variables that should be measured, the contextual limitations, and the intended use of the results.

Table 2.

Evaluation Techniques Presented by Knussen et al. (1992)

Technique	Characteristics	Advantages	Disadvantages
Systematic Observation	Predefined goal Limits information Stable and replicable results Objective recording and analysis Instruments are Checklists, event recording and time sampling	Objective Minimal interpretation Convenient to identify flaws	Time-consuming Limited to what is predefined
Naturalistic Observation	Not goal oriented Records what happens	Identify unexpected outcomes Identify side-effects Identify points to pursue in depth	Difficult to record Difficult to analyze Amount of information
Self-Reported Measures (Attitudinal Scales)	Closed items A position has to be taken	Efficient way to record attitudes Saves time compared to Interviews	Misses unanticipated information Reliability
Interviews	Set of questions to elicit oral information from the subjects Can be structured or open	Provide deep information Clarification can be done Provide complete and reliable data	Costly Time-consuming
Questionnaire	Set of written questions Can be closed or open-ended Range of questions is predetermined	Applicable for large samples Saves time Less expensive than interviews	Focused information Difficult to control understanding of questions
Automated Measures (Monitoring, Tracing)	They are unobtrusive Built into the programme	No experimenter effect Highly reliable and detailed	Does not record why a specific action is taking place Can lead to misinterpretation

Technique	Characteristics	Advantages	Disadvantages
Psychometric tests	The content should reflect objectives of evaluator and material Items vary in degree	Reliable Valid Some may be applied to large samples	Can be difficult to interpret Can be time-consuming

Nielsen (1990b), focusing specifically on hypermedia, also provides some suggestions concerning the kinds of techniques and measurements that should be used for each of the parameters he suggests should be considered when testing the usability of a hypermedia product. This information is also presented in table 3.

Table 3.

Usability Parameters and Types of Measurement Presented by Nielsen (1990b)

Parameter	Type of Measurement
Easy to Learn	Answering time Time taken to achieve objective
Efficient to Use	Time spent in answering Number of remembered concepts Essays scored by judges
Easy to Remember	Observations (Not well developed)
Few Errors	Error frequency at different time intervals
Pleasant to Use	Lickert or Osgood attitude scales Preference compared to other materials

Criteria for the Evaluation of Instructional Software

Table 3 presented some of the criteria that Nielsen considers important in the usability of a hypermedia programme. Various instruments--mainly questionnaires and checklists--specifying the criteria that should be taken into consideration to evaluate instructional software are described in the literature. Table 4, presented below, summarizes these criteria.

Table 4.

Comparison of Suggested Criteria for Instructional Software Evaluation.

Author	Criteria Used
Blum-Cohen (1983) She proposes a Yes/No Checklist to be used by students and teachers.	Curriculum Use Mode of Interaction Sequence Text Format Graphics Cues and Prompts Animation Manual User Control Management Feedback Record Keeping Alter content Packaging Random Generation Quick Response
Rothe (1983) He focuses on social issues	Language Use Knowledge Ideology Marketability Cultural tastes Ethics (Values)
Duquette, Ch. (1985) She developed a questionnaire consisting of Lickert scales and open-ended questions for these eight dimensions.	Objectives and Pretesting Content Questions posed Post-test Instructional Supervisor Technical Aspects Workbook General
Council of Ministers of Education, Canada. Suggests guidelines for reviewing software by teachers and experts along several criteria. It is based on comments rather than closed or open-ended questions.	Objectives Pedagogical Content Scope, Sequence, Depth, Accuracy, Bias, Readability Instructional Format Interaction, Questioning technique, Feedback, Evaluation, Branching, Types of Control Technical Design Screen displays, Colour, Sound, Ease of use Implementation Support Ease of implementation in class, Management System and Summary
Scheckler and Shuell (1989) They review different instruments and criteria used for software evaluation and create four categories for the criteria found.	Fundamental characteristics Instructional Concerns Social interactions, User orientation, Pre-requisite skills, Objectives, Content, Teaching style, Presentation, Appropriate use. Principles of learning and teaching Teaching, Motivation, Feedback, Record keeping, Cognitive level, Evaluation methods. Overall Rating

Author	Criteria Used
Tolhurst (1992) Suggests a checklist encompassing the general criteria for computer-assisted instruction, and special features particular to hypertext and hypermedia.	Implementation Considerations Special peripherals for presentation or storage Documentation and Packaging Provision of maps with links Description of branching techniques (binary, probability) Classroom Management Path can be recorded, and printed Facility for students notes Curriculum considerations Encourage guided discovery learning, Appropriate words for links User Interface Adequate level of learner control and guidance, Navigation aids, Provision of different contexts of use, Appropriate style of navigation for audience

A combination of these criteria, with an emphasis on instructional issues, was used for the evaluation form used for the prototype evaluation.

Research Issues Raised by the Utilization of Hypermedia

The characteristics mentioned have also lead to some suggestions concerning research for instructional uses of hypermedia Most of them focus on the need to know more about the effects of learner control both for preferences in the presentation formats and for sequence of presentation. Thus Park (1991) suggests investigation of learner control principles and search strategies, as well as research on information representation forms and the use of intelligent hypermedia that can generate knowledge and which can interpret natural language.

Studies on the effects of the amount of learner control on learning for high and low skilled students (Ross & Morrison 1989) have shown that too much control can lead to less learning. According to their research this is even more remarkable in low ability students, who easily get lost in the system For high ability students there do not seem to be very predictable outcomes since some of them benefit from more control whereas others do not. Therefore, the differences between experienced and novices in content and medium was considered interesting to analyze in this study.

Some research has been done by Marchionini (1989) on the searching strategies exhibited by children, pointing out the need for hypermedia literacy so that full advantage can be taken from the system characteristics In fact, he stresses the point that some of the limitations and problems are that too much freedom can lead to chaos because of disorientation, distraction and the effects of visual characteristics (Marchionini, 1988) The latter are related to cultural variables: different learners attribute different meanings to the same graphical representation. He agrees that learner control and searching strategies are main issues in research for this type of technology, but he also adds the need to investigate further the interaction patterns that it facilitates, both human-machine and human-human, when using the systems in pairs (Marchionini, 1990). The study of patterns of interaction with hypermedia system can be easily studied by implementing tracing facilities and organizing the content in well defined categories. In the present study an attempt to capture patterns of interaction for an analysis was made

Certainly one of the main issues in hypermedia systems is the need to know more about learner control. However, so far research on this area has focused only on the learning effects on high and low ability learners Although some measure of the effects the effects of a specific hypermedia programme on the satisfaction of the users is a common element in any evaluation report, (Nielsen, 1990b; and Hutchings et al. 1992) no reference has been made to the way in which learner control effects user satisfaction Satisfaction is a variable that is closely related to motivation for learning, and it is a truism that it is the learner who chooses whether to learn or not Therefore, it would also be interesting to focus on the satisfaction that different degrees of learner control can produce in order to enhance learner motivation. Such a study could be performed once the other modules of the programme are finished.

As for the preferences for different presentation formats controlled by the learner, not much research has been done. One of the reasons might be that the systems so far developed do not provide access to the same information in different formats. Designers tend to choose the presentation format they consider most appropriate according to instructional and design principles There are some rules and principles that have been specified and suggested for hypermedia visual design (Faiola, et al., 1988) In the field of intelligent tutoring systems, the situation is similar There may be alternative

presentation formats, but choices over which alternative to present are characteristically made by an expert system according to certain prespecified rules, rather than by the learner (Elsom-Cook, 1991). There are also interesting approaches to the evaluation of the understanding and clarity of visual presentations such as icon testing (Hardman, 1989 cited in Nielsen, 1990b). Although icon testing was done very informally in the evaluation of this particular prototype, the preferences for formats of access to information (graphical versus textual) was systematically tested.

Another feature very characteristic of hypermedia environments that has not been widely investigated is interactivity. Interactivity can be understood in different ways, as even a cursory review of the literature shows. So far, most studies have focused on which screens have been visited by the learner, taking advantage of the tracing features of developed systems. However, the number of physical moves does not always correspond to the number of cognitive moves, as Marchionini points out (1990).

Another approach has been to explore time of response to a question (Kreitzberg and Shneiderman, 1987 cited in Nielsen, 1990b). Egan (1988) also takes this measure and reports a study on human-computer interaction based on the ranges of response time across different types of users and different tasks Other authors focus on interaction from a different perspective, thus suggesting the integration of what they define as different kinds of interaction (e.g. browsing, asking questions, choosing, dragging in hypermedia systems) (Hutchings, et al. 1992). Studies on verbal interaction have focused on the analysis of observed interaction between pairs of students while using the system (Mayes et al, 1990).

Reports on interaction show that it has been understood in many different ways Although interaction analysis is an observation technique that has been used for a long time in the classrooms to evaluate the quality of interactions between teacher and students, this technique has not been applied to analyze the data reported from observations of students using computer systems. In fact, the study by Mayes et al. (1990) seems to be the only one that uses observation techniques to analyze the interaction and address cognitive processes. Nevertheless, there do not seem to be any reports of a similar approach used to analyze interactions between human and machine It is true that the richness of the communication and types of interaction that can happen in a classroom cannot be matched in computer-mediated

instruction, because of the lack of beliefs, attitudes and social background on the side of the system. Nevertheless, it seems to be an interesting challenge to try to extend Maye's et al. (1990) work in this direction

Some of the ideas summarized above regarding research on interaction were included in the evaluation of the prototype (e.g., frequency and sequence of visited screens, time spent, use of help features, depth of content accessed). However, due to time constraints, gathering data to study verbal interaction in pairs and analyzing cognitive moves through videotaped sessions could not be included as part of the present evaluation These remain as issues for further research.

Having reviewed the characteristics of hypermedia systems and the design of the module under study, as well as the models and techniques for formative evaluation of instructional software, the next chapter presents the method used for the evaluation of the prototype produced for this module

Method

In this section, a thorough explanation of the subjects, location, timing, instruments and procedures for the study, is provided. A flowchart of the evaluation plan is presented in figure 3.

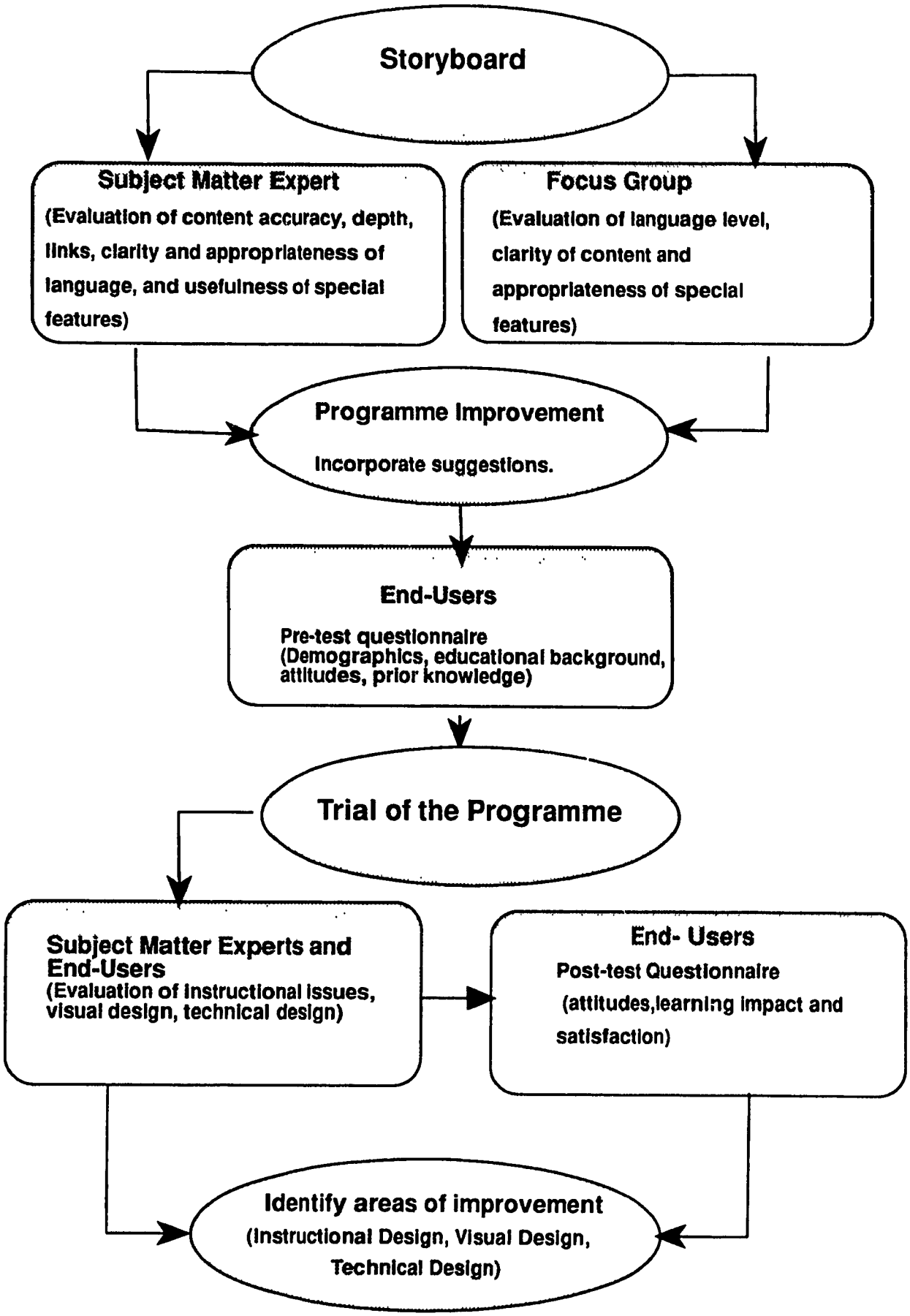
Subjects

The subjects included two content experts who are experienced in the development of hypermedia products. They were selected according to their experience in developing hypermedia products for learning purposes. Since the availability of people with these characteristics is limited, selection was done by reference. The experts evaluated the product both during the storyboarding phase, and after completion of the module. They assessed accuracy of content, appropriateness of format presentation for that content, scope of the content, links among the pieces of information, navigation opportunities and special features provided.

Another group of subjects comprised a focus group formed by volunteers of educational technology students (three students who were new in the program, and two who were in their second year), who assessed language level of the content, depth of presented content, presentation and visual characteristics of the interface, navigation opportunities and special features

A third group of subjects was formed by a sample of 16 educational technology students enrolled in a summer course (Scripting for Multimedia), with whom the final prototype was tested. After signing a consent form and trying out the programme, measures concerning knowledge, user satisfaction, interaction patterns, and use of special features available were obtained All participants had at least limited experience with computers and all of them had taken courses in instructional design and computers in education. However, nearly half of them had previous experience with hypertext or hypermedia programmes. Their characteristics matched, therefore, those of the target population described in the chapter regarding the instructional design of the module. A more detailed description of the demographics and previous knowledge of the sample is presented in appendix I.

Figure 3. Evaluation Plan



Design

The evaluation plan described here is a multifaceted one with various stages, each including special subgoals. Different designs were used in accordance to those different goals.

As mentioned before, an expert review was done during the initial and final stages A focus group was used during the initial stage. However, quasi-experimental designs were used for the trial of the final module in order to test its impact on learning and satisfaction.

In order to measure the impact on learning, a repeated measures design was implemented, where prior knowledge was compared against what was learned after using the programme. An immediate post-test and a delayed one were implemented.

To measure learner satisfaction, a one-shot design was used. As suggested by Nielsen (1990), it is not advisable to test attitudes or satisfaction on something to which students have not previously been exposed. Nevertheless, it is always wise to know the prior attitudes towards computer assisted instruction in general, in order to detect any possible prejudices that may affect learner satisfaction, even if this result cannot be compared against learner satisfaction. Therefore, a section referring to these issues was included in the questionnaire that was distributed as a pretest.

Data regarding navigation was traced by the system. Information was obtained concerning percentage of content covered, depth of covered information, time spent on each screen, and frequency and location of use of special features (glossary and help). One screen was designed to test users' preferences concerning access to deeper information (graphical versus textual interface features).

Instruments

As mentioned before, given the differences in the objectives of each stage, different instruments were used according to those goals, as recommended by Knussen et al. (1991).

Structured interviews were used during the pre-production phase of the prototype, both with the subject matter experts and the focus groups. The basic questions for the interviews are presented in appendix A. Questions were open-ended and covered the aspects that were mentioned before for these

groups as well as questions intended to clarify some of the issues brought up in the interview.

Both groups were provided with a description and a map of the program and copies of the storyboard before the actual interview or meeting, so that they could have time to look at it and complete a semantic scale type of questionnaire on the following issues: clarity of content, links among the pieces of informations, relevance of examples provided, language appropriateness, navigation opportunities and special features For the subject matter experts, this scale included two more questions evaluating the accuracy and completeness of the content (see appendix B.) In order to determine the interrater reliability, correlations between judges were calculated (Henerson et al., 1987). Since the interrater reliability of this instrument was not very high, the original seven grade scale was reduced to five points for analytical purposes. The two extreme positive and the two extreme negative points of the scale were collapsed. The correlation coefficient between the assessment of the two subject matter experts was r= 0.49 before correction, and r= .0.54 after collapsing the extreme points. Correlation coefficients among student responses ranged from r= 0.55 to r= 0.78 originally, and r= 0.57 to r= 0.80 after correction. The fact that the subject matter experts' correlation was weaker than the students' may be due to the differences in experts' working experiences. One of them designs computer-based training, while the other designs training courses relating to the use of development applications (specifically, rapid prototyping tools).

For the actual trial of the prototype, a consent form was distributed in the classroom followed by a pretest questionnaire divided into four main sections (see Appendix C.) The sections collected data on: 1) demographics, 2) relevant characteristics of the learner (previous experience with hypermedia programs, educational background, instructional design and computer related courses taken), 3) knowledge of the conception and production processes for hypermedia products, 4) attitudes towards computer assisted instruction

Questions for the two first sections were selected according to what the literature indicates as relevant variables to be addressed in the evaluation of hypermedia programs (i.e. sex, age, and previous skills and knowledge) (Park, 1991, and Landauer, 1988). To ensure the content validity of the third section, multiple choice questions were designed according to the instructional objectives stated in the description of the program. All of the stated objectives

are represented in the test. In order to avoid the remembering factor in re-testing, a parallel form of the pre-test was developed for the post-test. The equivalency of both forms was tested with volunteer educational technology students who completed both forms. The item by item correlation coefficient was calculated. (r= 0.82). After a week of having used the program, the knowledge related section used as a pre-test was implemented as delayed post-test, to measure retention.

The fourth section consisted of a semantic differential scale. The adjectives chosen for its construction comprised descriptive terms collected from people who dislike working with computers, and people who enjoy using these tools. This method has been considered effective in the construction of semantic differential scales (Lemon, 1973). The internal reliability for this section of the instrument was calculated using Cronbach's alpha (α = 0.78).

After trying the prototype, subject matter experts and end-users filled in an evaluation form to assess the pedagogical and technical aspects of the program (see appendix D.) The content of this form was developed according to the review of different instruments reported in the literature (See table 4 in Literature Review). It includes closed questions to facilitate the processing of collected data, and spaces for comments at the end of each section. Interrater reliability was calculated based on the subjects who answered all the questions. The correlation coefficient between the two subject matter experts was 0.38, again a very low coefficient, since one of them focused on instructional design issues, while the other one was more critical regarding aspects of visual design. For students, a more homogeneous population, coefficients ranged from r= 0.65 to r= 0.79. These data again support the need for the collection of qualitative data, which in this case was collected through the provision of spaces for comments.

For the post-test, a questionnaire that included the same third and fourth sections of the pretest was used, adding another section to measure learner satisfaction with the program (see appendix E.) This last section consisted of 25 statements to be rated by the student on a five point scale. This kind of instrument has been suggested as an effective format for the measurement of learner satisfaction (Nielsen, 1990b; Kirakowski, 1992). The reliability of the instrument was calculated using Cronbach's alpha (α = 0.83).

Analysis of Data

Data collected before the actual production of the module was analyzed only through descriptive statistical procedures. Frequencies and percentages were used. The same procedures were utilized for the analysis of learners' attitudes to computer-assisted instruction in general.

Data obtained from the prototype evaluation combined descriptive and inferential statistics as appropriate. Descriptive statistics were used for the evaluation of instructional design, and the visual and technical design of the system. For the analysis of the impact on learning, ANOVA was used. Differences for learners who had taken each of the related courses of the Master's programme were tested. Comparisons between learners with experience and novices in hypermedia were conducted for (a) previous knowledge, (b) knowledge acquired, and (c) retention after a week. Learner satisfaction is reported using descriptive statistics.

Procedure

1. The subject matter experts, (who were contacted beforehand) evaluated the accuracy, depth and appropriateness of the content, the links among the different nodes in the programme, the clarity and appropriateness of the language used, and the usefulness of the special features provided. They had time (two weeks) to look at the storyboard and complete a semantic differential scale type of questionnaire, as was mentioned in the instruments section. Their open suggestions were gathered through interviews held at the researcher's office in one case, and at the expert's office in the other The results and suggestions from both experts were compared and integrated in an effort to improve the storyboard and programming.

2. Parallel to step one, an evaluation of the language level, clarity of the content and appropriateness of the special features was carried out with a focus group. This group consisted of five volunteer students from the educational technology department, who were provided with copies of one section of the storyboard and a semantic differential scale instrument to complete. After a week, a time was arranged to meet individually and discuss suggestions as well as to hand in their instruments Again their suggestions were gathered by interviews held at the researcher's office, and suggestions were integrated in the storyboard and production

3 Once the programmers had finished the module, an evaluation form for the subject matter experts was provided to have them evaluate the aspects already described in the instruments section. Each subject matter expert had a chance to try the module, working alone in a room at a pre-arranged time. No time constraints to utilize the module were imposed.

4. The teacher from the summer course was contacted and permission was asked to run the experiment with his group and to use one class to implement the pretest during the first week of classes. The teacher, instead of the researcher, was the one to conduct the session in an effort to ensure the confidentiality of the results of the experiment In class, the teacher explained the purpose of the study, asked for the collaboration of the students and ensured the anonymity of their responses. During the explanation it was emphasized that knowledge was going to be tested after using the material and that in this type of study the experimenter does not evaluate subjects, but rather the subjects evaluate materials.

5. Before the pretest was distributed, a consent form was signed by the students willing to participate in the study. All of them accepted to participate in it, even though some of them were lost during the subsequent phases of the evaluation.

6. During the third week of classes, trials began. The class dedicated to this step was held at ECHO, a centre of excellence for multimedia research and development, where four computers were used to try out the prototype. In an attempt to let all the students interact with it during that session, the teacher gave them 30 minutes for the trial plus the necessary time to complete the evaluation form and the immediate post-test.

7. Given the time constraints and the environmental conditions (extreme heat and no air conditioning), only nine students could try out the programme For the seven students missing, appointments were made to interact with it at the university's facilities. The five students who attended these appointments had no time constraints to try out the programme.

8. A week after the trial, a delayed post-test was administered by the researcher during the first 15 minutes of class. Students and teacher were thanked for their participation.

9. Collected data were organized and analyzed to identify suggestions for improvement

Results

The presentation of results has been divided into two main sections. the evaluation of the storyboard by the subject matter experts and the focus group, and the evaluation of the prototype with subject matter experts and end-users.

Storyboard Evaluation

The storyboard was evaluated by two subject matter experts and five students. Quantitative data were gathered using a semantic differential questionnaire along five dimensions: (a) content, (b) examples, (c) navigational tools, (d) special features, and (e) language and vocabulary Data were analyzed using Osgood's procedure (Lemon, 1973) Since the interrater reliability of this instrument was not very high, the original seven grade scale was reduced to five points for analytical purposes. The two extreme positive and the two extreme negative points of the scale were collapsed. For each question in the scale a value was assigned ranging from -2 to +2 (from the least desirable to the most desirable state, respectively) Table 5 summarizes the results for each variable evaluated. The first row indicates the number of questions in the questionnaire addressing that dimension, followed by the mean and standard deviation for each variable. Positive means were obtained for the five dimensions included. Language and content received the lowest scores.

Table 5.
Storyboard Evaluation: Summary of Results per Evaluated Variable.

	Content	Examples	Navigation Tools	Special Features	Language
No. of questions	11	5	3	2	4
Mean	1.28	1.74	1.86	1.93	1.00
Standard Dev.	1.25	0.50	0.36	0.27	1.63

The analysis per question revealed that the means for all the individual questions were positive, except for content difficulty, which was considered slightly difficult (mean = -1.00), and for language and vocabulary level, which was rated as being high (mean = -1.14) (see appendix II for results per question) Depth of content, richness of illustrations and challenging degree

of the content were other items with low means, within the range of 0.71 to 1.14. Nevertheless, the only negative means obtained were for content difficulty and language level. Modifications in language were made according to the evaluators' suggestions, while content difficulty, depth, and degree of challenge were remediated by adding examples.

Qualitative information was gathered through interviews with the subject matter experts and students in the focus group. Table 6 summarizes the results obtained per participant for each of the questions. The first column presents the question and all obtained answers. Since the purpose of this evaluation phase was to obtain information to improve the prototype, the second column indicates whether or not suggested changes were incorporated in the prototype before the end-users' trial. Even though the initial attempt was to make all necessary changes, time was a critical factor in the decision concerning which modifications would be ignored. The next columns indicate the answers per participant. The two subject matter experts' responses are presented first. Student 3 and student 5 are senior students, while students 1, 2, and 4 are new in the Educational Technology program.

Table 6

Storyboard Evaluation: Summary of Interview Results.

Answer	Done	SME 1	SME 2	St. 1	St. 2	St. 4	St. 3	St. 5
1.Meets expectations								
1.1 Yes		✔	✔	✔	✔	✔	✔	✔
2. Missing contents								
2.1 Objective analysis tools from other theories.			✔					
2.2 CANDO for the Amiga production platform	N/A							✔
2.3 Define technical terms	✔							✔
2.4 Provide examples for Instructional Design Section	✔	✔		✔	✔			
..2.5 None						✔	✔	
3. Irrelevant Information to discard.								
3.1 Use concise language	✔	✔				✔	✔	✔

Answer	Done	SME 1	SME 2	St. 1	St. 2	St. 4	St 3	St 5
3.2 Avoid full sentences in lists and overlays	✔							✔
3.3 None			✔	✔	✔			
4. Examples are interesting								
4.1 Yes		✔	✔		✔		✔	✔
...4.2 Needs more examples	✔	✔		✔		✔		
5. Need for more examples								
5.1 Yes	✔	✔	✔	✔		✔	✔	
...5.2 No					✔			✔
6. Suggested examples								
...6.1 Illustrate Gagné's Events of instruction	✔	✔				✔		
...6.2 Examples for levels of performance and content.	✔	✔		✔		✔		
...6.3 An example of a fully developed unit following all the steps in the process.			✔					
...6.4 None					✔		✔	✔
7. Clarity of content								
...7.1 Clear		✔	✔		✔	✔	✔	✔
...7.2 It is confusing to jump from one theory to another	✔			✔				
8. Conducive to learning								
8.1 Yes		✔	✔		✔	✔	✔	✔
...8.2 Boring to review Instructional Design	✔							
9. Helpful for ETEC students								
9.1 Yes		✔	✔	✔	✔	✔	✔	✔
10. Other suggestions								
10.1 Add a student's working pad to keep relevant information and to print later.				✔				
...10.2 Provide literature references	*		✔					

N.A. not applicable to the prototype

* Had already been included.

Prototype Evaluation

The design of the prototype was evaluated by the two subject matter experts and by end-users. Students also participated in a field-test to evaluate the learning impact and satisfaction with the program.

Learning impact. The 16 students of the chosen summer course completed a pre-test questionnaire consisting of four main sections: (a) demographics, (b) previous knowledge, (c) attitudes towards CAI in general, and (d) previous content knowledge. Descriptive statistics were used for the demographics and previous knowledge sections. Results are presented in Appendix II. All students, except one, had taken related courses from the Educational Technology program either in instructional design or in computers for educational purposes.

One-way ANOVA was utilized to test if there were any differences in previous content knowledge between students who had taken each of the related courses and those who had not (ANOVA summary tables are presented in Appendix J). In spite of the violation of assumptions for this type of test and the small and unequal sample sizes, it was selected since interval data were being used as dependent variable. No significant differences were found for three of the four courses considered -- Instructional Design II, Computers in Education, and Multimedia ($F = 2.97$, $p > .05$; $F = 0.30$, $p > .05$, and $F = 0.58$, $p > .05$, respectively). A significant difference was found for those students who had taken Instructional Design I ($F = 6.55$, $p < .05$). A significant difference in previous knowledge was also found for experience in hypermedia ($F = 7.62$, $p < .05$).

After the trial of the prototype, the impact on learning and retention was tested using paired t-tests Table 7 presents the descriptive statistics for the three measures taken. In the three cases, scores were low; however, there was almost no difference between the post-test and the delayed post-test.

Pre-test scores were compared against post-test and delayed post-test scores (See appendix J for summary tables). The differences between the pre-test and the other two post-test scores were significant ($t = -4.22$, $p < .05$ for the post-test, and $t = -2.81$, $p < .05$ for the delayed post-test). No significant difference was found between the post-test and delayed post-test means ($t = .2$, $p > .05$).

Table 7.

Descriptive Statistics for Knowledge Scores.

	N	Mean	S.D
Pre-test	16	4.44	1.26
Post-test	14	5.79	0.82
Delayed Post-test	12	5.67	1.43

From the 16 students that were part of the study, 62% had experience with hypermedia. Since a one-way analysis conducted for the pre-test and post-test results had reported a significant interaction, an ANOVA for repeated measures was conducted to assess differences in content knowledge and learning impact between those who had some experience in hypermedia and those who did not, even though the number of subjects per cell was small in some cases. Table 8 presents the number of students per cell and mean scores for each of them. Means are plotted in figure 4. No significant interaction was found for the variables considered ($F = 2.42$, $p > .05$). A significant main effect was found for knowledge ($F = 8.49$, $p < .05$) (See appendix J for summary table). Students with experience outperformed novices in the pre-test and delayed post-test. However, in the post-test novices had higher scores than experienced users.

Table 8

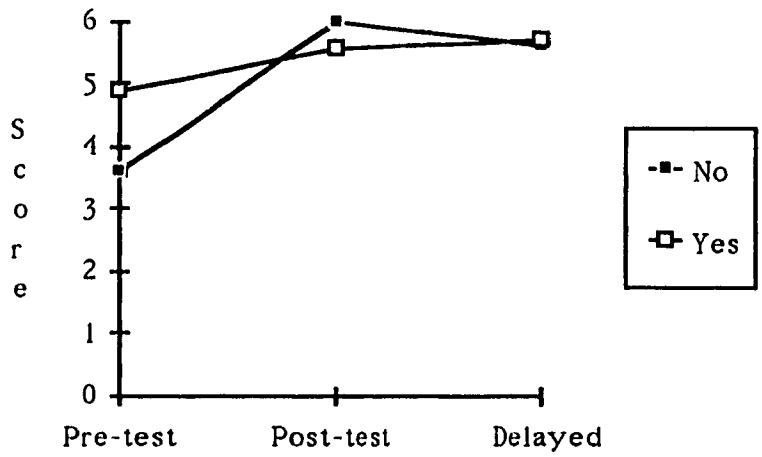
Incidence Table for Knowledge Scores According to Experience in Hypermedia.

The AB Incidence table

Repeated Mea...		Pre-test	Post-test	Delayed	Totals
Experienc.	No	5 3.6	5 6	5 5.6	15 5.067
	Yes	7 4.857	7 5.571	7 5.714	21 5.381
Totals:		12 4.333	12 5.75	12 5.667	36 5.25

Figure 4

Plot of Means for Knowledge Scores According to Experience in Hypermedia.



Note: Nonsignificant interaction.

A similar analysis was conducted for those who had taken Instructional Design I and those who had not (see appendix J for summary table). In this case again the interaction was not significant ($F = 0.32$, $p > .05$); the two main effects, however, were ($F = 8.6$, $p < .05$ for course taken, and $F = 7.1$, $p < .05$ for the repeated measure). Table 9 presents the number of cases and means per cell. Figure 5 shows the plot of means. Although in this case non-experienced people did not outperformed the experienced ones in the post-test, the same score decay phenomenon encountered above is present for novices in the delayed post-test. Experienced students again maintained their scores from post-test to delayed post-test.

Table 9

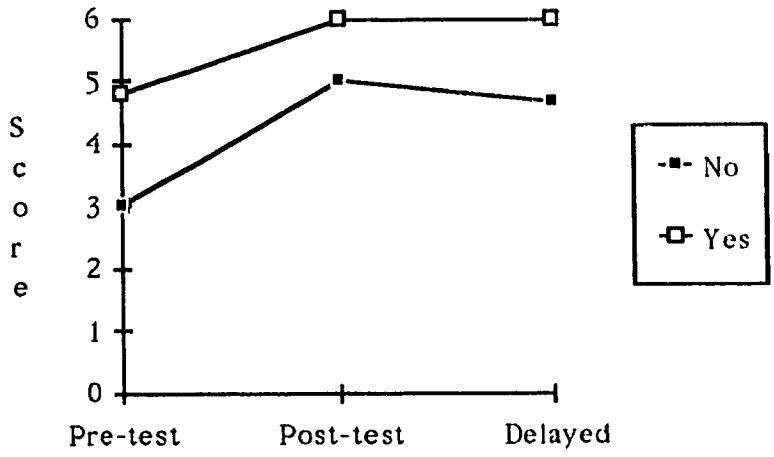
Incidence Table for Repeated Measures and Experience in Instructional Design.

The AB Incidence table

Repeated Mea...		Pre-test	Post-test	Delayed	Totals
ETEC 710	No	3 3	3 5	3 4.667	9 4.222
	Yes	9 4.778	9 6	9 6	27 5.593
Totals:		12 4.333	12 5.75	12 5.667	36 5.25

Figure 5

Plot of Means for Knowledge scores According to Experience in Instructional Design.

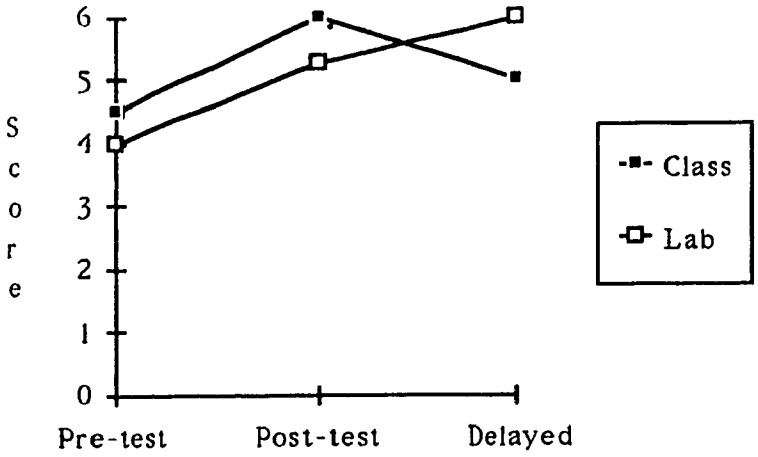


Note: Nonsignificant interaction

In order to establish whether or not the trial condition had an effect on learning and retention, another ANOVA for repeated measures was conducted (see summary table in Appendix J), although, in this case, one must be aware of the small and unequal cell sizes. No significant interaction (F= 2.22 p > .05) or main effect were found (F = .04 p > .05 for the repeated measure, and F = .04 p > .05 for trial condition). Although both groups improved their scores from the pre-test to the post-test, a small decay was observed for the delayed post test in those who tried the product in class, as shown in figure 6 and table 10.

Figure 6

Plot of Means for Knowledge Scores According to Trial Condition.



Note: Nonsignificant interaction.

Table 10.

Incidence Table for Repeated Measures According to Trial Condition.

The AB Incidence table

Repeated Mea..		Pre-test	Post-test	Delayed	Totals
Trial con.	class	8 4.5	8 6	8 5.5	24 5.333
	lab	4 4	4 5.25	4 6	12 5.083
Totals:		12 4.333	12 5.75	12 5.667	36 5.25

Navigation. The system kept track of screens visited and time spent on them for each user. The use of glossary and help buttons was also recorded. An example of the tracing report is presented in appendix K. Results are summarized in table 11. The total number of screens visited per subject and the percentage that they represent from the total program are indicated. The rest of the columns indicate the number of visited screens for each content level and the percentage from the total number of available screens. None of the students followed a strictly linear pattern that would have kept them always at level two. They all explored information at levels three and four to a high degree, as indicated by the percentages below.

Table 11.

Frequency and Percentages of Screens Visited per User and Content Depth Level

Subject	Total	Level 1	Level 2	Level 3	Level 4	Help	Glossary
SME 1	44	4	7	18	15	5	1
	62.86%	9.09%	15.90%	40.91%	34.09%		
SME 2	21	4	7	4	6	2	1
	30.00%	19.05%	33.33%	19.05%	28 57%		
St.1	58	4	8	26	20	1	
	82.86%	6.89%	13.79%	44 82%	34 48%		
St.2	42	4	6	23	9	1	2
	60.00%	9.52%	14.28%	54 76%	21 43%		
St.3	27	4	6	10	7	4	2
	38.57%	14.82%	22.22%	37.04%	25.92%		
St.4	29	4	4	20	1	1	
	41.43%	13.79%	13.79%	68.96%	3 45%		
St.5	20	4	6	8	2		
	28.57%	20.00%	30 00%	40.00%	10 00%		
St.6	18	4	6	5	3	1	
	25.71%	22.20%	33.33%	27.78%	16 67%		
St.7	33	4	4	16	9	2	
	47.14%	12.12%	12.12%	48 48%	27 27%		
St.9	37	4	6	19	8		
	52.86%	10.81%	16.21%	51 35%	21.62%		
St.11	36	4	8	19	5		
	51.43%	11.11%	22 22%	52.78%	13.88%		
St.12	45	4	3	30	8		2
	64.29%	8.89%	6.67%	66 67%	17 78%		
St.13	20	4	7	7	2	3	
	28.57%	20.00%	35.00%	35 00%	10.00%		
St.14	34	4	6	15	9	1	1
	48.57%	11.76%	17.64%	44.11%	26 47%		
St.15	23	4	5	4	10	1	
	32.86%	17.31%	21.74%	17.39%	43 48%		
St.16	30	4	9	13	4	5	
	42.86%	13.33%	30.00%	43 33%	13 33%		
Total No.	70	4	30	20	20		

An analysis per screen and the number of students visiting them is presented in appendix K. Even though the most frequently visited screens were those at level two, frequencies indicate that some examples and hypertext explanations at levels three and four were almost as frequently used as the ones in the upper levels

An analysis of the time spent on each screen indicated that people spent the most average time in two screens: "Structuring" and "Gagné's events of instruction" (114 to 101 seconds, respectively). Frames where less time was spent were examples and jumping menu screens (e.g., Merrill's prescriptions). The average time for those screens ranged from 5.52 to 8.72 seconds (See appendix K).

The help and glossary features were not frequently used as indicated in table 11 The analysis per screen presented in appendix K showed that the help button was used in a total of six screens. This feature was used ten times in total for the screen "Performance Content Matrix", four times for the screen dealing with organization of content, and three times for the screens "Structure and Sequence" and "Concept Map". The Glossary was accessed seven times in total from the main menu, and never accessed from any content screen.

Preferences in the format to access deeper information were tested using a screen where the same information could be accessed from a graphic or from hypertext. The number of times each student used these features was recorded by the system. Table 12 presents the frequency by which each subject used a graphic or a textual accessing point, as well as the level of experience with hypermedia programs. There appears to be a preference for the graphic mode of access.

Table 12

Preferences in Format of Information Access.

	St. 1	St. 2	St. 3	St. 4	St. 5	St. 6	St. 7
Graphic	3	1	3	1	0	1	2
Text	2	1	0	2	0	0	2
Experience	Exp	Exp	Nov	Nov	Nov	Nov	Nov

	St. 9	St. 11	St. 12	St. 13	St. 14	St. 15	St. 16	Total f
Graphic	1	3	4	2	0	1	2	24
Text	1	0	1	1	1	0	0	11
Experience	Nov	Exp	Exp	Exp	Nov	Nov	Exp	

Users' attitudes and satisfaction. Results on attitudes towards CAI in general are presented in table 13. Means and standard deviations for each related item in the questionnaire are reported Responses were coded in a scale of -2 to +2 in consistency with the approach used for the analysis of responses in the storyboard evaluation phase. Except for the item on objectivity of content, the means obtained were positive in all cases, remaining between the range of 0.5 to 1.57.

Table 13
Descriptive Statistics for Attitudes towards CAI in General

	Effi-cien cy	Inter est	Flexi-bility	Objec tivity	Diffi-culty	Crea-tivity	Moti-va tion	Fair-ness	Foster higher order skills	Effec tive-ness
Mean	0.82	2.08	1.27	-0.58	0.50	0.83	1.42	1 08	0.25	1.25
S.D.	1.78	1.24	1.74	1.24	1.19	1.47	1 08	1.24	0 87	1.36

The means for each participant were also calculated to determine if any biases or prejudices against the use of computers in education existed Means ranged from -0.5 to 1.7 in the scale of -2 to +2. Table 14 presents the global mean and standard deviation for each participant.

Table 14
End-users' Attitudes towards CAI: means and standard deviations per participant.

User	St. 1	St. 3	St. 4	St. 5	St. 6	St. 7	St. 8
Mean	0.60	-0.50	1.70	0.20	0.80	-0.2	1 10
S.D.	0.84	1.41	0.67	0.42	0.42	1 48	1 10

User	St. 9	St. 11	St. 12	St. 13	St. 14	St. 15	St. 16
Mean	1.00	1.30	0.50	1.30	1 00	0 70	0.50
S.D.	1.05	0.94	1.27	0.67	0.82	1 06	1 78

Note: 2 users did not answer this section. They considered their opinions would vary depending on the software.

After the trial of the prototype, users' satisfaction was measured with a five-grade scale of agreement. A summary of the frequencies and percentages

for each item is presented in appendix L. The differences in the distribution were tested using X^2 with continuity correction. No significant differences were found for any of the items

High ratings were obtained for questions dealing with the value of the system as a learning tool for educational technology students (94%). All students would like to see the rest of the product and 93% of them enjoyed trying it out. Its ability to invite the user to get involved in multimedia production was also rated positively by 78.5% of the students. Opinions regarding its ability to enhance motivation and keep interest in the content were divided, and many users were undecided (35.7% and 21.4% of undecided, respectively).

In order to determine the relationship between attitudes towards CAI in general and the degree of satisfaction, the scores of the latter were converted to interval data ranging from 1 to 5, from the less desirable to the most desirable state, respectively. Means for each participant are presented in table 15. Pearson's correlation coefficient was r =.07 (see appendix L for summary table).

Table 15

End-users' Satisfaction: descriptive statistics.

User	St.1	St. 2	St. 3	St.4	St.5	St. 6
mean	3.48	3.92	3.52	4.12	3.68	3.04
S.D.	0.77	0.40	1.50	0.78	0.69	0.54

User	St. 7	St. 9	St. 11	St. 12	St. 13	St.15	St. 16
mean	3.84	3.44	3.24	2.60	3.84	3.56	3.60
S.D.	1.21	0 65	0.88	0.91	0.47	0.87	0.87

Evaluation by subject matter experts and end-users. Results concerning the evaluation of the instructional design, and the visual and technical design of the prototype are presented in appendix M. Most of the items referring to instructional design issues were rated positively by the subject matter experts. One of them rated as poor the clarity of instructions, the ease of interaction, and the provision of explanations for unclear assignments On the other hand, the other subject matter expert commented that the interface was transparent

and easy to interact with. Two other items rated as poor were the control for sequence and sound. Positive comments were made by both experts for the content of the program and the glossary. (Subject matter experts' and students' comments are presented in appendix M)

Students also rated most items under the sufficient or good categories. Three issues that received low ratings were: (a) the statement of pre-requisite skills, (b) the amount of practise provided, and (c) the sensitiveness of the program to user's motivational needs. Even though the characteristics of the target audience were stated in the documentation package, 84.6% of the users considered that pre-requisite skills had not been stated Opinions were divided for the other two aspects, where 50% of the users rated them as poor or non-existent. Comments written by students showed that other aspects needing improvement were clarity of instructions, and selection of examples Positive comments were obtained regarding:

(a) completeness and accuracy of content

(b) variety of interaction techniques

(c) value of content for instructional design courses

(d) value of references in the glossary

(e) variety of examples

Regarding the visual and technical design, the subject matter experts' evaluation indicated the need to improve the color consistency on screens, the degree of control regarding access to screens and the possibility of marking content. Comments by one of the experts supported these ratings.

Students' evaluations for this dimension were positive; however, low ratings were obtained for the appropriate use of sound and the time required for transitions. Most students considered the use of colours as appropriate; nevertheless, written comments agreed with the subject matter expert's opinion. Another point of agreement was the need to have easier access to the map to orient the user and to have the system mark on it the topics already covered by the user.

Discussion and Conclusions

The different phases of the evaluation process provided useful information for the improvement of the system. The evaluation of the storyboard indicated specific areas to improve in terms of content and language. The trial of the product by experts and end-users allowed the identification of needs in terms of access to instructions, visual design and navigational aids The knowledge and satisfaction tests posed interesting questions for further research in terms of retention of learned materials and motivation.

Regarding the evaluation of the storyboard, it was difficult to use low and high ability learners for the focus groups as some evaluation models suggest (Dick & Carey, 1990; Dick, et al., 1992 and Ragsdale, 1982). However, the selection of judges with different fields and levels of experience provided information from different points of view -- even though this was paid for in the interrater reliability coefficients of the quantitative instruments.

In this phase, the use of qualitative data gathered through interviews proved to be more helpful in the identification of areas needing improvement. One of the subject matter experts focused on content accuracy and language; the other one tried to emphasize the clarity of the content. Senior students provided useful suggestions in terms of examples and other content areas to include in the prototype. Students new to the program concentrated on language structure and clarity of content.

Most of the needs identified during this phase were integrated in the prototype, and those which were not -- due to the programmers' time constraints -- were brought up by end-users during the trial phase. An illustration of this is the provision of an example consisting of a fully developed unit of instruction indicating all the decisions made for its instructional design Such an example would be very useful for students with no background in instructional design.

Regarding the evaluation of the prototype, its learning impact was assessed using a repeated measures design. It must be kept in mind that two important threats to internal validity particular to this design are testing-treatment effect and mortality. The use of parallel testing forms provided some control for the first one; however, students knew there was going to be a post-test, and this may have affected their attention to the contents Mortality

is difficult to control, and four subjects were lost from the beginning to the end of the process. Their responses were eliminated from the data analysis. Another threat was the selection of subjects. Since participation was on a voluntary basis, the result was a heterogeneous group with different levels of experience. Such a selection, which would be a serious problem in research, was an advantage in the case of evaluation, thus allowing interesting comparisons according to different fields and levels of experience.

Another serious threat in the case of this evaluation was the fact that trial conditions were different and it is difficult to provide an accurate evaluation of a product when not enough time to interact with it is given. Nevertheless, the contrast between the two conditions -- more favorable and conducive to learning and satisfaction in one case than in the other -- allowed the evaluator to make some inferences about the effectiveness of the program in ideal as well as in bad conditions, and consider suggestions for implementation.

The significant differences found in the previous knowledge scores for those who had some experience in instructional design and in hypermedia, indicate that the test was a valid one, and that it discriminated between those who mastered the content, and those who did not. Thus the results of the t-tests -- indicating that there had occurred some learning after the trial of the prototype, and that learned materials were retained after a week -- were supported by the factorial analyses conducted to take into consideration the differences in expertise.

Even though these analyses have to be carefully interpreted, given the violation of some assumptions including the small and sometimes unequal cell sizes, they indicate that learning and retention had occurred, since in both cases a main effect for the repeated measure was found This means that the prototype meets the "easy to learn" and "efficient to use" parameters stated by Nielsen (1992).

However, and contrary to what has been stated in the literature (Perkins & Solomon, 1989, Duffield, 1991, Marchionini,1988), the fact that no interaction was found with level of experience in any of the cases would mean that level of experience did not affect learning or retention One possible explanation for these results are that the program did facilitate its use by novices through the implementation of direct manipulation and 3-D techniques suggested in the literature to enhance learning and retention

(Vacherand-Revel & Bessiere, 1992; and Pezk, in Mayes, 1992). Another explanation would be related to the testing-treatment interaction threat discussed above. Knowing that learning from the program would be tested may in fact have made students pay more attention to what was being presented. This explanation seems to be supported by the fact that novices outperformed experts from both related fields in the post-test, but their scores dropped in the delayed post-test.

The testing of knowledge for the different trial conditions reported that students learned the same in bad and in ideal conditions. These results may again be a consequence of knowing that they were expected to learn from the program However, the decay in the delayed post-test scores nullifies, in this case, the main effect for the repeated measure, thus making one suspect that there might be an effect in the long run rather than in the immediate retention. The trends in the regression lines seem to support this idea, since they could mean that students in better trial conditions retain the learned materials longer than those who tried it in class. The question of what effect the different trial conditions would have in the long run remains open.

In the interpretation of the results regarding knowledge, it is important to notice the low scores obtained for the three measures taken Low performance could be explained by the limited time of exposure to the material (one trial only), or by the partial use of the system's content, as the percentage of visited screens in the navigation analysis suggests. To clarify this issue, it would have been useful to employ an instrument with more items (covering the content more exhaustively), and to subject this instrument to an item analysis With this approach, items which were problematic would be identified, along with the corresponding screens. The data collected on-line regarding patterns of usage could then be examined to resolve the issue of whether low scores were a function of exposure time, of not accessing screens, or of the measuring instrument itself.

Regarding navigation results it was interesting to see that, again contrary to previous findings (Marchionini, 1990, and Locatis, 1988), experts and novices used the linking facilities offered by the medium and did not travel in a strictly linear way. The percentages of screens visited per subject in each level indicate that users did take advantage of deep layers of information. These findings would then support the assumption made above about the efficiency of the facilities provided by the system to help the novice

navigate in the program. The low frequencies for the use of the help and glossary facilities also support this inference.

Although one must take into consideration that these were students enrolled in a multimedia scripting class, who therefore they may already have heard how hypermedia works, informal talks with the students revealed that they thought they were going in a linear way, when in fact they were not. The spiral structure of the program may have helped them have that feeling, as Faiola and DeBloois (1988) point out. These special cases, as well as written comments on the variety of interaction techniques, seem to support the good structuring and help features of the program. As a matter of fact, the layout of the screen did also play a role in the interaction dynamics. Frames with graphical sensitive areas, as opposed to hypertext only, to access deeper information were the preferred format, both by experts and novices.

The analysis of time spent per screen revealed that the two screens where most time was spent were those with too much information (in the case of "Structuring") or too many pop-up balloons (in the case of "Gagne's Events of Instruction"). One of the comments emphasized the fact that in some screens too much text was presented, thus resembling a text-book style However, the fact that more time was spent in these screens does not necessarily mean that the student was passive, she may have been asking for pop up information. In such a case, Marchionini's (1992) phrase that a physical move is not equivalent to a cognitive one, may be turned around· the inverse is equally true.

The evaluation in terms of learners' satisfaction supported the value of the program as a learning tool, and its relevance for the master's program in Educational Technology. However, in some other cases answers seem to be contradictory. Items asking whether users enjoyed trying out the product, were willing to see the rest of it, or felt it invited the learner to get involved in multimedia production, seem to support the value of the product as a pleasant tool --another of Nielsen's usability parameters (1990b). On the other hand, items referring to its ability to motivate, keep students interest and avoid frustration, were neutral. This might be due to the fact that this was not a fully developed product and that students did not leave with the feeling of having accomplished something -- as the comments on the absence of a product at the end of the session suggest. The lack of difference in the satisfaction distribution for the different trial conditions seems to indicate that

the low motivation was due to characteristics particular to the program itself rather than being a consequence of external events.

Another consideration in these interpretations is the kind of content that was addressed. Instructional design is quite theoretical and there seems to be a special fear associated with this content. As one of the members in the focus group confessed, this fear interfered with her evaluation of the storyboard, since she found the content boring. As a matter of fact, feelings of leaving without the sense of accomplishing something and not knowing what was expected from them were related in comments made by students who do not have any background in instructional design and who, therefore, did not fully understand the learning objective. Besides, if the off-line materials were not read, the learning objective was certainly ignored. In any case, it is not clear which factors played an important role in raising or decreasing the users' motivation and further investigation is needed to identify them.

Suggestions for Improvement

The evaluation of the instructional design, and the visual and technical designs, allowed the identification of the program's strengths and weaknesses. Written comments from the students emphasized the need for certain features that, though contemplated in the storyboard, were not integrated in the prototype due to time constraints. These features included a printing facility from the glossary, a student's note pad, and a navigational map icon. Other suggestions that had not been contemplated were also presented. Some students felt that their understanding of terms had been blocked by the use of examples from fields of which they are not very knowledgeable (e.g., science and arts). Other suggestions referred to issues the development team was aware needed improvement, such as the use of inconsistent colours for choices and sensitive objects in the working area. Specific suggestions for improvement are presented next, according to what was gathered from quantitative as well as qualitative data.

Suggestions for instructional design.

(1) Make available the off-line information within the program, since most students did not read it. This would avoid the confusion of students not knowing what the learning goal is, and the frustration of students who do not meet the requirements for its use.

(2) Include the example of a fully developed unit of instruction to illustrate instructional design decisions. This would support the use of the program by persons who do not have a strong background in instructional design, and would clarify the instructional goal.

(3) Include other anchors related to more basic common knowledge as opposed to arts or science. This will allow students who have some fears and prejudices against these fields to feel more confident and understand better the illustration of concepts.

(4) Review feedback messages that can be interpreted as threatening, use humour, perhaps.

(5) Provide some sort of system response for choices where no right or wrong answers exist and no feedback can be given. This would allow students to feel more secure while using the program, and may well help limit frustration

(6) Provide explanations for the teacher about the time allotted for interacting with the program as well as suggested ways and conditions for its use. This will avoid inefficient and ineffective implementations that might appear effective in the short term but fail to yield full benefits in the long term.

(7) Specify that knowledge will be tested. This seemed to have helped students pay more attention to what was being presented and enabled them to learn regardless of the environmental conditions.

(8) Make a schedule to maintain the reference list in the system. The few subjects who accessed it emphasized its value for future use.

(9) Use it as supporting material for production courses in the program All users agreed on the value of its contents for Educational Technology students.

Suggestions for visual and technical design.

(1) Use consistent colours for sensitive and decision areas, so that learners know whether to read or to make a decision. This will clarify their role when interacting with the program.

(2) Provide a printing option for references in the glossary This will ensure its use and make the maintenance of the database worthwhile

(3) Include a navigational map icon for every screen so that the user knows where she is and what contents she has covered.

(4) Reduce the amount of information in screens like "Structuring", where the user is not having an active role

(5) Reduce full frames with little information that can be compared to overlay windows or pop up balloons.
(6) Keep the differentiation of the explanation and working areas for the rest of the program. This seemed to facilitate novices' navigation, and invites them to explore content in a non-sequential manner.
(7) Keep the variety of interaction styles for the rest of the system. This strategy proved to keep students' interest and help learning and retention.
(8) Keep the restriction of access according to levels and pre-requisite knowledge. The balance between learner and system control for non-sequential access seemed to be adequate and helped novices to retain information, as well as to review it.
(9) Keep graphic accessing points for important deeper information, since it seems to be the format preferred by novices.

Suggestions for further research. Given that this was an evaluation study, rather than an experimental one, where all conditions are controlled, and the sample size is bigger, many questions from the analyses performed did not yield conclusive responses, thus leaving questions open for further investigation. Some of them are:

(a) Do different trial conditions have effect on the retention in the long-run?

(b) What are the best conditions for evaluating educational courseware, in terms of timing and interaction (individually or in pairs, restricted or not restricted trial time, ideal or bad environmental conditions)?

(c) What kind of cognitive moves take place while interacting with the program?

(d) If pairs were used, how would this affect the number of times the user asks the system for more information, thus reducing or enhancing the use of the linking capabilities of the medium?

(e) What are the kind of human-human interactions that would be supported while using the program?

(f) Would the use of pairs have a better effect on retention and satisfaction of students using hypermedia?

(g) How can well-suited anchors be identified for the different kinds of learners?

(h) What would be the effect of the different degrees of learner control from the other modules envisaged for the final product on novice learners?

(i) What is the set of variables that can be associated with the motivation of a student when interacting with hypermedia programs?

(j) Would the differences between the two modules favour student's motivation, or not?

(k) What approaches could be used to implement a quicker, yet valid evaluation of courseware for learning?

These questions remain open for further research using this particular system; however, they do address issues that can be found in other educational hypermedia courseware, and they still await answers

As a concluding remark it should be said that the evaluation of this prototype had to be adapted to the conditions in which the program was to be used, and to the time constraints of the development team. Nevertheless, these conditions are not particular to this project, and have to be contemplated as part of the feasibility and propriety standards set by the Joint Committee on Evaluation for Standards of Educational Evaluation. (1981) Most evaluation studies need to maximize time, money, availability of judges and subjects, and the availability of material resources appropriate for the setting where the product will be used; all this in order to ensure the quality of a product that can be introduced in a timely fashion and be competitive in the market The use of quantitative data, combined with qualitative data, which may clarify interpretations, was certainly valuable in this case It permitted the evaluator to maximize the information obtained using limited resources, leading to practical and specific suggestions for improvement.

The value of information provided through evaluative studies that take into consideration the different aspects involved in production (e.g., instructional, visual, and technical design) is unquestionable not only in terms of ensuring the quality of the product itself, but also in clarifying the way it should be implemented. As Harbour (1992) points out, "success of technological implementation [...] deals more with humans than with technology." Even though courseware developers have been somewhat successful in accelerating courseware production through strategies like rapid prototyping (Tripp & Bitchmeyer, 1990), they still need to work more on developing efficient and effective ways of conducting evaluations to avoid flooding the market with low quality or wrongly implemented products

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Appendix A

Interview Questions

Basic Questions for Interview with Subject Matter Experts and with Focus Group.

These questions were used for the unstructured interview with subject matter experts and students from the focus group. All interviews except two, took place at the researcher's office, after the evaluators had reviewed the storyboard.

- Does the programme correspond to what you expected?
- Are there any important contents missing?
- Is there any irrelevant information that should be discarded?
- Are examples interesting?
- Are more examples needed?
- What other examples would you suggest to include?
- Is the content clear?
- Is it conducive to learning?
- Do you think this programme will be helpful?

Appendix B

Storyboard Evaluation Instruments

May 5, 1993

Dear Mrs.

Thank you for accepting to participate as a subject matter expert in the evaluation process of this product. In this first stage, the content accuracy and language use is being evaluated. Attached to this letter you will find three packages:

1) a description of the product and a map of the content structure,
2) the storyboard with the content screens for the first and third modules of the programme (i.e. ,instructional design and production)
3) two evaluation instruments: one that evaluates the product in general, and another where content to be changed should be specified.

Each instrument has its own instructions for you to follow Since the first instrument is an attitudinal scale, try to fill it in without being influenced by the second instrument. Should you have any questions as how to proceed or how to fill them in, please do not hesitate to contact me (home 524-3975, university 848-8643.)

Sincerely,

Laura Helena Porras-Hernández

May 5, 1993

Dear Student.

Thank you for accepting to participate in the evaluation process of this product. In this first stage, the content depth and language use, as well as special features are being evaluated. Attached to this letter you will find three sections·

1) a description of the product and a map of the content structure,
2) the storyboard with the content screens for one of the modules of the programme (i.e., instructional design or visual design or production)
3) two evaluation instruments: one that evaluates the product in general, and another where content to be changed should be specified.

Each instrument has its own instructions for you to follow. Since the first instrument is an attitudinal scale, try to fill it in without being influenced by the second instrument. Should you have any questions as how to proceed or how to fill them in, please do not hesitate to contact me (home 524-3975, university 848-8643)

Sincerely,

Laura Helena Porras-Hernández

Description of the Product

A Tutorial on the Design and Production of Hypermedia
(Module: Hypermedia for Education)

Objective

Allow the user to experience the process of design and development of a hypermedia product for educational purposes

Learner Characteristics

a) Graduate Students in Educational Technology
b) Have some background in instructional design
c) Interested in production of educational materials
d) Little or no knowledge of tools and technologies for hypermedia production

Description of the Product

Strategy:

Tutorial that guides the user along the phases involved in the process of design and production of an instructional hypermedia application The user takes an active role and is able to act at three different levels:

- decision-making
- exploration
- simulation

Content:

The process is divided into three main phases:

1) Instructional Design
2) Storyboarding and Visual Design
3) Production

Each phase has a specific instructional goal. At the end of the Instructional Design phase the learner will be able to define the strategy, content structure

and appropriate architecture of her product according to a chosen instructional objective.

By the end of the Storyboarding and Visual Design Phase, the learner will be able to identify the key principles for functional and aesthetic design as well as the best format for illustrating the content. For this purpose the learner will have access to the theory behind these issues; moreover, he/she will be able to apply the principles by selecting illustrations in different formats from a database.

The Production phase is intended to give the learner the opportunity to:

a) be aware of the hardware and software available for hypermedia production.

b) experience simulations of image scanning, sound recording and video digitizing in the Mac environment.

c) develop a simple prototype (twenty screens maximum) where she can edit text, images and sounds and specify links among cards.

At the end of each phase a checklist is provided to make the learner aware of the need to conduct formative evaluation of intermediate products -instructional design, storyboard, prototype- as well as testing and summative evaluation of the final product.

A detailed map of the content and the structure of the tutorial is provided in Figure 1

Features:

a) Practice and Feedback

Different opportunities for practice are provided in each phase.

- Instructional Design.

  The learner will define the learning scenario where his product will be used, classify his learning objective, build a concept map and decide the kind of architecture of the product. Feedback is provided for the classification of objectives.

- Storyboarding and Visual Design.

  The learner will select materials in different formats to illustrate the content. Feedback on the appropriateness of her choices will be provided according to the variables defined in the learning scenario.

- Production.

The learner will create a small prototype of a hypermedia tutorial as was explained before. Since this is an open environment, no feedback is provided.

b) Navigation:

The user will be able to follow the whole process or directly jump to any of the phases she is interested in through a navigational map that is always available

Other options for accessing detailed contents are provided by hypertext, or sensitive areas in illustrations This additional information will be displayed in different ways according to its complexity and its source (hypertext or sensitive areas):

- balloons for small pieces of information associated with illustrations.
- overlay windows when only verbal information is associated with hypertext.
- full screen windows when verbal information plus illustrations are provided. These screens have the same interface characteristics as the ones at the main level.

c) Functionalities:

- Glossary of terms and related references
- Local Help
- Navigational Map with tracing
- Recording of individual sessions
- Recording of time spent on each screen

Style

The style of the product is very direct and tries to create a comfortable working and exploratory environment. In order to do so, language is kept simple and direct, (although the use of some technical vocabulary cannot be avoided), and it was the authors' intent to create a relaxing atmosphere where three basic areas can be identified: 1) the dialogue box where instructions and information is provided, 2) the working area that has objects with 3-D effect to

give the sensation of space to invite the student to manipulate things and explore., and 3) the navigation area, where buttons to navigate and access special functionalities are provided.

Rationale for Media Selection

Considering the kind of content to be addressed as well as the instructional objectives to be achieved, hypermedia was selected as the appropriate environment to allow the user to get engaged in the learning experience at two levels:

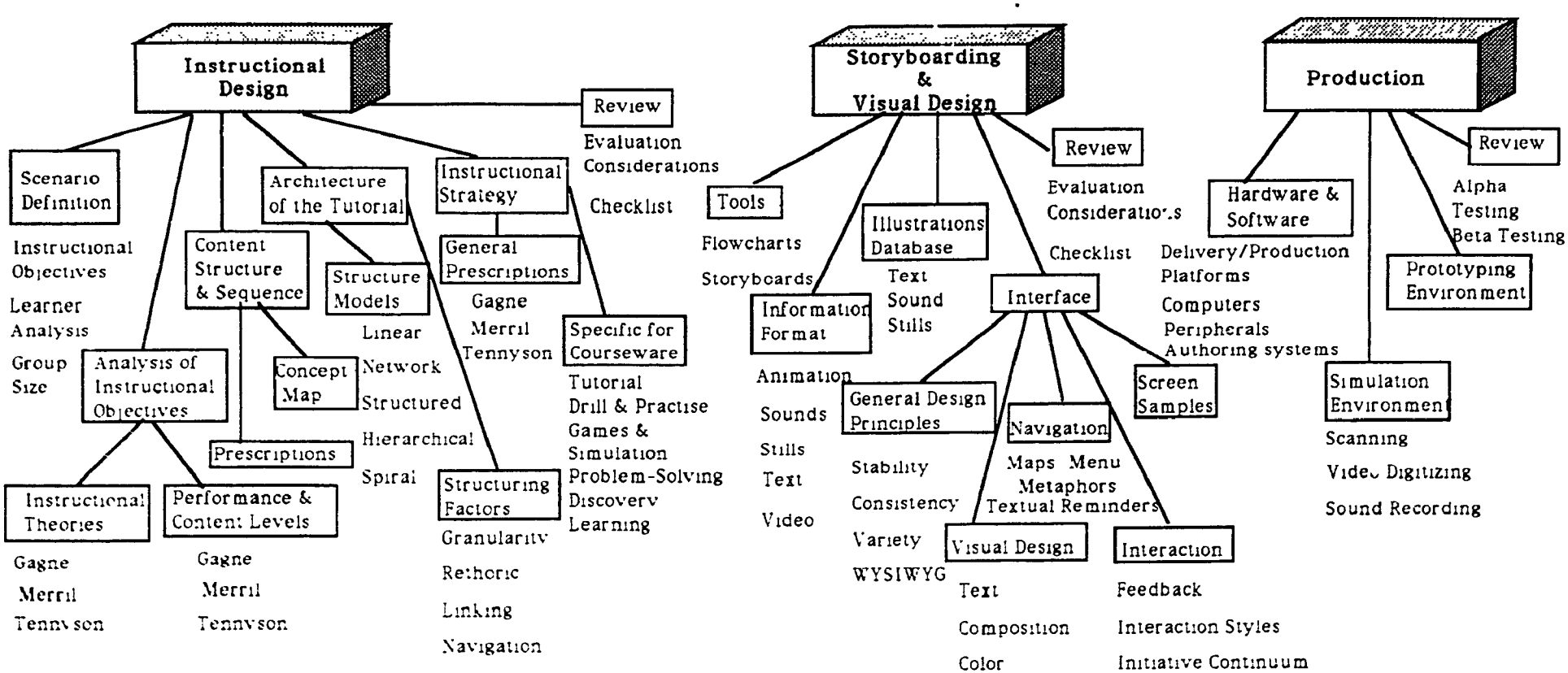
1) As a user of a hypermedia product

2) As a designer and developer of hypermedia products

Besides the instructional reasons above provided, the technical considerations also played an important role in the media selection. If another medium had been used, it would have been almost impossible to simulate the actual development steps because of the production tools and the variety of information formats involved.

Production Platform and Authoring tool

The final product will be developed in a Macintosh Quadra 700 using SuperCard 1.6 as an authoring tool. This platform was selected for development as well as for delivery because the available memory allows rapid and easy manipulation of images, sound and animation. SuperCard was selected because of its capability to use color and build sensitive areas with different shapes, its facilities to build windows, keep a trace of students' paths and interfacing external applications.

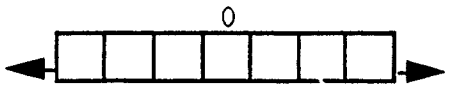

Instructional Design
Review
Evaluation
Considerations
Checklist
Scenario Definition
Instructional Objectives
Learner Analysis
Group Size
Analysis of Instructional Objectives
Instructional Theories
Gagne
Merril
Tennyson
Performance & Content Levels
Gagne
Merril
Tennyson
Content Structure & Sequence
Concept Map
Prescriptions
Architecture of the Tutorial
Structure Models
Linear
Network
Structured
Hierarchical
Spiral
Instructional Strategy
General Prescriptions
Gagne
Merril
Tennyson
Specific for Courseware
Tutorial
Drill & Practise
Games & Simulation
Problem-Solving
Discovery
Learning
Structuring Factors
Granularity
Rethoric
Linking
Navigation
Storyboarding & Visual Design
Review
Evaluation Considerations
Checklist
Tools
Flowcharts
Storyboards
Information Format
Animation
Sounds
Stills
Text
Video
Illustrations Database
Text
Sound
Stills
Interface
General Design Principles
Stability
Consistency
Variety
WYSIWYG
Navigation
Maps Menu
Metaphors
Textual Reminders
Visual Design
Text
Composition
Color
Icon Design
Visual Effects
Interaction
Feedback
Interaction Styles
Initiative Continuum
Input/output devices
Screen Samples
Production
Review
Alpha Testing
Beta Testing
Hardware & Software
Delivery/Production Platforms
Computers
Peripherals
Authoring systems
Prototyping Environment
Simulation Environment
Scanning
Video Digitizing
Sound Recording

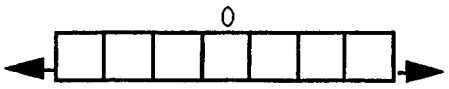
Evaluation Instrument I

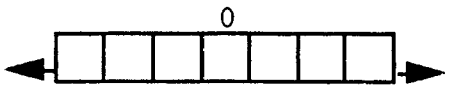
Evaluation of Content and Language Use.

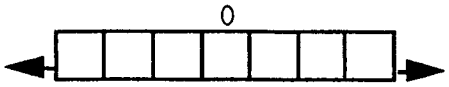
Instructions: For each question, please tick in the one box which best rates the characteristics of this programme.

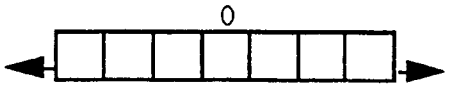
The **content** of this programme is:

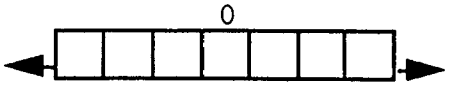
1 Incomplete  Complete

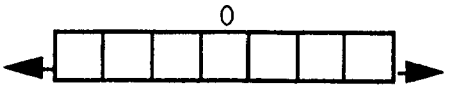
2 Well linked  Wrongly linked

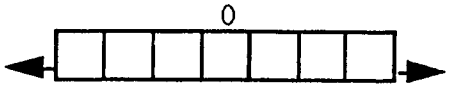
3. Accurate  Inaccurate

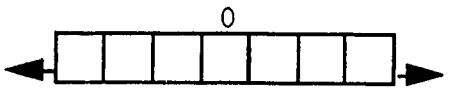
4. Deep  Superficial

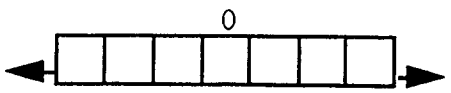
5. Neutral  Biased

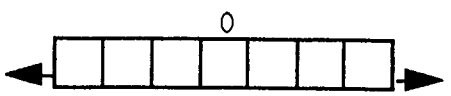
6 Unclear  Clear

7. Simple  Difficult

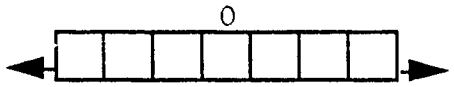
8 Boring  Challenging

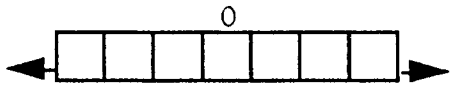
9 Focused on topic  Diverges from topic

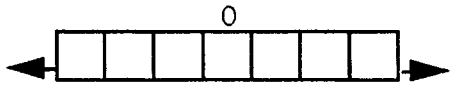
10 Irrelevant  Relevant

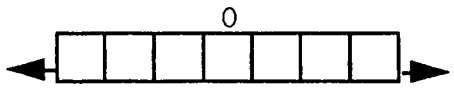
11 Consistent with objectives  Inconsistent with objectives

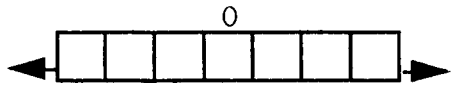
The illustrations and examples used are:

12.Interesting  Boring

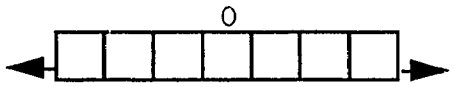
13.Relevant  Irrelevant

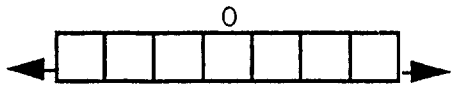
14.Useless  Useful

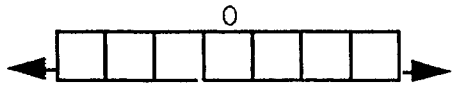
15.Clear  Unclear

16.Poor  Rich

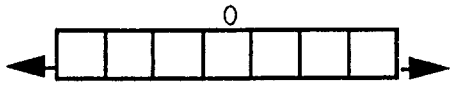
The **navigational tools** provided are.

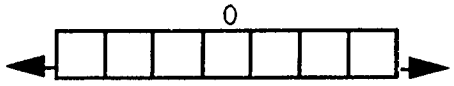
17.Clear  Unclear

18.Useless  Useful

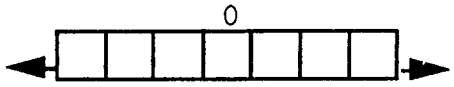
19.Enough  Not sufficient

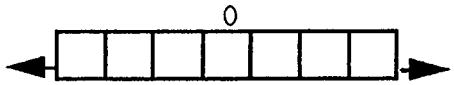
The **special features** provided by the programme (i.e , navigational map, help, glossary and references) are:

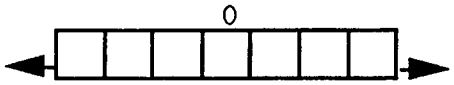
20.Useful  Useless

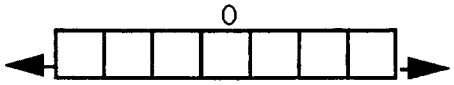
21.Clear  Unclear

The **language and vocabulary** used to present it is:

22.Clear  Unclear

23.Low  High

24.Appropriate  Inappropriate

25.Straightforward  Complex

Evaluation Instrument II

Suggested Content Changes.

Instructions: Find any content misconceptions or errors in the storyboard Record on the grid the storyboard's screen number, the error, and the changes to be made, under the appropriate column.

Screen No.	Error (says)	Correction (should say)

Screen No.	Error (says)	Correction (should say)

Appendix C

Consent Form and Pretest Questionnaire

June 22, 1993

Dear Student,

A prototype of a multimedia programme that is intended as a teaching and instructional tool in educational technology is presently being developed at Concordia University. In order to ensure the quality of the product, a formative evaluation is being conducted.

One of the phases of the evaluation schedule is the trial of the product by educational technology students who will act as end-user evaluators of the product. Therefore, your participation is being solicited. It must be said that all the information collected through this process will be anonymous and will be handled confidentially. Only processed results (i.e. summary data) will be used by the team for the improvement of the product.

If you agree to participate, you will be taking part in a three phase evaluation process:

1) a pre-test questionnaire, which will collect data on demographics, previous experience, previous knowledge and general attitudes to computers.

2) the actual trial of the prototype on an individual basis.

3) a post-test questionnaire, which consists of your evaluation of the product across several dimensions, and measures concerning attitudes, satisfaction and learning impact.

If you are willing to enrich our project with your valuable feedback, please sign this consent form to participate in the study.

If you have any questions about the process, do not hesitate to ask.

Sincerely,

Laura Helena Porras-Hernández

I (*name*)_____ hereby accept to participate in the three phases of the evaluation process described.

_____ _____

Date Signature

Pretest Questionnaire

Last 4 digits of ID___ ___ ___

Thank you for accepting to participate in this study. The first instrument for the evaluation process is divided into four sections. Please, follow the instructions in each section and make sure to answer all the questions. Any answer provided in this questionnaire will be held in anonymity and confidentiality and will be used only with the purpose of improving this product.

Instructions: Tick the appropriate box

I. Demographics

1. Sex

Male ☐ Female ☐

2. In which programme are you presently enrolled?

Diploma (ETEC) ☐ MA (ETEC) ☐

PhD (ETEC) ☐ Other (specify)_____

3. How many years have you been enrolled in this programme?

0-1 ☐ 2-3 ☐ 3 or more ☐

4. What is your student status?

Full-time ☐ Part-time ☐

5. Indicate previous university degrees obtained. (Specify level and field)

Degree (BA, Diploma, etc.)	Field
_____	_____
_____	_____
_____	_____

II. Previous Experience

6 Indicate any courses you have taken related to Instructional design or the use of computers in education.

_____ _____

_____ _____

_____ _____

7. What is your experience using computers?

None ☐ Little ☐ Moderate ☐ Extensive ☐

8 What kind of computers do you use?

Mac ☐ PC or clone ☐

Amiga ☐ Other (specify)_____

9 Have you any experience with hypertext programmes?

Yes ☐ No ☐

10. If yes, what kind of experience was it?

From reading ☐ From watching ☐

From trying ☐ From developing ☐

11.Have you any experience with hypermedia programmes?

Yes ☐ No ☐

12 If yes, what kind of experience was it?

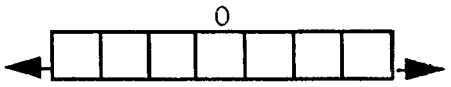
From reading ☐ From watching ☐

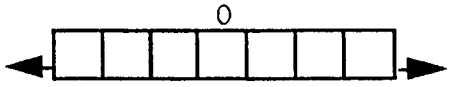
From trying ☐ From developing ☐

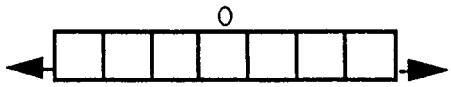
III. Attitudes

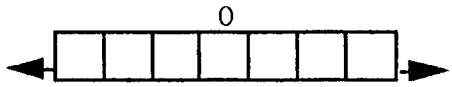
Instructions: Rate the following statement ticking your sincere answer in the scales provided.

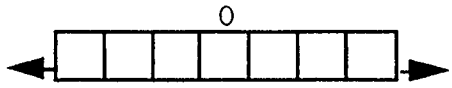
I think that the use of computers in education is:

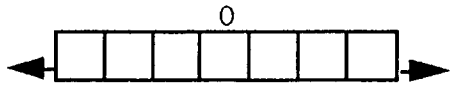
11. efficient consuming  time

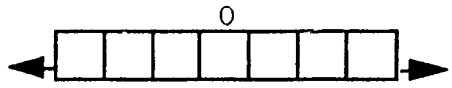
12. boring  interesting

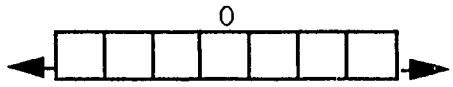
13. flexible  rigid

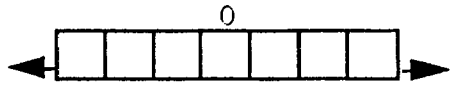
14. content neutral  content biased

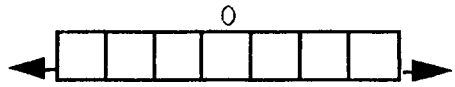
15. difficult  easy

16.a hinders creativity  enhances creativity

17. frustrating  exciting

18. socially egalitarian  socially unfair

19. for lower-order skills  for higher-order skills

20. effective  ineffective

IV Previous Knowledge

Instructions: This section refers to specific knowledge of the process of hypermedia design and production. Please check the most appropriate answer for each of the questions. If you do not know an answer, please select the "e) I do not know" choice.

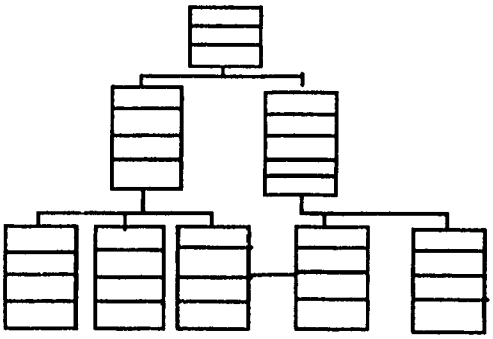
1 What kind of instructional strategy would be most appropriate to use for teaching a completely new topic to small children, if the programme should be a stand alone product?

a) Problem-Solving
b) Tutorial
c) Drill and Practise
d) Discovery Learning
e) I do not know
Why?_____

2. What kind of graphical representation would you use for an instructional objective where the application of a general rule is being taught.

a) List of concepts
b) Concept tree
c) a & b
d) Causal chain
e) I do not know

3 If your content is linked as in the following graphic, what kind of architecture would it be most appropriate to use?



a) Structured
b) Network
c) Hierarchical
d) Spiral
e) I do not know

4. The phases for the design and production of hypermedia systems are:

a) visual design, production, and review

b) Instructional design, visual design and review

c) Instructional design, visual design and production

d) Instructional design, production and review

e) I do not know

5. The three variables of an instructional setting playing a key role in the design of instructional hypermedia are:

a) Content, expected performance, instructional strategy

b) Objective, learner characteristics, learning conditions

c) Objective, learner's age, learner's experience

d) a & c

e) I do not know

6. The analysis of instructional objectives allows the designer to:

a) Determine the level of expected performance

b) Determine the kind of content

c) Determine prescriptions for instruction

d) All of the above

e) I do not know

7. At the end of the instructional design phase of a hypermedia programme for education, external evaluators are:

a) Graphic design experts,

b) The production team

c) Subject matter experts

d) None of the above

e) I do not know

8. If you were to consider external as well as internal sources of information for learning, which instructional design theory would be most appropriate to use?

a) Gagné's
b) Merrill's
c) Tennyson's
d) a and/or b
e) I do not know

9. The design of narrations is most commonly used with:

a) drill and practice
b) microworlds
c) tutorials
d) presentations
e) I don not know

10. Around which type of organization would you structure your content if your aim is to facilitate the completion of a work?

a) concepts
b) tasks
c) knowledge
d) decision making
e) I do not know

Thank you for your help

Appendix D

Evaluation Form

EVALUATION INSTRUMENT

GENERAL INFORMATION ON THE SOFTWARE

NAME OF SOFTWARE: _____

SUBJECT/CONTENT: _____

TARGET AUDIENCE LEVEL: _____

DATE OF REVIEW: _____

LAST 4 DIGITS OF REVIEWER's ID:_____, _____, _____, _____ .

Instructions: Please, evaluate the software used ticking one box per item. If a feature was not used or explored, mark "N.E". General comments can be written in the "Comments" boxes at the end of each section. Thank you

DOCUMENTATION

On-line and off-line.

	poor	sufficient	good	N.E
clear and logical presentation of content	☐	☐	☐	☐
clear instructions to operate the program	☐	☐	☐	☐
examples of on-screen visual display	☐	☐	☐	☐
bibliography for related information	☐	☐	☐	☐
source to contact for problems	☐	☐	☐	☐

Comments:

INSTRUCTIONAL ISSUES

entry skills

prerequisite skills stated yes ☐ no ☐

content presentation

	poor	sufficient	good	N.E
appropriate vocabulary for target audience	☐	☐	☐	☐
content accuracy	☐	☐	☐	☐
content free of biases	☐	☐	☐	☐
consistency of content with stated objectives	☐	☐	☐	☐
possibility of updating content	☐	☐	☐	☐
cross-referencing between contents	☐	☐	☐	☐
branching opportunities	☐	☐	☐	☐
variety of explanations	☐	☐	☐	☐
clues to key concepts	☐	☐	☐	☐
outlines, summaries, reviews to organize ideas	☐	☐	☐	☐
motivating and challenging environment	☐	☐	☐	☐

practice & interaction:

	none	poor	sufficient	good	N.E
instructions for interaction	☐	☐	☐	☐	☐
ease of interaction	☐	☐	☐	☐	☐
amount of practice	☐	☐	☐	☐	☐
relevance to stated objectives	☐	☐	☐	☐	☐
opportunity for transfer & generalization	☐	☐	☐	☐	☐

questioning techniques

various techniques are used	yes ☐	no ☐
questions are appropriate for audience	yes ☐	no ☐
questions are appropriate for content	yes ☐	no ☐
explanation is provided for unclear assignments	yes ☐	no ☐
questions are effectively randomized	yes ☐	no ☐
unpredictable patterns are considered	yes ☐	no ☐

feedback

appropriate for the audience	yes ☐	no ☐
accurate evaluation of right or wrong answers	yes ☐	no ☐
motivational and sensitive to users needs	yes ☐	no ☐
immediate	yes ☐	no ☐
flexible in accepting learning responses	yes ☐	no ☐
providing cues or prompts for wrong answers	yes ☐	no ☐
relevant to history of responses	yes ☐	no ☐
assistance provided within the lesson	yes ☐	no ☐
re-explanation provided	yes ☐	no ☐

evaluation

	none	poor	sufficient	good	N.E
systematic review of learned materials	☐	☐	☐	☐	☐
appropriate presentation of post test	☐	☐	☐	☐	☐
consistency of post-test and objectives	☐	☐	☐	☐	☐

control for

	none	poor	sufficient	good	N.E
content sequence	☐	☐	☐	☐	☐
rate of presentation	☐	☐	☐	☐	☐
timed input	☐	☐	☐	☐	☐
type of feedback (graphic vs. text)	☐	☐	☐	☐	☐
sound control	☐	☐	☐	☐	☐
content of feedback	☐	☐	☐	☐	☐
mastery level	☐	☐	☐	☐	☐

Comments:

TECHNICAL DESIGN

screen displays:

	none	poor	sufficient	good	N.E.
appropriate text size	☐	☐	☐	☐	☐
appropriate amount of material	☐	☐	☐	☐	☐
text easy to read	☐	☐	☐	☐	☐
smooth screen transitions	☐	☐	☐	☐	☐
time required for transitions	☐	☐	☐	☐	☐
appropriate use of colors	☐	☐	☐	☐	☐
graphics support to instruction	☐	☐	☐	☐	☐
relevance to learner's age and ability	☐	☐	☐	☐	☐
animation support	☐	☐	☐	☐	☐
quality and clarity of displays	☐	☐	☐	☐	☐
appropriate use of sound	☐	☐	☐	☐	☐
appropriate use of multimedia	☐	☐	☐	☐	☐
control degree for screens	☐	☐	☐	☐	☐

special features:

	none	poor	sufficient	good	N.E.
glossary	☐	☐	☐	☐	☐
navigational map	☐	☐	☐	☐	☐
possibility of marking parts of the content	☐	☐	☐	☐	☐
record storing for future student retrieval	☐	☐	☐	☐	☐

Comments:

GENERAL COMMENTS OF THE REVIEWER:

Appendix E

Post-test Questionnaire

Post-test Questionnaire

Last 4 digits of ID __ __ __ __

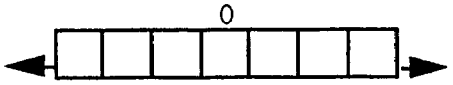
After having tried the programme, the information collected through this instrument will be very helpful to improve the quality of our product. Any answer provided in this questionnaire will be held in anonymity and confidentiality.

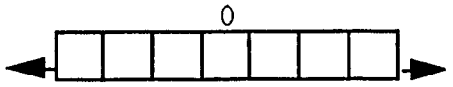
This instrument is divided into four sections. Please, follow the instructions in each section and make sure you answer all the questions.

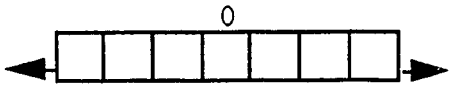
I. Attitudes

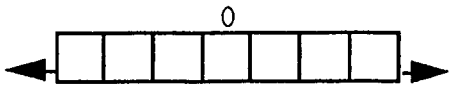
Instructions: Rate the following statement ticking your sincere answer in the scales provided.

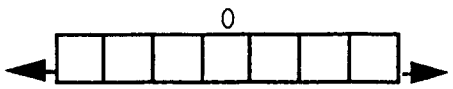
I think that the use of computers in education is:

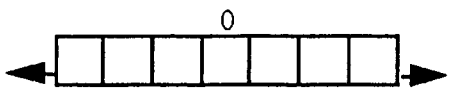
11. efficient  time consuming

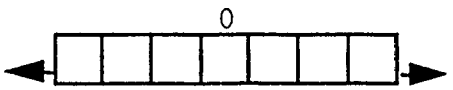
12 boring  interesting

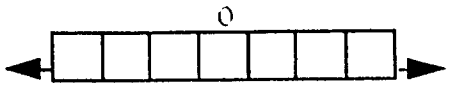
13. flexible  rigid

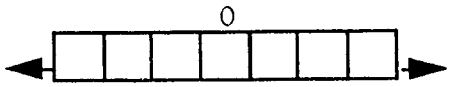
14. content neutral  content biased

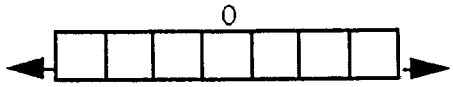
15. difficult  easy

16. hinders creativity  enhances creativity

17 frustrating  exciting

18. socially egalitarian  socially unfair

19. for lower-order skills  for higher-order skills

20 effective  ineffective

II. Knowledge.

Instructions. This section refers to specific knowledge of the process of hypermedia design and production. Please check the most appropriate answer for each of the questions If you do not know an answer, please select the "e) I do not know" choice

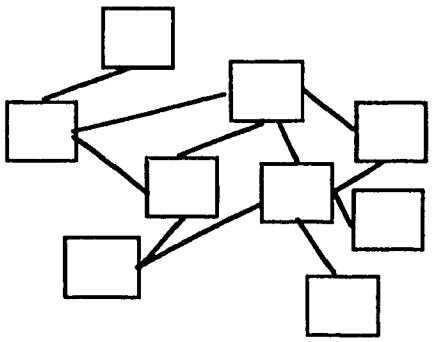
1 What kind of instructional strategy would be most appropriate to use for teaching a completely new topic to young adults, if the programme should be a stand alone product?

a) Problem-Solving
b) Tutorial
c) Drill and Practise
d) Discovery Learning
e) I do not know
Why?_____ _____

2. A concept tree would be the best graphical representation of an instructional objective whose content is:

a) Factual information
b) Procedural knowledge
c) Hierarchical knowledge
d) b&c
e) I do not know

3. If your content is linked as in the following graphic, what kind of architecture would it be most appropriate to use?



a) Structured
b) Network
c) Hierarchical
d) Spiral
e) I do not know

4. Phases corresponding to the pre-production stage in hypermedia design and development are:

a) visual design, production, and review

b) Instructional design, visual design and review

c) Instructional design, visual design and production

d) Instructional design, production and review

e) I do not know

5. The three variables of an instructional setting playing a key role in the design of instructional hypermedia are:

a) Objective, learner characteristics, learning conditions

b) Content, expected performance, instructional strategy

c) Objective, learner's age, learner's experience

d) b & c

e) I do not know

6. The analysis of instructional objectives allows the designer to:

a) Determine the sequence and structure

b) Determine the kind of content and performance

c) Determine prescriptions for presentation and practice

d) All of the above

e) I do not know

7. At the end of the instructional design phase, external evaluators can be:

a) Subject matter experts

b) Other instructional designers

c) Graphic design experts

d) a & b

e) I do not know

8 If you were to consider internal sources of information for learning only, which instructional design theory would be most appropriate to use?

a) Gagné's

b) Merrill's

c) Tennyson's

d) a and/or b

e) I do not know

9. The design of microworlds is based on:

a) drill and practice

b) discovery learning

c) narrations

d) presentations

e) I don not know

10. Around which type of organization would you structure your content if your aim is to represent subject matter knowledge?

a) concepts

b) tasks

c) knowledge

d) decision making

e) I don not know

III Satisfaction

Instructions: Rate the following statements by selecting the one appropriate box

	Strongly Agree	Agree	Un decided	Disagree	Strongly Disagree
1. The system characteristics match with what I expected.					
2. I did not like the examples provided.					
3. I felt satisfied with the content covered.					
4. The programme was able to keep my interest in the content.					
5. I will never use this programme again.					
6. I do not feel to have learned much from this programme.					
7. The information covered is relevant for ETEC students.					
8. I felt frustrated when using the programme.					
9. This programme adds nothing to the present multimedia classes.					
10.It was pleasant to work with this system.					
11.This system invites the learner to explore the content.					
12.It is a boring programme.					
13.This is not a useful learning material for ETEC students.					

	Strongly Agree	Agree	Un-decided	Disagree	Strongly Disagree
14.The programme is not motivating.					
15.I was 'isappointed by the programme content.					
16.I do not see any application of this programme in ETEC courses.					
17 The programme is challenging					
18.I enjoyed trying out the product.					
19. I would not recommend this system to other students.					
20. I would like to see the rest of the programme.					
21. I wish more students could use it.					
22. I learned interesting things through the programme					
23. It invites the user to get involved in multimedia production					
24. I did not like the programme at all.					
25. It adds more to the mere technicalities of production					

Thank you very much for your time and valuable help.

Appendix F

Documentation

Hyperworld
(Documentation)

• What this Programme is about.

The objective of this programme is to guide the user through the process of design and development of hypermedia for different purposes: a) presentations, b) information, and c) education and training.

Since this product is a prototype, the only topic available is the instructional design section of hypermedia for education and training. In this section, you will make a series of decisions regarding instructional design. By the end, you will have a clear idea of the objective, users, content structure, and instructional strategy of a hypermedia instructional unit of your choice.

This is a self-paced material, with no time restrictions. However, your knowledge will be evaluated through a post-test, that the instructor will give to you as soon as you finish using the programme.

• Who is this programme for.

a) Graduate Students in Educational Technology

b) Those who have some background in instructional design

c) Those interested in production of educational materials

d) Those with little or no knowledge of tools and technologies for hypermedia production.

• How to Start.

1) Double-click on the stack named Hyperworld. After a few seconds the presentation window will be displayed.

2) Press anywhere to stop the animation and start the programme.

3) Answer the questions asked by the programme. Your answers will be used for software evaluation purposes.

4) Select "Hypermedia for Education and Training"

5) Follow the instructions in the window. When choosing the topic you want to start with, remember that only the Instructional Design section is active

(green on the map.) A map of this section is reproduced on paper at the end of this document.

5) Each screen presents some information in a dialogue box Important terms that can be explored in more depth are presented in violet-rose Instructions to use the programme are presented in blue.

6) As soon as you finish the programme, ask the instructor for a post-test and an evaluation form.

• How to Navigate in the Programme.

Navigational Map

The second screen presents a map of the content. Browsing on the different topics (by moving the cursor around the map) you will be able to see what is included in each of them at different levels. From this screen you can access any topic in opaque green or start with the first one.

Hypertext

Any word in violet is linked to more information on the subject. If you are willing to explore the theory behind the information presented, this is the way to access it.

Buttons

On the right hand-side of the screen a series of buttons is presented Dim buttons indicate that they are not active.

Glossary. Brings you to the glossary list displaying a term related to the screen from which you accessed the glossary. You can type the first letter(s) of the word you want to look at and an explanation will be given To go back, press the "Quit Glossary" button

Help. Complementary instructions on what to do in each screen are given in the form of audio or text. The information given by this button is specific to the current screen.

Go Up. If you have accessed a topic through hypertext, you can go back one level of the map. By pressing this icon at the second level, you can access the map and jump to any other topic of your interest.

Quit. Leave the programme. There are two ways of quitting:
a) saving your session. (mem.session.) In this way you can start later from the point where you exited in the last session. All your decisions will be recorded.
b) without saving. (quit) The computer won't remember your decisions, or where you left off, if you restart later.

Go Forward. Brings you to the next screen at the same level, according to the map.

Go Back. Brings you to the previous screen in the same level of the map.

Close Window. Closes an overlay window.

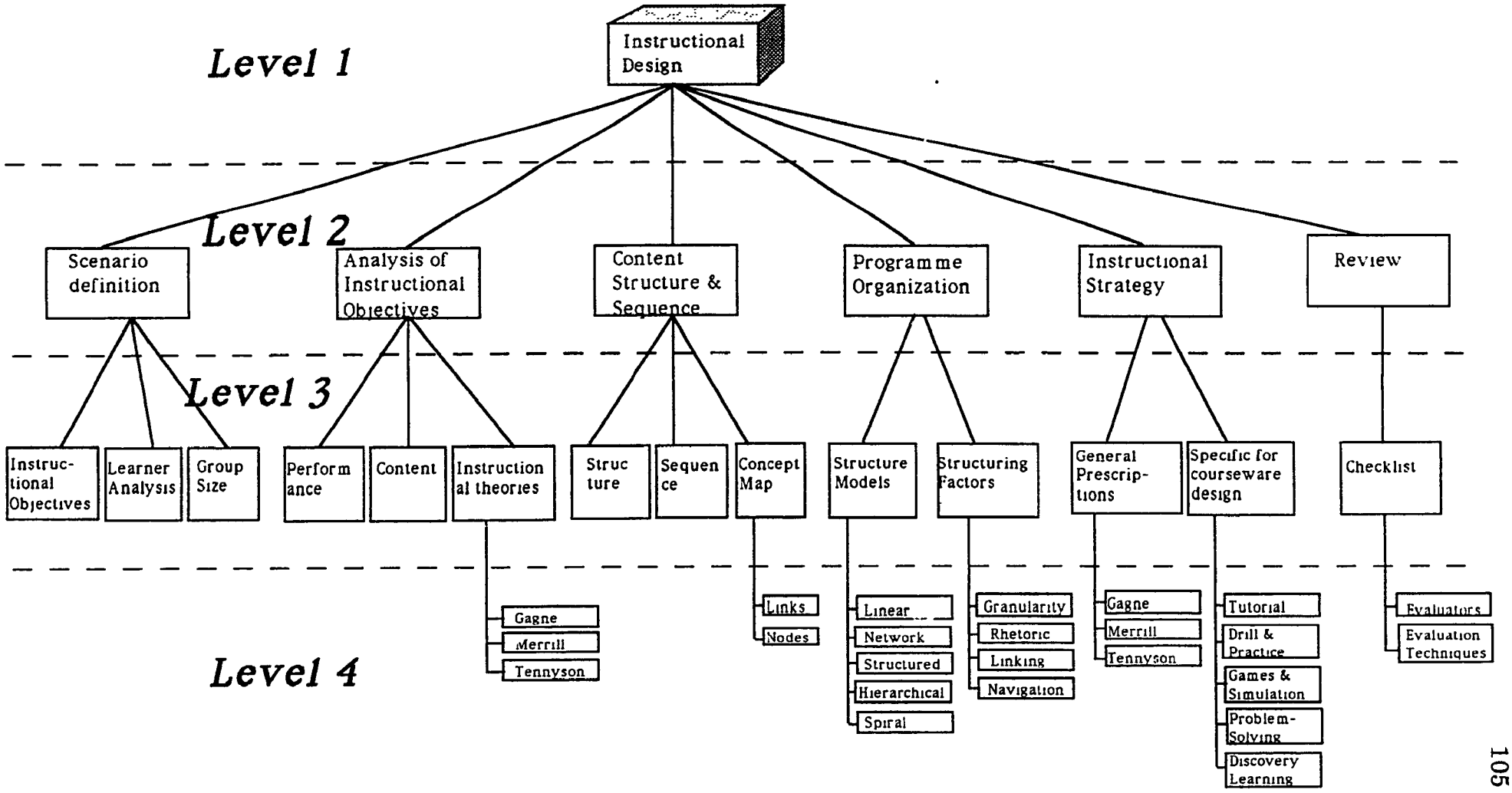
Design Tips. Presents overlay windows with deeper information about a particular screen.

Quit Glossary Brings you back to the screen from which you accessed the glossary

Credits. Presents the design and production team.

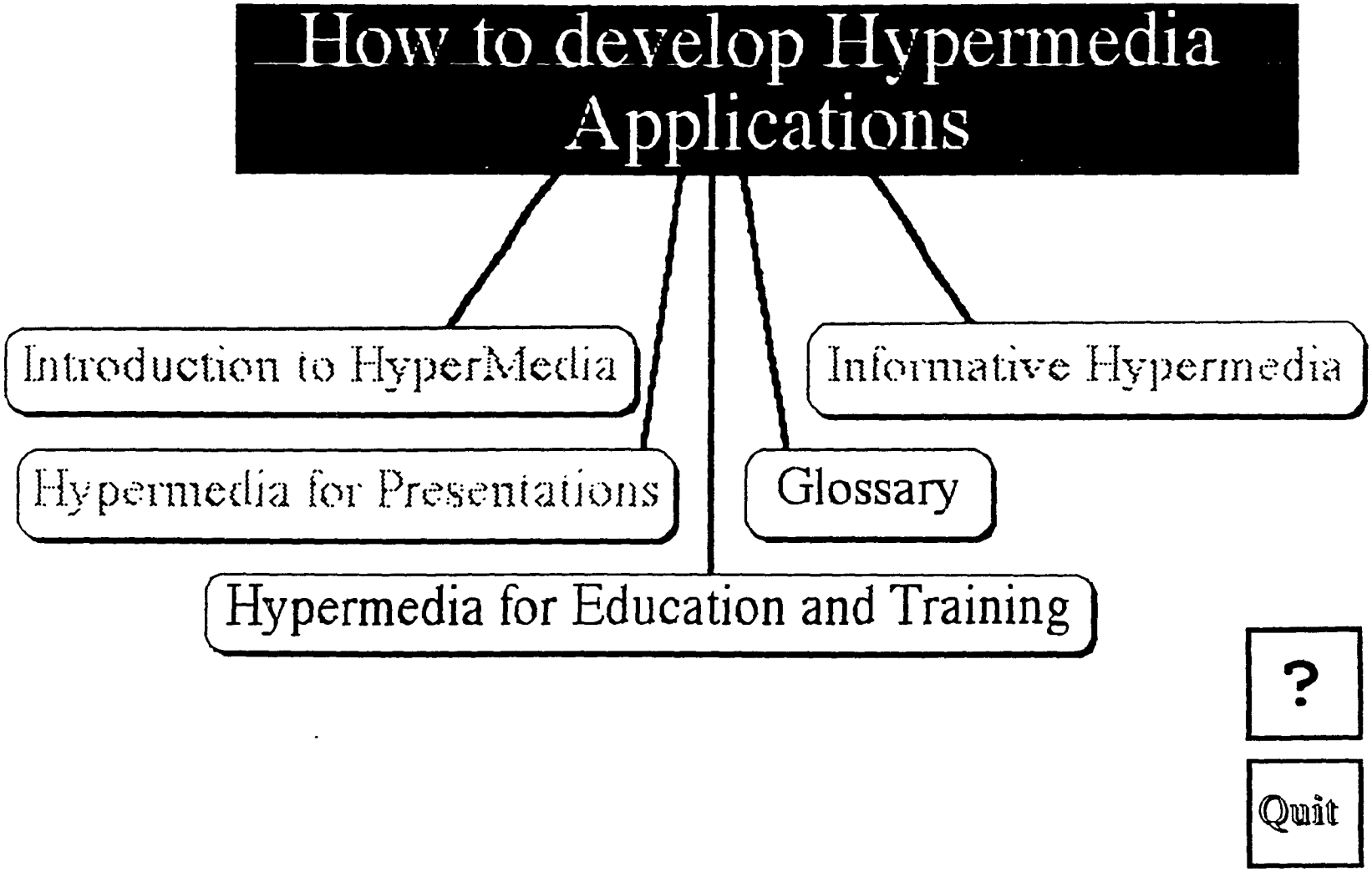
• Questions?

Use the help button or ask the monitoring person. Do not feel afraid to explore or try anything. Good Luck!!!.


Level 1
Instructional Design
Level 2
Scenario definition
Analysis of Instructional Objectives
Content Structure & Sequence
Programme Organization
Instructional Strategy
Review
Level 3
Instruc-tional Objectives
Learner Analysis
Group Size
Perform ance
Content
Instruction al theories
Struc ture
Sequen ce
Concept Map
Structure Models
Structuring Factors
General Prescrip-tions
Specific for courseware design
Checklist
Level 4
Gagne
Merrill
Tennyson
Links
Nodes
Linear
Network
Structured
Hierarchical
Spiral
Granularity
Rhetoric
Linking
Navigation
Gagne
Merrill
Tennyson
Tutorial
Drill & Practice
Games & Simulation
Problem-Solving
Discovery Learning
Evaluators
Evaluation Techniques

Appendix G

Examples of Screen Layout.


How to develop Hypermedia Applications
Introduction to HyperMedia
Informative Hypermedia
Hypermedia for Presentations
Glossary
Hypermedia for Education and Training
?
Quit

There are three main phases in the design and development of an instructional product : '

Instructional design , Storyboarding & visual design and Production .

The process starts with the definition of the learning scenario where your product will be implemented. If you already know the process you can jump to the topic of your interest (by clicking the corresponding red box) or go to the first topic (button 'First Topic').

Instructional design

Storyboarding & visual design

Production

?

Quit

First Topic

Scenario Definition

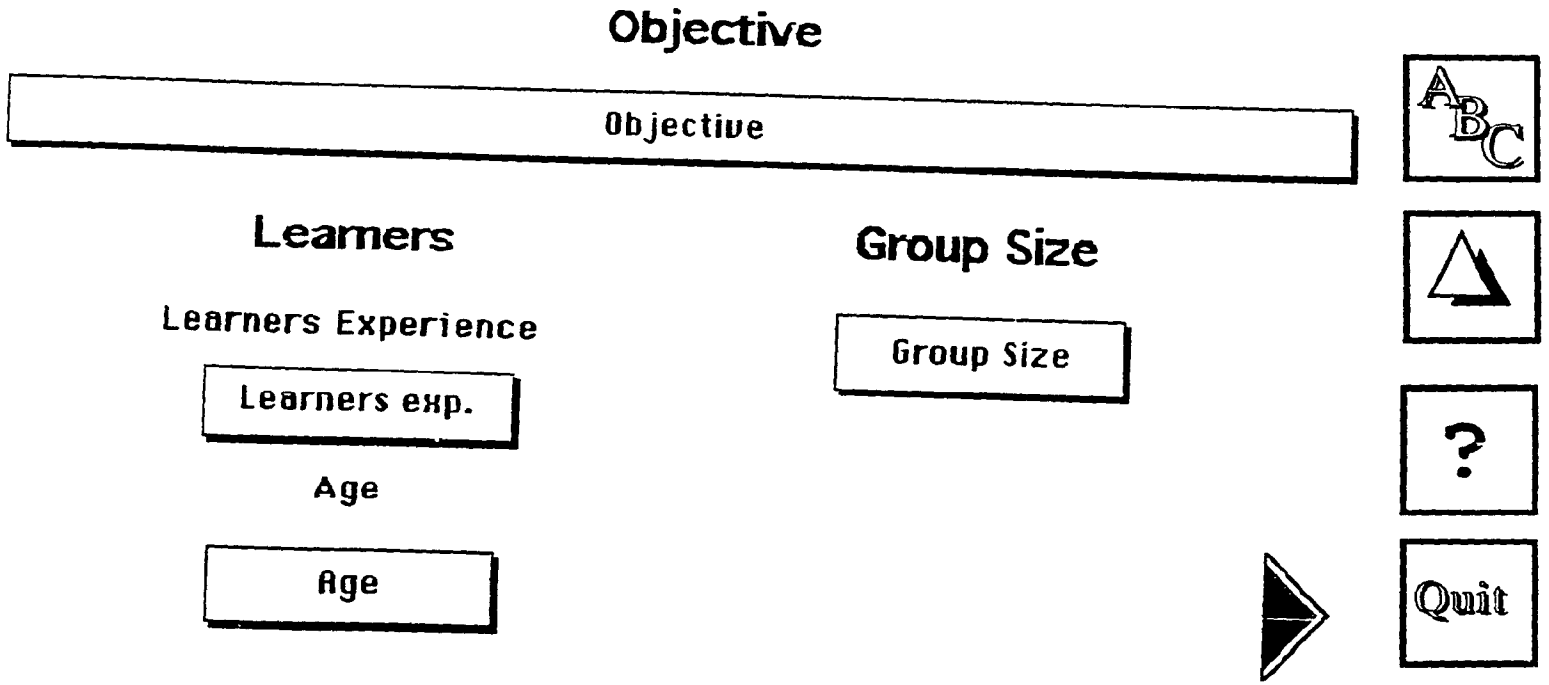
Before starting designing any kind of intruction you need to answer to three basic questions:

What is to be learned ? (Intructional objectives)

Who will learn it ? (Learner characteristics)

How will it be learned ? (Learning conditions e.g. Group size)

These variables play an important role in design decision making.
Click on each of the blue boxes and choose the characteristics of your learning scenario.



Instructional Design Theories

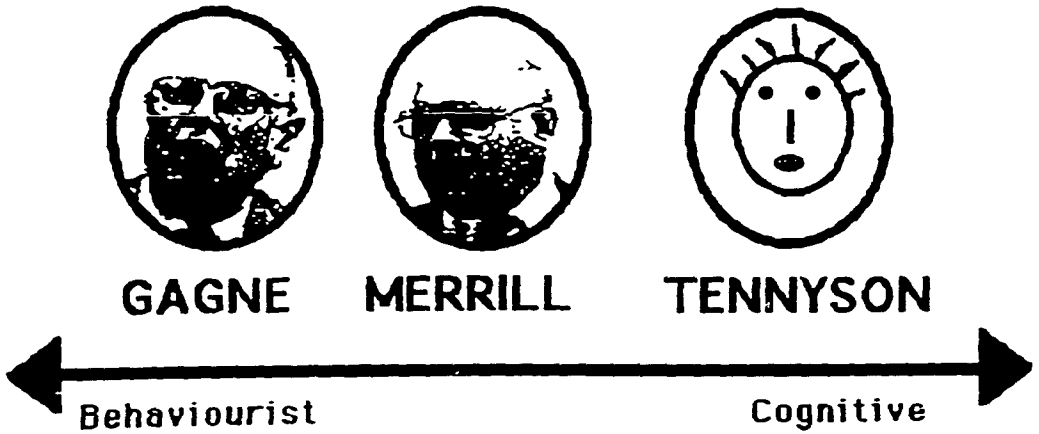
Instructional design is the process of making decisions about the best methods of instruction to achieve the desired goal.

More than 400 models based on different theories have been developed to help designers in such decisions.

-Those based on behaviourist psychology have developed specific prescriptions.

-Those based on cognitive psychology are trying to develop them.

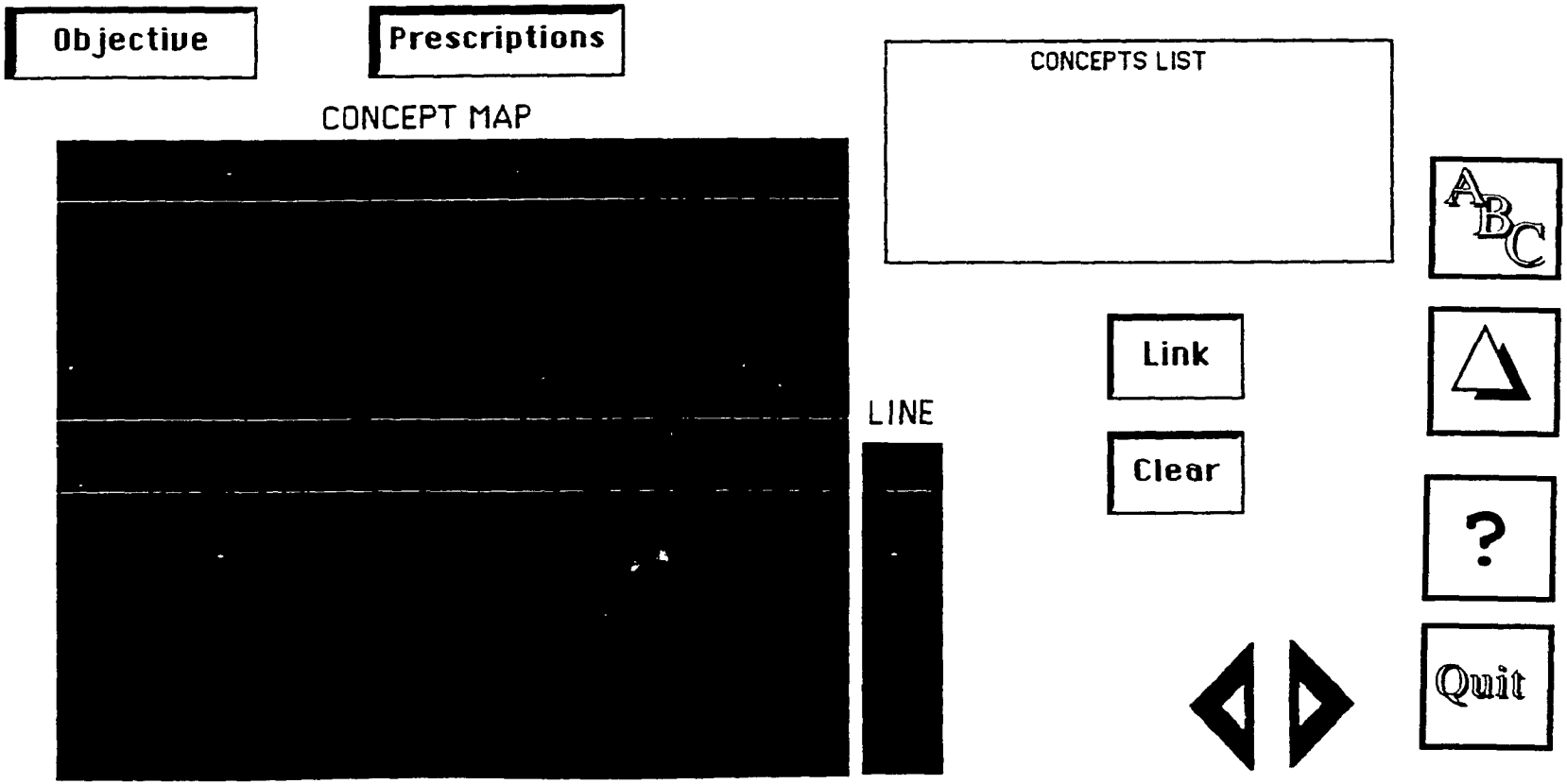
Here are three theories you may find interesting to look at. Click on the desired theory to get information.



Concept map

A useful tool to structure and sequence the content is a visual representation of the concepts entailed and their links to establish their relationships.

If an Objective is active, here is a board where you can represent your content by choosing from the list of concepts given. Remember your objective and your Instructional Design prescriptions.



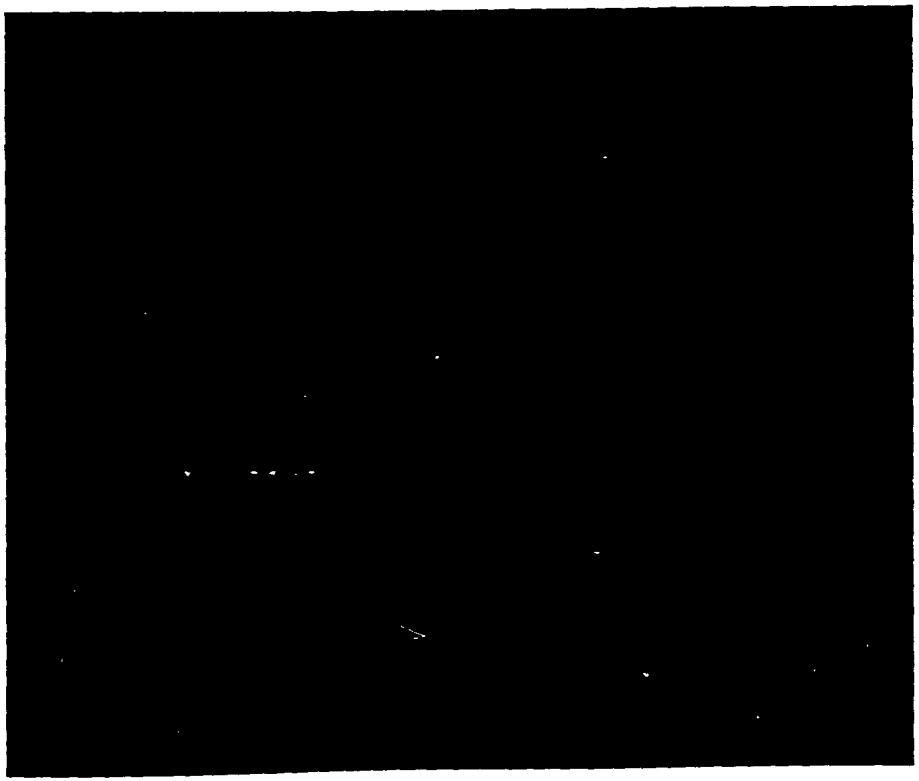
Architecture of the program

The structure of the program is determined by the nature of the content (information structure) as well as by its efficiency of information access.
Please choose a structure among these: Linear, Network, Hierarchical, Structured or Spiral/Helix .

Show examples

The concept map can help you for this choice. You should also consider some Structuring Factors typical of hypermedia design.

CONCEPT MAP



Linear

Network

Hierarchical

Structured

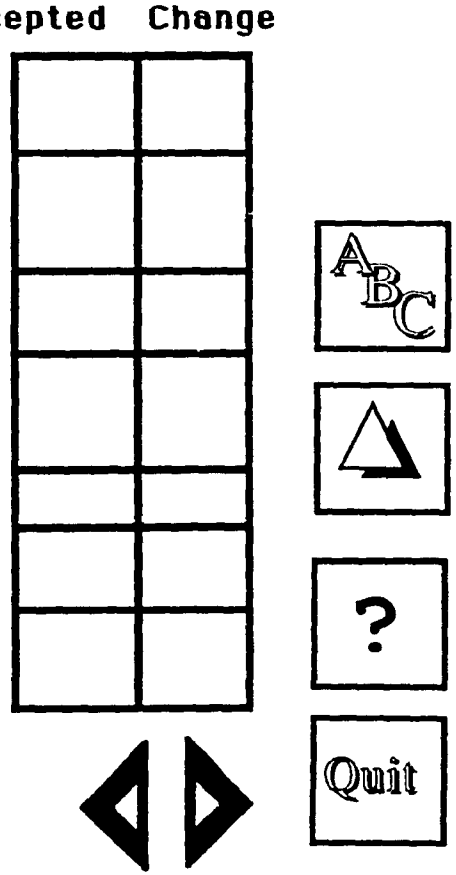
Spiral/Helix

Review

Production is an iterative process. After completing the instructional phase, it is useful for you as designer to review your work and make all necessary changes.
You can do it by having external evaluators using any of the evaluation techniques or doing it by yourself.
You can use the list below to evaluate your work by clicking on the appropriate box.

Evaluation Item

Definition of instructional objectives
no choice made.
Analysis of the learner
Educational Level : no choice made.
Age : no choice made.
Definition of instructional conditions
Group Size : no choice made.
Analysis of instructional objective
Type of Content : no choice made.
Level of Performance : no choice made.
Representation of content structure
Definition of program architecture
Type of Structure : no choice made.
Selection of instructional strategy
Kind of Strategy : no choice made.

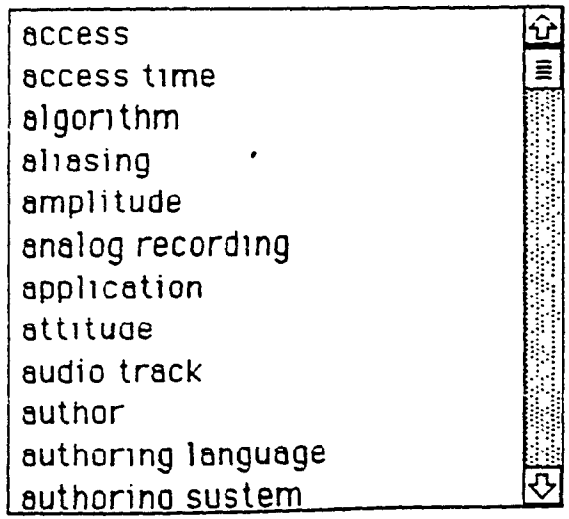


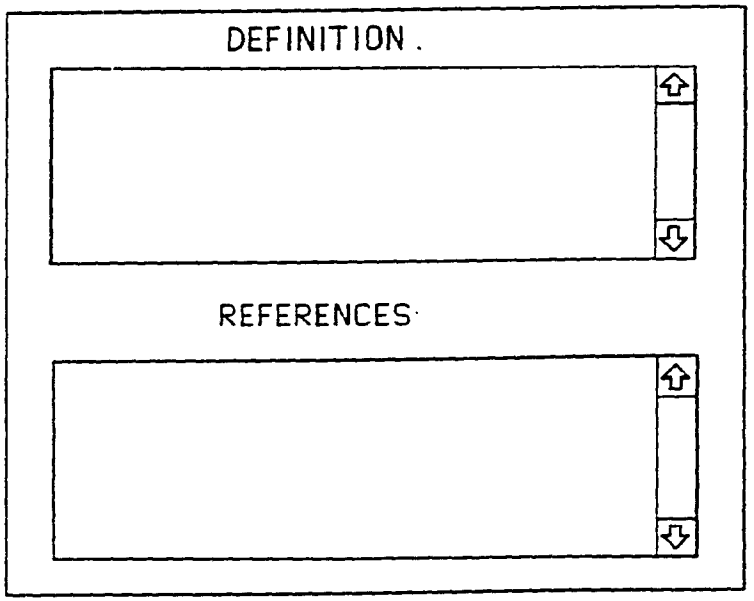
Glossary

Click the term you look for in the scrolling list below.To help the search, you can also type in the first letters of the word.

Looking for ...

Select your word:





QUIT

Appendix H

Storyboard Evaluation Results

Storyboard Evaluation Results: Analysis per Question

In each of the following tables, the desired state of each item in the questionnaire is equal to +2, and the opposite state equals -2.

Table 16
Summary of Results for Questions Addressing Content.

Question	Mode	Mode	Mean	S.D.
1. Completeness			1.50	0.71
2. Links	2		1.71	0.76
3. Accuracy	2		2.00	0.00
4. Depth	0	2	0.71	1.50
5. Neutrality	2		1.29	1.25
6. Clarity	2		1.71	0.76
7. Level of Difficulty	-1	-2	-1.00	1.41
8. Level of Challenge	2		1.14	1.21
9. Degree of focus on topic	2		1.86	0.38
10.Relevance	2		1.86	0.38
11.Consistency with objectives	2		2.00	0.00

Table 17
Summary of Results for Questions Addressing Illustrations and Examples.

Question	Mode	Mean	S.D.
12. Degree of Interest	2	1.71	0.49
13. Relevance	2	2.00	0.00
14. Usability	2	2.00	0.00
15. Clarity	2	1.86	0.38
16. Richness	1	1.14	0.69

Table 18
Summary of Results for Questions Addressing Navigational Tools.

Question	Mode	Mean	S.D.
17. Clarity	2	1.86	0.38
18. Usability	2	1.86	0.38
19. Sufficiency	2	1.86	0.38

Table 19
Summary of Results for Questions Addressing Special Features.

Question	Mode	Mean	S.D.
20. Usability	2	2.00	0.00
21. Clarity	2	1.86	0.38

Table 20
Summary of Results for Questions Addressing Language and Vocabulary.

Question	Mode	Mode	Mean	S.D.
22. Clarity	2		1.86	0.38
23. Level	-2	-1	-1.41	1.48
24. Apropriateness	2		2.00	0.00
25. Complexity level	2		1.29	1.50

For the following tables, SME represents subject matter experts. Students 3 and 5 are in the last year of their masters programme. Students 1,2 and 4 are new to the programme.

Table 21
Total Results per evaluator.

	Sum total	S.D. total	Mean total
SME 1	41	0.86	1.64
SME 2	43	0.89	1.72
Stud. 1	25	0.95	1.09
Stud. 2	35	1.08	1.52
Stud. 3	32	1.41	1.39
Stud. 4	36	1.04	1.57
Stud. 5	29	1.48	1.26

Table 22
Results for Content per Evaluator

	Sum Content	S.D. Content	Mean Content
SME 1	19	0.90	1.73
SME 2	19	0.65	1.73
Stud. 1	4	1.13	0.44
Stud. 2	13	1.13	1.44
Stud. 3	12	1.41	1.33
Stud. 4	12	1.32	1.33
Stud. 5	7	1.86	0.78

Table 23
Results for Examples per Evaluator

	Sum Examples	S.D. Examples	Mean Examples
SME 1	9	0.45	1.80
SME 2	10	0.00	2.00
Stud. 1	7	0.55	1.40
Stud. 2	8	0.55	1.60
Stud. 3	10	0.00	2.00
Stud. 4	9	0.45	1.80
Stud. 5	8	0.89	1.60

Table 24
Results for Navigation per Evaluator

	Sum Navigation	S.D. Navigation	Mean Navigation
SME 1	6	0.00	2.00
SME 2	6	0.00	2.00
Stud. 1	3	0.00	1.00
Stud. 2	6	0.00	2.00
Stud. 3	6	0.00	2.00
Stud. 4	6	0.00	2.00
Stud. 5	6	0.00	2.00

Table 25
Results for Special Features per Evaluator

	Sum Special F.	S.D. Special F.	Mean Special F.
SME 1	4	0.00	2.00
SME 2	4	0.00	2.00
Stud. 1	3	0.71	1.50
Stud. 2	4	0.00	2.00
Stud. 3	4	0.00	2.00
Stud. 4	4	0.00	2.00
Stud. 5	4	0.00	2.00

Table 26
Results for Language per Evaluator

	Sum language	S.D. Language	Mean Language
SME 1	3	1.53	0.75
SME 2	4	2.31	1.00
Stud. 1	8	0.00	2.00
Stud. 2	4	2.31	1.00
Stud. 3	0	2.31	0.00
Stud. 4	5	1.73	1.25
Stud. 5	4	2.31	1.00

Appendix I

End-Users Sample

Demographics and Previous Knowledge

Table 27

Frequency distribution for Demographics and Previous Knowledge.

Question	Frequency	Percentage
1. Sex		
Male	4	25.00%
Female	12	75.00%
2. Programme		
Diploma	3	18.75%
Master	13	81.25%
3. Year		
0-1	10	62.50%
2-3	4	25.00%
More than 3	2	12.50%
4. Student Status		
Full-time	8	50.00%
Part-time	8	50.00%
5. First Degree		
BA in Education	5	31.25%
BA in Computer Sc.	1	6.25%
BA other fields	14	87.50%
Diploma Education	6	37.50%
Diploma Computer Sc.	0	0.00%
Diploma other fields	2	12.50%
Master other fields	1	6.25%
6. Related Courses		
ETEC 710	13	81.25%
ETEC 711	9	56.25%
ETEC 660	10	62.50%
ETEC 661	5	31.25%
Other Courses	3	18.75%
7.Computer Experience		
Little	2	12.50%
Moderate	10	62.50%
Extensive	4	25.00%
8. Familiar Platforms		
Mac	13	81.25%
PC	9	56.25%
Amiga	4	25.00%
9. Experience with Hypertext	9	56.25%
10. Type of Experience		
Reading	6	37.50%
Watching	5	31.25%
Trying	7	43.75%
Developing	6	37.50%

Question	Frequency	Percentage
11. Experience with Hypermedia	10	62.50%
12. Type of Experience	•	
Reading	7	43.75%
Watching	5	31.25%
Trying	6	37.50%
Developing	7	43.75%

Appendix J

End-Users' Knowledge Results.

Summary Tables for Knowledge Scores.

Courses considered are: (a) Instructional Design I (ETEC 710), (b) Instructional Design II (ETEC 711), (c) Computers in Education (ETEC 660), and (d) Multimedia (ETEC 661).

Table 28

One-way ANOVA for previous knowledge and experience in Instructional Design I.

One Factor ANOVA X_1 : ETEC 710 Y_1 : Pre-test Knowledge Score

Analysis of Variance Table

Source:	DF:	Sum Squares:	Mean Square:	F-test:
Between	1	7.63	7.63	6.55
Within groups	14	16.308	1.165	p = .0227
Total	15	23.938		

Group:	Count:	Mean:	Std. Dev.:	Std. Error:
No	3	3	0	0
Yes	13	4.769	1.166	.323

Comparison:	Mean Diff.:	Fisher PLSD:	Scheffe F-test:	Dunnett t:
No vs. Yes	-1.769	1.483*	6.55*	2.559

* Significant at 95%

Table 29

One-way ANOVA for Previous Knowledge and Experience in Instructional Design II.

One Factor ANOVA X_1 : ETEC 711 Y_1 : Pre-test Knowledge Score

Analysis of Variance Table

Source:	DF:	Sum Squares:	Mean Square:	F-test:
Between	1	4.191	4.191	2.972
Within groups	14	19.746	1.41	p = .1067
Total	15	23.938		

Table 30

One-way ANOVA for Previous Knowledge and Experience in Introduction to Computers.

One Factor ANOVA X_1 : ETEC 660 Y_1 : Pre-test Knowledge Score

Analysis of Variance Table

Source:	DF:	Sum Squares:	Mean Square:	F-test:
Between	1	.504	.504	.301
Within groups	14	23.433	1.674	p = .5918
Total	15	23.938		

Table 31

One-way ANOVA for Previous Knowledge and Experience in Multimedia.

One Factor ANOVA X_1 : ETEC 661 Y_1 : Pre-test Knowledge Score

Analysis of Variance Table

Source:	DF:	Sum Squares:	Mean Square:	F-test:
Between	1	.956	.956	.582
Within groups	14	22.982	1.642	p = .4581
Total	15	23.938		

Table 32

Summary Table for Knowledge Scores According to Experience in Hypermedia.

Anova table for a 2-factor repeated measures Anova

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value.
Hypermedia exp.(A)	1	1.829	1.829	1.12	3109
subjects w. groups	12	19.6	1.633		
Repeated Measure B	1	11.571	11.571	38.571	.0001
AB	1	4.829	4.829	16.095	.0017
B x subjects within	12	3.6	.3		

One Factor ANOVA X_1 : Experience with hypermedia Y 1 Pre-test Knowledge

Analysis of Variance Table

Source:	DF:	Sum Squares:	Mean Square:	F-test.
Between	1	8.438	8.438	7.621
Within groups	14	15.5	1.107	p = 0153
Total	15	23.938		

Comparison:	Mean Diff.:	Fisher PLSD:	Scheffe F-test:	Dunnett t:
No vs. Yes	-1.5	1.166*	7.621*	2761

* Significant at 95%

Table 33

Impact on Learning

Paired t-Test X_1 : Pre-test Knowledge Score Y 1 : Post-test Score

DF:	Mean X - Y:	Paired t value:	Prob. (1-tail):
13	-1.286	-4.225	.0005

Paired t-Test X_1 : Pre-test Knowledge Score Y 1 . Delayed Post-test

DF:	Mean X - Y:	Paired t value:	Prob. (1-tail):
11	-1.333	-2.861	0077

Paired t-Test X 1 : Post-test Score Y 1 Delayed Post-test

DF:	Mean X - Y.	Paired t value:	Prob. (1-tail).
11	.083	.2	4226

Table 34
Repeated Measures for Pre-test, Posttest and Delayed Post-test by Experience Level in Hypermedia.

Anova table for a 2-factor repeated measures Anova.

Source	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Hypermedia exp.	1	.864	.864	.326	.5809
subjects w.	10	26.552	2.655		
Repeated Measure B	2	15.167	7.583	8.498	.0021
AB	2	4.319	2.16	2.42	.1145
B x subjects w.	20	17.848	.892		

The AB Incidence table

Repeated Mea...		Pre-test ...	Post-test...	Delayed...	Totals:
Experienc	No	5 3.6	5 6	5 5.6	15 5.067
	Yes	7 4.857	7 5.571	7 5.714	21 5.381
Totals:		12 4.333	12 5.75	12 5.667	36 5.25

Table 35
Repeated Measures for Pre-test, Post-test and Delayed Post-test by Experience in Instructional Design.

Anova table for a 2-factor repeated measures Anova.

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
ETEC 710 (A)	1	12.676	12.676	8.599	.015
subjects w.	10	14.741	1.474		
Repeated Measure B	2	15.167	7.583	7.06	.0048
AB	2	.685	.343	.319	.7305
B x subjects w	20	21.481	1.074		

The AB Incidence table

Repeated Mea..		Pre-test ...	Post-test...	Delayed...	Totals:
ETEC 710	No	3 3	3 5	3 4.667	9 4.222
	Yes	9 4.778	9 6	9 6	27 5.593
Totals:		12 4.333	12 5.75	12 5.667	36 5.25

Table 36
Repeated Measures for Post-test and Delayed Post-test by Trial Condition.
Anova table for a 2-factor repeated measures Anova

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value.
Trial condition (A)	1	.083	.083	.043	.8399
subjects w. groups	10	19.375	1.938		
Repeated MeasureB	1	.042	.042	.044	.8373
AB	1	2.083	2.083	2.222	.1669
B x subjects w.	10	9.375	.938		

The AB Incidence table

Repeated Mea...		Pre-test ...	Post-test...	Delayed...	Totals:
Trial con..	class	8 4.5	8 6	8 5.5	24 5.333
	lab	4 4	4 5.25	4 6	12 5.083
Totals:		12 4.333	12 5.75	12 5.667	36 5.25

Appendix K

Navigation Results.

Table 37

Summary table of Navigational Information.

Frame	Topic	Level	Help Total f	Glossary Total f	Visited Total f	No. of users	Average t
1	Wait	1	0		14	14	
2	Presentation	1	0		14	14	
3	Main Menu	1	0	7	19	14	11.77
4	Map	1	1	0	90	14	32.18
5	ID phase	2	0	0	18	3	32.18
6	SB phase	2	0	0	1	1	60.00
7	Prod. phase	2	0	0	1	1	21.00
8	Scenario Def.	2	0	0	47	14	47.76
9	Objective Ht.	3	0	0	4	4	17.43
10	Learners Ht.	3	0	0	4	4	13.55
11	Group. Ht.	3	0	0	3	3	27.25
12	Analysis of Ob	2	0	0	66	14	25.02
13	PC Matrix	2	10	0	88	14	37.16
14	Ex R. Instance	3	0	0	4	4	27.00
15	Ex. Find Gener.	3	0	0	8	6	32.06
16	Ex. Principle	3	0	0	4	3	20.00
17	Ex. Principle2	3	0	0	2	2	39.50
18	Ex. Procedure	3	0	0	5	4	15.88
19	Ex. Concept	3	0	0	3	2	10.75
20	Ex. Facts	3	0	0	6	5	22.60
21	Ex. Rem.Gener	3	0	0	15	7	38.49
22	Ex. Use Gener	3	0	0	10	9	51.83
23	ID Theories	3	0	0	34	9	11.68
24	Merrill PCM	4	0	0	12	8	72.94
25	Merrill Presc	4	0	0	8	6	71.75
26	M. Pres&Prac	4	0	0	55	7	6.79
27	M. Struct&Seq	4	0	0	37	5	5.52
28	Gagne domains	4	0	0	9	6	42.04
29	Gagne events	4	0	0	12	10	101.17
30	Ten. theory	4	0	0	8	8	73.75
31	Ten prescript	4	0	0	4	4	61.50
32	Content	4	0	0	14	10	28.22
33	Performance	3	0	0	15	11	32.05
34	M. Struct&Seq	2	3	0	114	12	19.96
35	Ex.Str. Facts	3	0	0	19	12	11.89
36	Ex.Str. Concept	3	0	0	14	11	12 11
37	Ex.Str. Proced	3	0	0	14	10	8 65
38	Ex.Str. Princ.	3	0	0	15	11	8.65
39	Ex.Seq. Facts	3	0	0	15	10	12.12
40	Ex.Seq. Concept	3	0	0	12	9	14.81
41	Ex.Seq.Proced	3	0	0	13	10	8.72
42	Ex.Seq.Princ	3	0	0	12	9	10.36
43	Pres. Find	3	0	0	8	7	14.47

Frame	Topic	Level	Help Total f	Glossary Total f	Visited Total f	No. of users	Average t
44	Pres. Use	3	0	0	6	6	12.45
45	Pres. R. Gener	3	0	0	6	6	9.72
46	Pres. R. Inst.	3	0	0	7	7	12.71
47	Prac.Find	3	0	0	5	5	12.50
48	Prac. Use	3	0	0	5	5	9.83
49	Prac.R.Gener.	3	0	0	7	5	10.25
50	Prac.R.Instance	3	0	0	5	5	18.28
51	Concept Map	3	3	0	35	11	61.34
52	Organization	2	4	0	37	9	56.44
53	Linear Struct.	4	1	0	2	2	16.50
54	Network Str.	4	0	0	2	2	63.00
55	Hierarchical	4	0	0	2	2	51.00
56	Structural	4	0	0	1	1	55.00
57	Spiral/Helix	4	0	0	2	2	55.50
58	Structuring	3	0	0	1	1	114.00
59	Info. Struct.	3	0	0	2	2	54.50
60	Info. Access	2	0	0	1	1	14.00
61	Instr. Strategy	4	0	0	50	11	39.59
62	Ex.Tutorial	4	0	0	3	3	19.50
63	Ex. Drill&Prac	4	0	0	3	3	14.50
64	Ex.Games&Sim	4	0	0	5	4	25.33
65	Ex. Prob-Solv	4	0	0	1	1	27.50
66	Ex. Discovery	4	0	0	3	3	20.25
67	Eval. Checklist	2	0	1	32	9	33.28
68	External Ev.	3	0	0	1	1	80.00
69	Ev. Techniques	3	0	0	1	1	62.00
70	Questionnaire	2	0	0	5	5	35.33

Table 38
Navigation: Frequency of visited screens by subject.

Screen Topic	Level	St.1 f	St.2 f	St.3 f	St.4 f	St.5 f	St.6 f	St.7 f	St.8 f	St.9 f	St.10 f	St.11 f	St.12 f	St.13 f	St.14 f	St.15 f	St.16 f	Sum of f	No. of users
1 Wait	1	1	1	1	1	1	1	1		1		1	1	1	1	1	1	14	14
2 Presentation	1	1	1	1	1	1	1	1		1		1	1	1	1	1	1	14	14
3 Main Menu	1	1	1	3	1	1	1	1		1		1	1	1	2	2	2	19	14
4 Map	1	12	3	6	5	5	4	4		4		8	1	10	14	8	6	90	14
5 ID phase	2		16									1					1	18	3
6 SB phase	2																1	1	1
7 Prod. phase	2											1						1	1
8 Scenario Def.	2	3	11	4	3	2	2	3		6		1	4	4	1	2	1	47	14
9 Objective Ht.	3	1			1					1			1					4	4
10 Learners Ht.	3	1			1					1			1					4	4
11 Group. Ht.	3							1		1			1					3	3
12 Analysis of Ob	2	7	12	4	5	1	3	5		8		3	5	5	2	3	3	66	14
13 PC Matrix	2	11	10	7	11	1	4	3		12		3	13	3	6	1	3	88	14
14 Ex R. Instance	3	1		1	1								1					4	4
15 Ex. Find Gener.	3	1		1	1					3			1		1			8	6
16 Ex. Principle	3				1								2		1			4	3
17 Ex. Principle2	3												1		1			2	2
18 Ex. Procedure	3		1		1								2		1			5	4
19 Ex. Concept	3				2								1					3	2
20 Ex. Facts	3		1		1		1			1			2					6	5
21 Ex. Rem.Gener	3	4	4	1	3		1			1			1					15	7
22 Ex. Use Gener	3	1	1	1	1					2		1	1	1	1			10	9
23 ID Theories	3	7	4		1			4		4			4	3	3	4		34	9
24 Merrill PCM	4	2	1				1	2					2		1	2	1	12	8
25 Merrill Presc	4	1	1					1					2		1	2		8	6
26 M. Pres&Prac	4	8	8					5				10	12		8	4		55	7
27 M. Struct&Seq	4	8	10					8					10			1		37	5
28 Gagne domains	4	3	2					1		1			1			1		9	6

Screen	Topic	Level	St.1 f	St.2 f	St.3 f	St.4 f	St.5 f	St.6 f	St.7 f	St.8 f	St.9 f	St.10 f	St.11 f	St.12 f	St.13 f	St.14 f	St.15 f	St.16 f	Sum of f	No. of users
29	Gagne events	4	2	2	1		1		1				1	1		1	1	1	12	10
30	Ten. theory	4	1	1					1		1			1	1	1	1		8	8
31	Ten prescript	4	1						1				1			1			4	4
32	Content	4	2	3	1	1		1	1		1		1	2				1	14	10
33	Performance	3	1	2	1	1			1		1		1	1	1		4	1	15	11
34	M. Struct&Seq	2	4	8	9	11	8	4	20		16		11		7	3		13	114	12
35	Ex.Str. Facts	3	2	2	1	1	1	1	3		2		1	1	3			1	19	12
36	Ex.Str. Concept	3	1	2	1	1	1	1	3		1		1	1				1	14	11
37	Ex.Str. Proced	3	1	1	2	1	1		4		1		1	1				1	14	10
38	Ex.Str. Princ.	3	2	1		1	1	1	3		1		2	1	1			1	15	11
39	Ex.Seq. Facts	3	1	1		1	1		4		1		3	1	1			1	15	10
40	Ex.Seq. Concep	3	1	1		1	1		3		1		1	2				1	12	9
41	Ex.Seq.Proced	3	1	1	2	1	1		3		1		1	1				1	13	10
42	Ex.Seq.Princ	3	1	1		1	1		3		1		1	1				2	12	9
43	Pres. Find	3	1	1					1				1	2		1	1		8	7
44	Pres. Use	3	1	1					1				1	1		1			6	6
45	Pres. R. Gener	3	1	1					1				1	1		1			6	6
46	Pres. R. Inst.	3	1	1					1				1	1		1	1		7	7
47	Prac.Find	3	1	1									1	1		1			5	5
48	Prac. Use	3	1	1									1	1		1			5	5
49	Prac.R.Gener.	3	1	1									2	2		1			7	5
50	Prac.R.Instance	3	1	1									1	1		1			5	5
51	Concept Map	3	2	5	5	1			1		7		2		1	2	4	5	35	11
52	Organization	2	10	3	3		1				8		1		2	4		5	37	9
53	Linear Struct.	4	1								1								2	2
54	Network Str.	4	1								1								2	2
55	Hierarchical	4	1								1								2	2
56	Structural	4	1																1	1
57	Spiral/Helix	4	1								1								2	2
58	Structuring	3																1	1	1
59	Info. Struct.	3	1								1								2	2

Screen Topic	Level	St.1 f	St.2 f	St.3 f	St.4 f	St.5 f	St.6 f	St.7 f	St.8 f	St.9 f	St.10 f	St.11 f	St.12 f	St.13 f	St.14 f	St.15 f	St.16 f	Sum of f	No. of users
60 Info. Access	2	1																1	1
61 Instr. Strategy	4	12	2	7		1	1			4		4		2	9	5	3	50	11
62 Ex.Tutorial	4	1		1											1			3	3
63 Ex. Drill&Prac	4	1		1											1			3	3
64 Ex.Games&Sim	4	1		1											2	1		5	4
65 Ex. Prob-Solv	4	1																1	1
66 Ex. Discovery	4	1		1												1		3	3
67 Eval. Checklist	2	4	3	5			3			6		1		4		2	4	32	9
68 External Ev.	3																1	1	1
69 Ev. Techniques	3																1	1	1
70 Questionnaire	2	1				1	1							1			1	5	5

Table 39
Navigation: Average time spent on each screen by subject.

Screen	Topic	Level	St.1 t	St.2 t	St.3 t	St.4 t	St.5 t	St.6 t	St.7 t	St.8 t	St.9 t	St.10 t	St.11 t	St.12 t	St.13 t	St.14 t	St.15 t	St.16 t	Average t
1	Wait	1																	
2	Presentation	1																	
3	Main Menu	1	27	8.7	6.7		5						3				6	26	11.77
4	Map	1	24	25	47	50	45	52	35		24		18	49	17	15	36	14	32.18
5	ID phase	2	30										60			22		17	32.18
6	SB phase	2	82															38	60.00
7	Prod. phase	2	20										22						21.00
8	Scenario Def.	2		18	51	27	122	163	37		17		71	18	6	41	37	13	47.76
9	Objective Ht.	3	22			17					11			20					17.43
10	Learners Ht.	3	13			9					10			22					13.55
11	Group. Ht.	3	47						27		11			24					27.25
12	Analysis of Ob	2	38	20	23	8.6	39	72	9		9.9		15	14	12	50	11	30	25.02
13	PC Matrix	2		16	14	7.2	63	52	63		13		65	18	32	22	22	97	37.16
14	Ex R. Instance	3			28	40								13					27.00
15	Ex. Find Gener.	3			33	17					18			40		52			32.06
16	Ex. Principle	3				21								13		26			20.00
17	Ex. Principle2	3												42		37			39.50
18	Ex. Procedure	3		15		11								9.5		28			15.88
19	Ex. Concept	3				7.5								14					10.75
20	Ex. Facts	3		29		23		28			17			16					22.60
21	Ex. Rem.Gener	3	39	23	61	18		76			27			26					38.49
22	Ex. Use Gener	3	82	30	49	24					52		123	52	18	37			51.83
23	ID Theories	3	11	13		4			9.2		15			11	9.6	20	13		11.68
24	Merrill PCM	4	40	136				71	34					29		113	31	131	72.94
25	Merrill Presc	4	118	96					42					43		123	9		71.75
26	M. Pres&Prac	4	9.4	4.4					4.4				6.2	9.9		6.5	6.8		6.79
27	M. Struct&Seq	4	5	6.5					2.7					6.4			7		5.52
28	Gagne domains	4	35	74					40		19			53			50	23	42.04

Screen Topic	Level	St.1 t	St.2 t	St.3 t	St.4 t	St.5 t	St.6 t	St.7 t	St.8 t	St.9 t	St.10 t	St.11 t	St.12 t	St.13 t	St.14 t	St.15 t	St.16 t	Average t
29 Gagne events	4	187	117	99		70		62				10	10		324	32		101.17
30 Ten. theory	4	110	254					29		9			86	29	20	53		73.75
31 Ten prescript	4	32						43				73			98			61.50
32 Content	4	22	25	30	22		37	50		10		44	20				23	28.22
33 Performance	3	53	7.5	45	37			35		5		75	27	31		26	11	32.05
34 M. Struct&Seq	2	17	7.4	11	8.9	41	21	4.6		8.5		7.5	10	105	8.3		9.5	19.96
35 Ex.Str. Facts	3	6	11	8	7	11	17	5.7		31		20	6	10			11	11.89
36 Ex.Str. Concept	3	6	6.5	9	5	8	61	4.7		5		7	14				7	12.11
37 Ex.Str. Prced	3	7	9	11	9	5		4		7		16	11				8	8.65
38 Ex.Str. Princ	3	6.5	7		8	5	8	4.7		8		10	8	5			25	8.65
39 Ex.Seq. Facts	3	6	9		7	5		17		5		12	19	26			15	12.12
40 Ex.Seq. Concep	3	8	52		10	7		6.3		10		10	7				23	14.81
41 Ex.Seq.Proced	3	7	8	13	4	3		4.7		9		9	19				11	8.72
42 Ex.Seq.Princ	3	6	13		17	5		17		6		7	8				14	10.36
43 Pres. Find	3	11	20					6.3				11	20		20	13		14.47
44 Pres. Use	3	11	9					4.7				11	20		19			12.45
45 Pres. R. Gener	3	11	12					4.3				10	10		11			9.72
46 Pres. R. Inst.	3	45	10					6				7	6		9	6		12.71
47 Prac.Find	3	10	14					7				11	14		19			12.50
48 Prac. Use	3	15	6					10				6	10		12			9.83
49 Prac.R.Gener.	3	13	8					5				4.5	11		20			10.25
50 Prac.R.Instance	3	8	48									8	10		17			18.28
51 Concept Map	3	123	15	69	16					24		27		160	39	18	124	61.34
52 Organization	2	22		36		59				22		6		191	45		71	56.44
53 Linear Struct.	4	25								8								16.50
54 Network Str.	4	105								21								63.00
55 Hierarchical	4	90								12								51.00
56 Structural	4	55																55.00
57 Spiral/Helix	4	94								17								55.50
58 Structuring	3																114	114.00
59 Info. Struct.	3	67								42								54.50

Screen	Topic	Level	St.1 t	St.2 t	St.3 t	St.4 t	St.5 t	St.6 t	St.7 t	St.8 t	St.9 t	St.10 t	St.11 t	St.12 t	St.13 t	St.14 t	St.15 t	St.16 t	Average t
60	Info. Access	2	14																14.00
61	Instr. Strategy	4	26	73	30		31	44			15		49		50	22	29	67	39.59
62	Ex.Tutorial	4	22		17														19.50
63	Ex. Drill&Prac	4	11		18														14.50
64	Ex.Games&Sim	4	22		26												28		25.33
65	Ex. Prob-Solv	4	26													29			27.50
66	Ex. Discovery	4	11		12											30	28		20.25
67	Eval. Checklist	2	19	126	22			18			18		39		20	24	14	34	33.28
68	External Ev.	3																80	80.00
69	Ev. Techniques	3																62	62.00
70	Questionnaire	2	14												18			74	35.33

Note: Time for the first two screens was not recorded, since they are not relevant for the content.

Tracing Report

6/18/93 5:08 PM	--Date and Time--
FEMALE 9023	--Gender and I.D.--
instructional design	--Knowledge--
experienced	--Experience--
5:08:54 PM 3	--Time and Screen--
5:09:34 PM glossary	--Time and Feature--

5:19:19 PM help	5:31:48 PM 34	5:45:51 PM 52
5:19:28 PM 4	5:31:52 PM 37	5:46:02 PM 54
5:21:20 PM 8	5:32:10 PM 34	5:46:53 PM 52
5:21:47 PM 9	5:32:14 PM 41	5:47:06 PM 53
5:22:05 PM 8	5:32:33 PM 34	5:47:53 PM 52
5:22:58 PM 12	5:32:38 PM 36	5:48:05 PM 55
5:23:26 PM 32	5:32:46 PM 34	5:48:49 PM 52
5:23:55 PM 12	5:32:50 PM 40	5:49:01 PM 57
5:24:01 PM 33	5:33:06 PM 34	5:50:05 PM 52
5:25:04 PM 12	5:33:09 PM 36	5:50:54 PM 61
5:25:16 PM 13	5:33:15 PM 34	5:51:14 PM 52
5:25:26 PM help	5:33:19 PM 35	5:51:29 PM 61
5:26:13 PM help	5:33:28 PM 34	5:51:34 PM 52
5:26:38 PM help	5:33:32 PM 39	5:52:34 PM 61
5:26:58 PM help	5:33:42 PM 34	5:53:10 PM 29
5:27:34 PM help	5:33:56 PM 4	5:57:36 PM 61
5:27:49 PM help	5:34:13 PM 34	5:57:48 PM 26
5:28:25 PM 12	5:34:17 PM 51	5:58:05 PM 46
5:28:31 PM 8	5:35:17 PM help	5:58:13 PM 26
5:29:11 PM 12	5:39:25 PM 52	5:58:17 PM 45
5:29:16 PM 13	5:40:15 PM 58	5:58:34 PM 26
5:30:15 PM 34	5:40:50 PM 52	5:58:43 PM 43
5:30:53 PM 38	5:41:02 PM 59	5:58:50 PM 26
5:31:05 PM 34	5:42:25 PM 52	5:58:55 PM 47
5:31:13 PM 42	5:42:38 PM 55	5:59:02 PM 26
5:31:36 PM 34	5:43:43 PM 52	5:59:11 PM 48
5:31:39 PM 38	5:44:09 PM 56	5:59:18 PM 26

5:59 26 PM 61
5:59.37 PM 31
6:00:53 PM 61
6 01:36 PM 62
6:02 02 PM 61
6:02:26 PM 63
6:02:42 PM 61
6:03:07 PM 64
6:03 43 PM 61
6:04:29 PM 65
6:05:08 PM 61
6:05:28 PM 66
6:06:01 PM 61
6:06:46 PM 67
6:08:22 PM 51
6:08:54 PM 67
6:09:11 PM 61
6:09:26 PM 67
6:09:42 PM 4
6:10:08 PM 67
6:10:18 PM 4
6:10:31 PM 8
6:10:39 PM 4
6:13:57 PM 3
6:14:19 PM 70
6:15:41 PM 4

Appendix L

End-Users' Satisfaction Results.

Table 40

Degree of Satisfaction: Summary of Results

The first line shows the frequency, the second shows the percentage.

	Strongly Agree	Agree	Un-decided	Disagree	Strongly Disagree	X^2 Trial
1. The system characteristics match with what I expected.	2 14.3%	6 42.8%	3 21.4%	2 14.3%	1 7.1%	6.01
2. I did not like the examples provided.	2 14.3%	3 21.4%	2 14.3%	7 50.0%	0 0.0%	.52
3. I felt satisfied with the content covered.	1 7.1%	7 50.0%	4 28.6%	2 14.3%	0 0.0%	1.09
4. The programme was able to keep my interest in the content.	0 0.0%	7 50.0%	3 21.4%	3 21.4%	1 7.1%	4.87
5. I will never use this programme again.	0 0.0%	1 7.1%	3 21.4%	9 64.3%	1 7.1%	2.38
6. I do not feel to have learned much from this programme.	0 0.0%	3 21.4%	1 7.1%	10 71.4%	0 0.0%	3.55
7. The information covered is relevant for ETEC students.	5 35.7%	8 57.1%	0 0.0%	0 0.0%	1 7.1%	2.24
8. I felt frustrated when using the programme.	1 7.1%	4 28.6%	4 28.6%	4 28.6%	1 7.1%	6.38
9. This programme adds nothing to the present multimedia classes.	0 0.0%	0 0.0%	4 28.6%	8 57.1%	2 14.3%	0.39
10.It was pleasant to work with this system.	0 0.0%	7 50.0%	6 42.9%	1 7.1%	0 0.0%	0.73
11.This system invites the learner to explore the content.	0 0.0%	11 78.6%	2 14.3%	1 7.1%	0 0.0%	2.12
12.It is a boring programme.	0 0.0%	0 0.0%	5 35.7%	7 50.0%	2 14.3%	3.05
13.This is not a useful learning material for ETEC students.	0 0.0%	1 7.1%	1 7.1%	9 64.3%	3 21.4%	1.42

	Strongly Agree	Agree	Un-decided	Disagree	Strongly Disagree	X^2 Trial
14.The programme is not motivating.	0 0.0%	2 14.3%	5 35.7%	7 50.0%	0 0.0%	3.05
15.I was disappointed by the programme content.	0 0.0%	2 14.3%	4 28.6%	7 50.0%	1 7.1%	1.09
16.I do not see any application of this programme in ETEC courses.	0 0.0%	0 0.0%	4 28.6%	6 42.9%	4 28.6%	0.93
17. The programme is challenging.	1 7.1%	4 28.6%	7 50.0%	2 14.3%	0 0.0%	3.42
18.I enjoyed trying out the product.	2 14.3%	11 78.6%	1 7.1%	0 0.0%	0 0.0%	0.73
19. I would not recommend this system to other students.	1 7.1%	1 7.1%	3 21.4%	8 57.1%	1 7.1%	2.93
20. I would like to see the rest of the programme.	3 21.4%	11 78.6%	0 0.0%	0 0.0%	0 0.0%	0.34
21. I wish more students could use it.	2 14.3%	7 50.0%	4 28.6%	1 7.1%	0 0.0%	1.24
22. I learned interesting things through the programme	1 7.1%	7 50.0%	5 35.7%	1 7.1%	0 0.0%	6.53
23. It invites the user to get involved in multimedia production	1 7.1%	10 71.4%	0 0.0%	3 21.4%	0 0.0%	0.64
24. I did not like the programme at all.	0 0.0%	2 14.3%	2 14.3%	7 50.0%	3 21.4%	1.45
25. It adds more to the mere technicalities of production.	1 7.1%	9 64.3%	3 21.4%	0 0.0%	1 7.1%	0.50

Table 41

Correlation between attitudes towards CAI in general and satisfaction after trial.

Corr. Coeff. X | : Attitude towards CAI Y | . Satisfaction

Count:	Covariance:	Correlation:	R-squared:
12	5.265	.067	.005

Note: 4 cases deleted with missing values.

Appendix M

Evaluation of Instructional Design, and Visual and Technical Design.

Table 42
Evaluation Form: Summary of Subject Matter Experts' Results

Evaluation Items	None	Poor	Sufficient	Good	N.A. or N.E.
Documentation	f	f	f	f	f
Clear and logical presentation of content			2		
Clear instructions to operate de program			1	1	
Examples of on-screen visual display			1	1	
Bibliography for related information				1	
Source to contact for problems			1	1	
	Yes	No			N.A. or N.E.
Entry Skills	f	f			f
Pre-requisite skills are stated	2				
	None	Poor	Sufficient	Good	N.A. or N.E.
Content Presentation	f	f	f	f	f
Appropriateness of vocabulary for target audience				2	
Content Accuracy				2	
Content free of biases				2	1
Consistency of content with stated objectives				1	1
Possibility of updating content			1	1	
Cross-referencing between contents			1	1	
Branching opportunities			1	1	
Variety of explanations			1	1	
Clues to key concepts			1	1	
Outlines, summaries, reviews to organize ideas			1	1	
Motivating and challenging environment			1	1	
Practise and Interaction					
Instructions for interaction		1		1	
Ease of interaction		1		1	
Amount of practise			2		
Relevance to stated objectives				2	
Opportunity for transfer and generalization			1	1	

	Yes	No			N.A. or N.E.
	f	f			f
Questionning techniques					
Various techniques are used	2				
Questions are appropriate for audience	2				
Questions are appropriate for content	1				1
Explanation is provided for unclear assignments	1	1			
Questions are effectively randomized	1				
Unpredictable patterns are considered	2				
Feedback					
Appropriate for the audience	2				
Accurate evaluation of right and wrong answers	2				
Motivational and sensitive to users' needs	2				
Immediate	2				
Flexible in accepting learning responses	2				
Provides cues or prompts for wrong answers	2				
Relevant to history of responses	2				
Assistance provided within the lesson	2				
Re-explanation is provided	2				
	None	Poor	Sufficient	Good	N.A. or N.E.
Evaluation	f	f	f	f	f
Systematic review of learned materials			2		
Appropriate presentation of post-test			1	1	
Consistency of post-test and objectives			1	1	
Control for					
Content sequence		1		1	
Rate of presentation			1	1	
Timed input			1		1
Type of feedback			1	1	
Sound control		1	1		

	None	Poor	Sufficient	Good	N.A or N.E.
	f	f	f	f	f
Content of feedback			1	1	
Mastery level			1	1	
Technical design					
Appropriate text size				2	
Appropriate amount of material				2	
Text easy to read			1	1	
Smooth screen transitions			1	1	
Time required for transitions			2		
Appropriate use of colors		1	1		
Graphic support to instruction			1	1	
Relevance to learner's age and ability				2	
Animations support				2	
Quality and clarity of displays				2	
Appropriate use of sound			1	1	
Appropriate use of multimedia			1	1	
Control degree for screens		1		1	
Special features					
Glossary				2	
Navigational Map				2	
Possibility of marking parts of the content		1			1
Record storing for future student retrieval				1	1

Notes: N.A. means not applicable. N.E. means not explored
The item referring to post-test was rated only by subject matter experts

Table 43
Evaluation Form: Summary of End-User's Results

Evaluation Items	None		Poor		Sufficient		Good		N.A. or N.E.	
Documentation	f	%	f	%	f	%	f	%	f	%
Clear and logical presentation of content	0	0.0	1	7.1	5	35.7	8	57.1	0	0.0
Clear instructions to operate de program	0	0.0	1	7.1	1	7.1	12	85.7	0	0.0
Examples of on-screen visual display	0	0.0	0	0.0	3	23.1	10	76.9	0	0.0
Bibliography for related information	1	8.3	0	0.0	1	8.3	8	66.7	2	16.7
Source to contact for problems	1	8.3	1	8.3	0	0.0	7	58.3	3	25.0
	Yes		**No**						**N.A. or N.E.**	
Entry Skills	f	%	f	%					f	%
Pre-requisite skills are stated	2	15.4	11	84.6					0	.0.0
	None		**Poor**		**Sufficient**		**Good**		**N.A. or N.E.**	
Content Presentation	f	%	f	%	f	%	f	%	f	%
Appropriateness of vocabulary for target audience	0	0.0	0	0.0	2	15.4	11	84.6	0	0.0
Content Accuracy	0	0.0	0	0.0	1	7.1	12	85.7	1	7.1
Content free of biases	0	0.0	0	0.0	4	28.8	9	64.3	1	7.1
Consistency of content with stated objectives	0	0.0	0	0.0	3	21.4	9	64.3	2	14.3
Possibility of updating content	0	0.0	1	7.1	2	14.3	7	50.0	4	28.6
Cross-referencing between contents	0	0.0	1	7.7	3	23.1	8	61.5	1	7.7
Branching opportunities	0	0.0	0	0.0	4	28.6	9	64.3	1	7.1
Variety of explanations	0	0.0	1	7.7	7	53.8	5	38.5	0	0.0
Clues to key concepts	0	0.0	3	23.1	4	30.8	6	46.1	0	0.0
Outlines, summaries, reviews to organize ideas	1	7.1	1	7.1	6	42.8	5	35.7	1	7.1
Motivating and challenging environment	0	0.0	3	21.4	6	42.8	4	28.6	1	7.1
Practise and Interaction										
Instructions for interaction	0	0.0	1	7.1	8	57.1	5	35 7	0	0.0
Ease of interaction	0	0.0	1	7.1	5	35.7	8	57.1	0	0.0
Amount of practise	2	14.3	5	35.7	4	28.6	0	0.0	3	21.4
Relevance to stated objectives	0	0.0	2	14.3	3	21.4	7	50.0	2	14.3
Opportunity for transfer and generalization	0	0.0	2	14.3	3	21.4	8	57.1	1	7.1

	Yes		No						N.A. or N.E.	
	f	%	f	%					f	%
Questionning techniques									0	0.0
Various techniques are used	9	75.0	3	25.0					0	0.0
Questions are appropriate for audience	10	83.3	2	16.7					0	0.0
Questions are appropriate for content	11	91.7	1	8.3					0	0.0
Explanation is provided for unclear assignments	8	61.5	5	38.5					0	0.0
Questions are effectively randomized	6	60.0	4	40.0					0	0.0
Unpredictable patterns are considered	4	44.4	5	55.0					0	0.0
Feedback										
Appropriate for the audience	7	58.3	5	41.7					0	0.0
Accurate evaluation of right and wrong answers	7	58.3	5	41.7					0	0.0
Motivational and sensitive to users' needs	6	50.0	6	50.0					0	0.0
Immediate	11	91.7	1	8.3					0	0.0
Flexible in accepting learning responses	7	63.6	3	27.3					1	9.1
Provides cues or prompts for wrong answers	8	72.7	3	27.3					0	0.0
Relevant to history of responses	6	54.5	4	36.4					1	9.1
Assistance provided within the lesson	8	66.7	4	33.3					0	0.0
Re-explanation is provided	6	54.5	5	45.4					0	0.0
	None		Poor		Sufficient		Good		N.A. or N.E.	
Evaluation	f	%	f	%	f	%	f	%	f	%
Systematic review of learned materials	1	7.1	2	14.3	4	28.6	1	7.1	6	42.9
Appropriate presentation of post-test	0	0.0	0	0.0	2	14.3	1	7.1	11	78.6
Consistency of post-test and objectives	0	0.0	0	0.0	12	92.3	1	7.7	1	7.7
Control for										
Content sequence	0	0.0	0	0.0	6	50.0	5	41.7	1	8.3
Rate of presentation	0	0.0	0	0.0	4	33.3	7	58.3	1	8.3
Timed input	1	8.3	0	0.0	5	41.7	1	8.3	5	41.7
Type of feedback	0	0.0	0	0.0	6	50.0	4	33.3	2	16.7
Sound control	2	16.7	2	16.7	4	33.3	2	16.7	2	16.7

	None		Poor		Sufficient		Good		N.A. or N.E.	
	f	%	f	%	f	%	f	%	f	%
Content of feedback	0	0.0	3	25.0	3	25.0	3	25.0	3	25.0
Mastery level	0	0.0	0	0.0	4	33.3	3	33.3	3	33.3
Technical design										
Appropriate text size	0	0.0	1	7.1	3	21.4	10	71.4	0	0.0
Appropriate amount of material	0	0.0	2	14.3	4	28.6	8	57.1	0	0.0
Text easy to read	0	0.0	1	7.1	8	57.1	5	35.7	0	0.0
Smooth screen transitions	0	0.0	1	7.1	6	42.8	7	50.0	0	0.0
Time required for transitions	0	0.0	3	21.4	6	42.8	5	35.7	0	0.0
Appropriate use of colors	0	0.0	0	0.0	5	35.7	9	64.3	0	0.0
Graphic support to instruction	0	0.0	0	0.0	5	35.7	8	57.1	1	7.1
Relevance to learner's age and ability	0	0.0	0	0.0	6	46.1	6	46.1	1	7.7
Animations support	0	0.0	2	14.3	2	14.3	3	21.4	0	0.0
Quality and clarity of displays	0	0.0	0	0.0	4	28.6	10	71.4	0	0.0
Appropriate use of sound	2	14.3	2	14.3	4	28.6	5	35.7	1	7.1
Appropriate use of multimedia	1	7.1	1	7.1	5	35.7	4	28.6	3	21.4
Control degree for screens	0	0.0	2	15.4	4	30.8	6	46.1	1	7.7
Special features										
Glossary	0	0.0	0	0.0	2	15.4	8	61.5	3	23.1
Navigational Map	0	0.0	0	0.0	3	25.0	5	41.7	4	33.0
Possibility of marking parts of the content	1	7.7	0	0.0	5	38.5	2	15.4	5	38.5
Record storing for future student retrieval	0	0.0	0	0.0	3	23.1	3	23.1	7	53.8

Notes: N.A. means not applicable. N.E. means not explored
The item referring to post-test was rated only by subject matter experts

Comments and Suggestions for Improvement

Instructional Design

Comments:

- Very Interesting. Rich in background (theoretical links).
- Written text and screens were interesting.
- Content is accurate and complete.
- Overall I find the content of Hyperworld very good.
- An interesting variety of examples, and types of interaction.
- The variety of techniques maintain interest.
- Interesting to use in that program presents variety of techniques.
- Navigational map and overview of instructional design process are helpful for students looking for an overview of the process.
- I would like to review the software as part of Instructional Design II.
- Useful for those who do not have a background in instructional design.
- References in the glossary are very useful.
- Interesting references.
- Glossary was easy to access.
- Main method to review was by navigating to previous screens.

Negative Aspects and Suggestions for Improvement:

- It requires advanced level skills in instructional design theory before it can be used.
- Add a story -line or scenario as example.
- Perhaps there should be a level "0" for beginners with examples on how to classify objectives, correct and wrong answers and why.
- You need to be a subject matter expert in instructional design to be able to learn with the program.
- State target audience on-line.
- Examples are too difficult and guessing answers is not appropriate.
- People with no knowledge will be lost in the first five minutes.
- Use general knowledge examples instead of science.
- There is no product at the end of the session.

- Unclear whether this is a learning tool or intended as a production tool for projects.
- Confusing (when should I only read the material and when should I do something?).
- I do not understand what is expected from me.
- It is condensed text-book-style. Lots of reading, maybe too much.
- Too much information. Did not find it concisely summarized, difficult to retain.
- More humor would be nice.

Visual Design

Comments:

- Very good design, good use of colour and screen design.
- Program is transparent to user, easy to use and very predictable.
- Screens are well designed in terms of appearance.

Negative Aspects and Suggestions for Improvement:

- Too many colours and letter sizes can be distracting.
- Pink is hard to read on marbled gray background.
- Interface needs improvement, especially navigation/ orientation. A map icon would be useful.
- Close box and instructional tips with the same icon can be misleading.
- Some full-screen explanations can be reduced to overlay windows.
- Reduce information for "presentation and practice" to one screen to be able to compare.
- Marbled black background is nice but it is distracting
- Should have a margin around text in boxes.
- Tennyson's bouncing head is cute but could be irritating to have to wait for the next sequence each time.
- Bubbles over events of instruction should be moved off the text.
- Bubbles after images are distracting.
- It was difficult to relate the screen design to the content for instruction
- I would rather have references in alphabetical order than in chronological order.

Technical Design

Comments:

• Transition time is acceptable

Negative Aspects and Suggestions for Improvement:

• Have the program keep track of where you have been and where you are (map)

• Have easier access to the map for orientation.

• Sometimes, balloons do not pop up.

• Finding the right spot to click on some boxes was difficult.

• Sometimes it is not clear which boxes to click.

• Have an area on the screen where I should type in my notes, questions, and then be able to go over them with someone and save them.

• When cursor is moved quickly across one box to another, and clicked, computes response time is so slow, that it accesses the box across which the cursor last traveled rather than the current one.

• Would be good to have print capabilities attached to glossary.

General

• Would like to try the software in an air-conditioned room.

• Good effort.

• Impossible to answer all these questions if insufficient time to work on software.

• The program is not complete, therefore, questions dealing with the program should be limited to what was used.

• In documentation, it would be helpful to give tips on how to approach Hyperworld for different purposes.

• I was very unfamiliar with the terms at first, and was a bit frustrated with the theories. If I use it again, next time I will be more efficient and knowledgeable.