ABSTRACT

The authors describe a joint research project employing cognitive mapping and expert system techniques for representation of a knowledge base concerning sexually transmitted diseases (STDs) to college-age populations. Development of an intelligent tutoring system involves expertise from a number of domains. In this case, the fields of medicine, education, computer science, artificial intelligence, nursing, and cognitive psychology are represented. The process of knowledge base construction in the form of concept map through consultations with health care experts is explained. This choice of knowledge representation can be extremely critical to both experts and novices concerned with the problem of STDs. The transformation of this representation into a SmartBook by employing hypertext tools is discussed as the first step towards building an Intelligent Tutoring System (ITS). The expert module, with accompanying expert systems, enabling queries to the knowledge base for accessing information vital to the learner and to the expert, is the next essential component of the system. Finally, the embellishment of a student modeler, a curriculum module, a tutoring module, and evaluation of the performance of the ITS at each stage in its development, is considered.

Introduction

Sexually Transmitted Diseases (STDs) in general, and more recently the life-threatening disease of AIDS, are widely recognized as important health problems. STDs are found more commonly in the age range which includes college age populations. College health officials and university administrators have become increasingly concerned with the rising incidence of several STDs. Educational efforts have become more direct, factually based, and comprehensive than previous attempts at "Sex Education" for the college student. Yet the incidence of most STDs is on the rise, and basic information as well as appropriate behavior directed toward prevention is often lacking (Keeling, 1989). In times of increased emphasis on individual responsibility, health problems become educational issues, particularly within an educational institution. College health centers usually have an abundance of pamphlets available, yet for students there is a general level of misinformation and incomplete understanding about the most common sexually transmitted diseases, as well as the most life-threatening ones.

This paper describes our work with domain experts using concept maps and group interviews to construct the STD knowledge base, the development, within Apple's HyperCard™ application, of an STD SmartBook, undergraduate student's use of the STD SmartBook, and finally implications for the construction of an STD intelligent tutoring system. The principle focus of this research has been in the areas of knowledge acquisition, knowledge representation, learning, and problem solving with respect to the identification, control, prevention, and treatment of STDs. Fundamental issues which are addressed are (1) the effective extraction, representation, and modification of an expert/novice knowledge base, (2) the design of an effective computer-based information system about STDs, and (3) the acquisition of problem solving techniques used by novice learners in a way that will encourage appropriate behavioral changes. These fundamental issues are placed within a framework of cognitive psychology which attempts to explain why the program will facilitate learning.

Experts and Skill Acquisition

Considerable effort has been expended towards study in the area of cognitive skills, their acquisition, and their modelling with such systems as GPS (Newell & Sinom, 1972), HAM (Anderson & Bower, 1973), and ACT (Anderson, 1976), but the principle problems which still remain are (a) what is knowledge (advice), (b) how should it be represented, and (c) how can it be effectively extracted and represented for novice learners?

It has been determined that there are essentially three areas of skill/knowledge acquisition: encoding, proceduralization, and composition (Anderson, 1982). The knowledge associated with such skill acquisition tends not to be constructed in a formal top-down manner. When solving problems experts seem to perform cognitive leaps based upon acquired know-how. These cognitive events may be a chain of mental actions that are usually so rapid or automatic that one has no awareness that these strategic routines have been specifically selected and are being executed, thus, the reputation for the expert's "intuition" in a particular clinical situation (Dreyfus and Dreyfus, 1988). However, there is substantial evidence for the contention that experts tend to be poor in articulating precisely just how they are able to solve difficult problems within their domains of expertise (Michie, 1984). Thus, methodologies for the teaching and learning expert skills is not readily accessible.

The Rationale for Computer-Based STD Education

General barriers to knowledge are lack of access to complete and accurate information, knowledge represented in ways which are inappropriate to the learner, lack of interest in the knowledge base, and a curriculum design which does not facilitate the kind of learning intended by the educator. Problems which are more specific to the domain of sexually transmitted diseases are issues of privacy, confidentiality, perceived potential for value conflicts, and the need for a level of understanding which can or will translate into behavioral changes for the learner.

Embarassment, fear, access to current information, and lack of knowledge about where to find such information are seen as major obstacles to adequate STD education (Keeling, 1989). The student's desire to have information about sexual matters is not considered to be an issue. It is believed that placing information in the knowledge environment of computer aided instruction will successfully address some of the shortcomings of current efforts toward STD education. To date, intelligent software has not been developed and employed to effectively disseminate the critical knowledge relevant to this epidemic. Since sexually transmitted diseases are a subject which few people feel comfortable asking about, the computer can provide an opportunity for learning about these diseases while providing anonymity.

The computer-assisted approach allows the student a wider range of access than information which is primarily available through written material at a student health center, if compatible terminals and software programs can be made reasonably available throughout a campus. A computer has the added advantage of being more approachable for the student who is initially too embarassed to ask questions. The student can anonomously sit at a terminal and progress as far as desired through a particular program on any one of a number of STDs, without concern about being seen at the "STD Clinic", and without the need to wait for an appointment.

Most college students in the 1990's are at least minimally acquainted with a computer keyboard. Many campuses in the United States have computer clusters in several campus locations, often in dormitories. Computer aided instruction can be made available on a floppy disc which can be obtained from libraries or student health centers, installed on hard discs, or accessed through a mainframe computer. Such easy access may allay feelings of fear and embarassment for many students seeking sensitive information. The use of a computer-based information environment as presented in this paper also allows for updating information easily, on an as-needed basis. Locating terminals and appropriate software in the campus health center, as well as incorporating appropriate clinical referral information into the program, reinforces the services offered by those practitioners who are available to the students.

The authors have developed an instructional program using the Macintosh application HyperCard. This medium allows a flexible format which makes use of the relationships between concepts in the presentation of information in a "Smart Book" (Feigenbaum, 1988). The STD SmartBook utilizes several educational principles. A primary advantage is the ability of the program to adapt to the learner's needs, rather than presenting information in an inflexible linear format. An educational heuristic referred to as concept mapping has been used for both the organization of the knowledge base, as well as the means for progressing through that information base.

Educational Psychology

The STD SmartBook has several other advantages, beyond flexibility, over a linear type of information presentation, such as that found in textbooks. Educational psychologists have found that in order to achieve meaningful learning, i.e. learning which indicates understanding to the extent that there will be behavioral changes, the learner must progress past rote learning (memorization) and procedural learning (rules, e.g. traffic rules, spelling rules, etc.) (Gowin, 1984). The relatively passive teaching/learning paradigms such as lectures in a classroom and reading from a book are not nearly as successful in promoting meaningful learning as more active teaching/learning paradigms such as one-on-one tutoring, intelligent tutoring systems, role-playing, and clinical or "in-the-field" experience (Bloom, 1984).

When the student learner has a more active role in selecting information to be learned, questioning, pursuing thoughts independently or with guidance, progressing at an individualized pace, going through the program of learning according to particular learning needs or interests, and receiving feedback and guidance with self-monitoring techniques, there is an increase in the storage of information in the long-term memory as well as an increased ability to transfer the information into relevant real life situations in which behavioral changes would be appropriate (Sternberg and Ketron, 1982).

A potential disadvantage to using the SmartBook may result from its flexibility. The learner may omit entire sections of basic information, either believing that these subconcepts are not relevant or interesting enough to attend to, or by failing to realize that these categories of information exist in the program. This drawback is attended to in several ways, primarily by making it clear to the student learner where s/he is in the program through a number of devices.

Six diseases are addressed: AIDS, genital herpes, syphilis, gonorrhea, chlamydia and venereal warts. Each disease will be presented in a format which utilizes a concept map, and each concept map for a specific disease will be organized along a similar general "schema" which is common to all sexually transmitted diseases. The organizational framework for representing the knowledge base for each disease will be divided along the lines of epidemiological information, general knowledge about the host and the organism, current clinical advice about transmission, signs, symptoms, treatment and prevention. The use of concept maps is consistent with educational theory relating to the need for a learner to put new information into a context of already-familiar concepts (Ausubel, 1963, Gowin, 1984)

Concept Maps as Used for Knowledge Representation

Within the discipline of cognitive science, a theory of knowledge known as "schema theory" has evolved from the work of Bartlett (1932), Ausubel (1963), Anderson (R.C.) and others (1975-1984), Anderson and Pearson (1984), Bobrow and Norman (1975), Minsky (1975), Norman, Rumelhart & the LNR Research Group (1975), Ortony (1975), Schank & the Yale AI

Project, Schmidt (1975), Schank (1972), Spiro (1977), and others. Rumelhart and Ortony (1977) describe schemata as follows:

> Schemata are data structures for representing the generic concepts stored in memory. They exist for generalized concepts underlying objects, situations, events, sequences of events, actions, and sequences of actions. Schemata are not atomic. A schema contains, as part of its specification, the network of interrelations that is believed to generally hold among the constituents of the concept in question....

There are four features which are essential to a schemata: (1) schemata have variables; (2) schemata can embed one within the other; (3) schemata represent generic concepts which, taken all together, vary in their levels of abstraction; and (4) schemata represent knowledge, rather than definitions (Rumelhart and Ortony, 1977). Theorists in the field of computer science found schema theory very useful in their efforts during the 1970's to explain and develop artificial intelligence (Anderson & Ortony, 1975; Mayer, 1976; Minsky, 1975; Schank & Ableson, 1975; and others).

There seems to be a natural progression from Ausubel's theories about the cumulative nature of knowledge, to that of schema theory. The way that schemata are generic, i.e. general concepts, fits with the idea that one develops a certain image of the world, with particular realities and classifications of relationships between those realities. The schematic variables are analogous to the progressive differentiation shown in concept mapping.

Schema theory is thus a theoretical model which compares knowledge representation to learning which may be thought of in a three dimensional framework/file system. As new information is received, it is placed into the most appropriate "file" in the system. When there is a need for retrieval, the encoding (file name) of the original piece of information is key for successful memory, i.e. retrieval (Kardash, Royer, and Greene, 1988). Learning is thought to be more difficult when new material is not readily encoded, e.g. when one does not know what to call something which is unfamiliar. The use of a concept map should facilitate encoding of new information.

Concept mapping has been successfully applied to a variety levels of formal classroom learning situations (Cliburn, 1990; Gowin, 1981; Schewel, 1989; Trochim, 1989; Novak and Gowin, 1984) as well as informal adult education (Brody, 1985). Concept Mapping has previously been somewhat independent of the AI domain intended here for its application. However, its roots in cognitive psychology and learning suggest its suitability for our investigations. In addition, we know of at least one other ongoing research effort which is based on this form of knowledge representation (Feifer, Dyer, and Baker, 1988). Concept mapping provides a framework for representing subject/expert/novice knowledge. The usefulness of this technique is based on the assumption that people think with concepts, and these concepts are linked together in meaningful idiosyncratic relationships by the learner. Large numbers of concepts and their relations are joined together into a major conceptual framework or schema. Concept maps with small numbers of subconcepts can then be joined together forming complex semantic networks representing schema (Collins and Loftus,1975).

Because concept mapping depicts a heirarchical set of categories of information in a particular domain of knowledge, it may be especially appropriate for representation of a data base for fields in which the knowledge base is changing rapidly. The old "details" can be discarded and replaced with new details, all under the same generic category heading. Thus, there is less to learn in a sense, because the file name (using schema theory) is unchanged, encoding is simplified, and recall is thus relatively unhampered.

Theoretically, a concept map could be made for any domain of knowledge, by an expert or a group of experts in that field. The ordering and representation of sub-categories within a field, as well as the defining of relationships between those sub-categories, should serve as a learning tool for novice learners. Rather than receiving volumes of new data, thousands and thousands of new bits of information (as in a lecture or book), the novice could begin with an organizing framework designed to assist the student in prioritizing information as it is initially received. This may enhance the encoding prodecure in learning.

In this study concept maps were used to help extract expert and novice knowledge, identify key concepts involved in STDs, and represent them in easily understandable formats for both future teaching and learning in a computer-based intelligent tutoring system. University of Maine Health Center medical doctors and health educators collaborated on the construction of concept maps for six STDs during group interviews. The resulting maps help make clear the relatively small number of concepts and relations that need to be focused upon in learning about STDs. The figure below is a concept map of the major subsuming concepts in an extensive network of maps related to STDs.

[Figure 1. The major concepts of STDs.]

Concept maps were constructed for six STDs by the campus health care experts and collectively represent their understanding of the infectious diseases. A number of critical concepts; signs symptoms, prevention, treatment, host, and transmission provide a pervading skeletal and hierarchical structure for each disease. This forms the basis of a semantic network knowledge base from which we plan to construct an intelligent tutoring system's expert and student model components.

[Figure 2. STDs for which concept maps have been constructed]

The "SmartBook"

The issues of knowledge representation and knowledge acquisition are fundamental to the study of artificial intelligence and intelligent tutoring. Most people would probably agree that much formal learning relies on books consisting of words which comprise textual information or photos which comprise graphical information. A well-written and well-structured book can be considered an excellent source of information on a subject and integral for a student's learning. Books tend to be complete and sequential in their presentation of material. There is also an implicit hierarchical structure for the knowledge in most books which attempt to present learning material. This structure entails the presentation of material in a linear and top-down form. That is, the general overview of a subject is presented first and then details on specific relevant topics or methods will follow. Each topic is presented in an order prescribed by the author. A good text will have all the important subject information as well as a table of contents and index detailed enough to direct the reader to information on a topic of interest which is covered in the book. Key words may also be highlighted in some way. However, traditional books lack flexibility in the order of presentation of information and will tend to omit the most important relationships between concepts presented in various parts of the book. This is due to the very static nature of this form of knowledge representation, the style and content being rigid and unchangeable once a book has been published. The primary advantage of our SmartBook is flexibility and the opportunity for the learner to explore relationships between concepts. That is, it can be used in many ways and important links between concepts are included in the presentation. The order in which material to be learned is presented is the choice of the user. In essence, the SmartBook represents a road map through the knowledge base of STDs.

[Figure 3. AIDS Smart Book -- Sample Card]

Information in the SmartBook is represented in two forms: graphically and textually. Graphical information has been derived from its knowledge representation in the concept maps. The structure of these maps can embellish the knowledge of experts in a domain. Typically any node on a screen can be "clicked" to proceed to the next screen with a new map segment and more information. The key to a SmartBook's flexibility is that one can move in many directions via the nodes and arcs in a graph. Concepts in nodes are connected by arcs. Importantly, at all times the user can quickly determine how the current node was reached and what are the possibilities for proceeding from the current node. Textual information is always presented in a brief, compact and clear form. The same is true for graphical information. The graphs on a card have deliberately been kept simple, hiding the complex connections which may comprise the concept map of the domain being represented. As an alternative to overloading the user with too much information in a particular card (or screen), we have left the edges with arrowheads (but no nodes attached) intact, representing topics which are further developed on subsequent cards.

The system has been developed in HyperCard, the Macintosh hypertext system, which enables the user to interface with many forms of information. Transparency in form and function is fundamental to the SmartBook. In addition to the existing ***pop-up windows, glossary of terms,*** and ***to map features***, there is the potential for adding *synonyms for key words, a retrace facility, expert advice, and video-disk presentation of graphical information.* As any good knowledge base, it is easy to modify, expand, and refine. The SmartBook is viewed as an important stepping stone to ultimate goal of building the STD/ITS.

Use of the STD SmartBook with Learners

Presently we are using the STD SmartBook (focusing on AIDS) with undergraduate nursing students. We are interested in how they access the information and how they interact with the system. A general introduction to the Macintosh computer emphasizing icons, pull down menus and point and click techniques was presented to an entire class. The students were asked to conscientiously use the STD SmartBook and familiarize themselves with its form and functionality, while at the same time attempting to be critical of its domain knowledge, style of presentation and human interface. Eleven students were interviewed as they used the system.

The interviewer asked student users specific questions about their understanding of the material presented onscreen as well as their feelings about their interactions with the system. Student use has been monitored through individual interviews during interaction with the program. The analysis has focused on the content, correctness, and human interface aspects of the SmartBook. Preliminary results indicate that the program is effective in providing relevant information on STDs and will help guide the design of an intelligent tutoring system. The research question which naturally follows from this work: "Is meaningful learning about a specific sexually transmitted disease facilitated by the use of a SmartBook?"

We will try to answer this question through a group of controlled experiments with student learners. The experimental group will consist of 30 student learners who proceed through the SmartBook in accord with standardized directions given at the beginning of each program. The control group will consist of 30 student learners who proceed through text which is arranged in standard linear format, with a "top down" approach and standard directions given at the beginning of each program. The third group, in effect a placebo group, will be 30 student learners who proceed through hardcopy produced by the Macintosh, and preceded with standardized instructions at the beginning of each learning format.

Evaluation will be based upon responses to questions designed to test higher-level learning in users of all three program styles. To eliminate as many differences as possible between the three groups, both programs will utilize the Macintosh SE, and all three programs will present exactly the same information. The interactive nature of the Smartbook program will be tracked for individual users as an additional means of learning how students using the SmartBook's progress through the concept map. This data should be of value in designing future SmartBooks, as well as making revisions in the existing program. In later studies the paths which student learners pursue as they travel through the SmartBook will be recorded and analyzed.

It is our expectation that the flexibility of the SmartBook approach will enable the students to learn in idiosyncratic ways and thus enhance meaningful learning about STDs. We also believe that because of the facility for rapid access to interconnections between various concepts that students will appreciate the system's ability to help them process information quickly and help facilitate the learning of clinical decision making processes.

Towards an Intelligent Tutoring System

Recent advances in learning have taken a particularly cognitive perspective (Carey, 1987) and many of the major findings have implications for education in general and the development of intelligent tutoring systems in particular. This perspective begins with the principle that what learners already know about new information will influence their subsequent learning of that material (Champagne and Klopfer, 1984). This is consistent with William Martin's Law (1978) which states that: "You can't learn something unless you almost already know it." The idea behind this is that learning rules from examples is most effectively accomplished by being able to isolate the smallest, but most significant different features of counterexamples. From this point of view the ways in which undergraduate nursing students access the STD SmartBook will be compared with how the medical experts constructed the original STD semantic networks. This information is integral to the construction of a student modeler in the STD/ITS since student models must be compared to expert understanding in order for the tutor to make appropriate suggestions for subsequent learning events.

[Figure 6. The STDs/ITS Architecture]

The figure above illustrates our perceived STD/ITS architecture and the scenario for how interaction, assessment, instruction and learning will take place. The nine steps of the *learning cycle* as we see it are described as follows:

1. The student interacts with the STDs SmartBook.
2. The STDs Expert questions the student about subjects presented in the SmartBook.
3. The student answers the STDs Expert's questions.
4. The STDs Student Modeler performs model tracing to record the student's performance (responses) in interacting with the expert system.
5. The STDs Student Modeler analyses the differences between the student's understanding of the content area and the expert's understanding of it.
6. The STDs Tutoring choses a tutoring strategy and feeds it to the curriculum module.
7. The STDs Curriculum makes known what methods of instructional feedback are available to implement a particular tutoring strategy.
8. Instructional feedback is provided to the student.
9. The student may be referred back to step one for another learning cycle.

The arcs marked "(a)", "(b)", "(c)", are labelled in this way in order to represent the sequence in which these steps are performed.

The STD/ITS Expert Module

In addition to refining the concept of the STD SmartBook, we are working on the implementation of an expert system based on the medical information embedded in the STD semantic network. It is our expectation that the expert system will be used in the STD/ITS in order to help the learners understand the relationship of general STD concepts to specific diseases. For example, after a learner has traversed the SmartBook and assimilated some knowledge he/she will be able to ask the expert system what types of measures can be taken to prevent infection. The expert system could then lead the student through an analysis by way of question-answer interaction with the user of the potential diseases under consideration, signs, symptoms and subsequently, prevention techniques.

More specifically the student learner might ask: ***"If I am in contact with a infected person can I get HIV?***

The expert system (ES) follows:

Have you had any interactions with the infected person which involve blood transfer, i.e. through needles or open wounds? *NO*

Have you had sexual relations with an infected person involving possible semen or blood transfer? *NO*

ES: Since your interactions with the infected person have involved no exchange of body fluids, either through sexual intercourse or through blood transfer, you are at no risk of getting HIV from the infected person.

A rule-based expert system of this kind has been developed using the Macintosh Expert System shell, MacSmarts Professional® version 3.0* .

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*Cognition Technology, Inc.

One important feature of MacSmarts Professional which has been exploited is the ability to interface with our SmartBook in HyperCard. We see potential for such diverse forms of traversal across our knowledge bases by example-based expert systems (another MacSmarts feature) and via an expert system which quizzes and then advises learners about specific information derived from concept maps.

The construction of an intelligent tutoring system to represent the knowledge bases of both experts and novices will allow the researchers to assess learners' knowledge and how that knowledge changes over time. The expert module of an intelligent tutoring system is critical to its success. Through a series of production rules (if then rules) expert systems can represent and embody the accumulated knowledge of human experts. Whether that knowledge is in a procedural or declarative form (Feifer, 1988) the difficult problems which must be solved are:

1) How can expert knowledge most accurately be encapsulated ?

2) How can the expert knowledge (rules) most effectively be employed for intelligent tutoring?

Traditionally, expert systems and ITS have been employed to facilitate understanding of subject matter and decision making by enabling problem solving. The critical issues for the domain in question, STDs, are not problem solving, but rather conceptual understanding (or misunderstanding) and the efforts to detect, represent, evaluate misunderstanding and consequently to help effect behavior changes. Other ITS, such as The LISP Tutor (Anderson, Corbett, and Reiser, 1985), MENDEL (Streibel et. al, 1987), and STEAMER (Hollan et. al. 1984) have been oriented towards improving problem-solving skills and technical abilities in well-defined task domains. In contrast, our expert system and subsequent modules, will use interactions with students to evaluate conceptual understanding (student modelling) to facilitate the choice of an appropriate tutoring strategy. The expert system, with its rich knowledge base, will ask the student a number of questions to test both factual (declarative) and (procedural) knowledge.

Earlier experience with an effort to construct an AIDS expert system taught us to avoid any attempt to perform diagnosis. That is not the role or the purpose of the STD/ITS. It should try understand the student learner's conceptualization of the domain in question and based on the analysis of it, attempt to inform, instruct, and support healthy behavior modifications.

The Student Modeler, Tutoring Module, and Curriculum Module

The student modeler will analyze students' interactions with the expert system to assess what kinds of misunderstandings (if any) might exist. Some errors may be of a simple factual nature while others may be of a deeper conceptual nature. In either case, these may be passed on to the tutoring module for evaluation and selection of an appropriate tutoring strategy. A typical and important issue which an ITS must contend with, namely, when and how to intervene in the student's interactions with the expert system, must be resolved at some point. Should intervention (instruction) occur immediately after a wrong answer to a question has occurred, or, should this be delayed until a clear conceptual misunderstanding has been analyzed? The tutoring module's decision should depend on a pre-classification of the expert system's "question base" -- that is, a question is either of a clear-cut factual (or declarative nature) or it is of a conceptual (or procedural nature). In either case, the appropriate card or sequence of cards from the SmartBook should be referred to the student for further learning. In this way the tutoring module will embody meta-knowledge about tutoring. Concurrently, a rich curriculum module may offer a variety of alternative forms of instruction, including video disks, microworld simulations like "Pat and Bobby go out for a date", discovery learning, abstraction, problem solving, and access to specialized information networks.

Conclusions

Our prototype system will serve as a testbed for investigation into a number of well known problem solving paradigms and in particular the acquisition of clinical decision making skills. Its ability to transmit information about STD detection, control and abetment will provide insight into future techniques for incorporating both expert and novice knowledge into existing knowledge bases. As each module of the STD/ITS is developed -- from SmartBook, to expert system, to student modeler, tutoring module, and curriculum module, we have the opportunity for the comparison and evaluation (under controlled conditions) of different knowledge representations as learning tools. This opportunity will not be overlooked.

Finally, it is important to note that our choice to represent the STD knowledge base on existing Macintosh applications is an important and practical one. The rationale behind the selection of these implementation tools is the growing concern within the AI community that systems must be developed which come to grips with the problems of applicability for the end-user. Our basic understanding of the intent of ITS development is to promote learning and this requires that the system be implemented in such a way that it is actually used by naive learners to answer their questions concerning, in this case, STDs. The growing availability of Macintosh computers on campus, pull down menus and icon based commands have all contributed to this decision.

Although our work in the knowledge rich and complex domains of STDs and ITS is still far from completion, it is clear to us that a sound educational theory, supported by valid cognitive psychological perspectives (Champagne and Klopfer, 1984), will enable the construction of a powerful system. Efforts to solve intermediary problems and measure the instructional effectiveness of diverse knowledge representations will drive the further course of our research. The scaffolding for the conceptual representation which we are constructing are the nodes of the concept maps. However the foundations of our approach are links connecting these nodes and their semantic implications.

We are fortunate to live in an advanced technological era whereby a multifaceted approach employing hypermedia including hypertext, graphics, videos, CD-ROM, and large knowledge bases which may be interconnected and interwoven in diverse and intricate ways to provide education (Woolf, 1989). However, in today's explosion of information media, both those which are smart and not so smart, opaque or transparent, as well as those which are flexible, dynamic or rigid, we must never lose sight of our higher aim here, which is to provide practical education in a socially critical domain.

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Figure 1. The major concepts of STDs

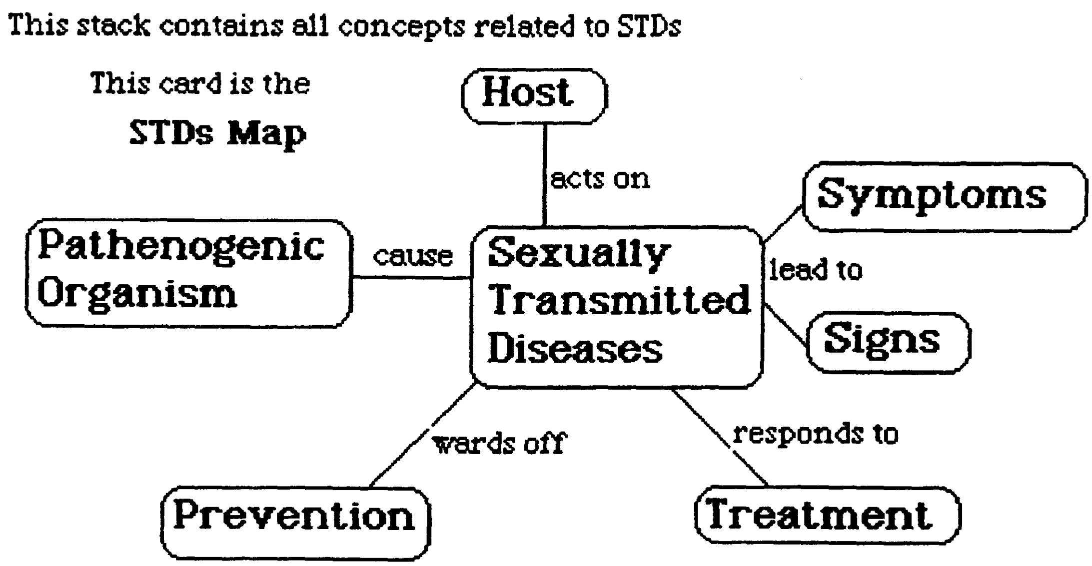

Figure 2. STDs for which concept maps have been constructed.

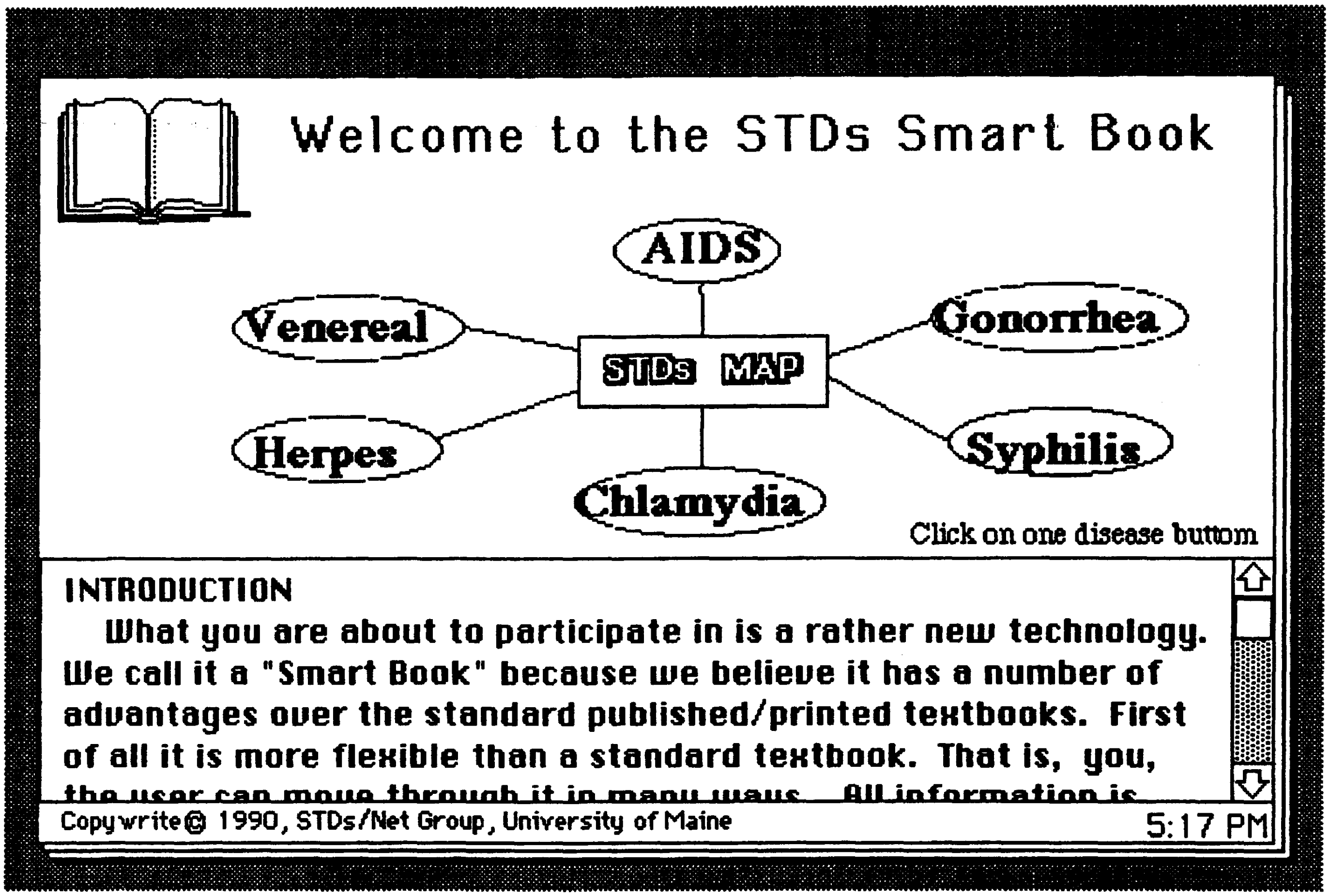

Figure 3. AIDS SmartBook -- Sample Card

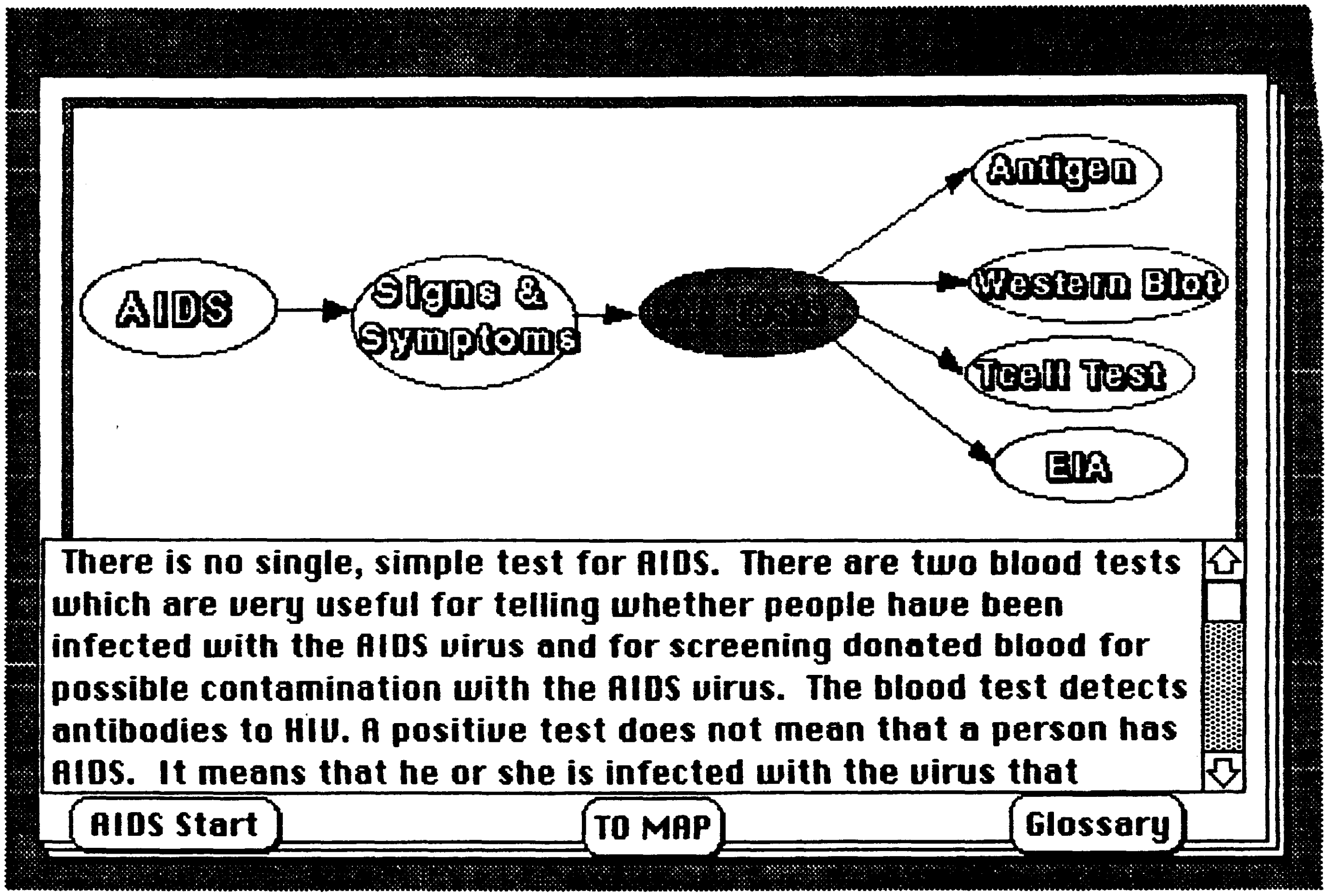

Figure 4: Smart Books vs. Standard Texts

Advantages

SmartBook			Standard Text
Concept Map Approach Multiple Expert Knowledge	Yes	No	Author(s)' Conceptual Knowledge
Flexible Order of Use	Yes	No	Rigid, Fixed Order
Any Combination of Graphical and Textual Knowledge	Yes	No	Mostly Textual Know
Virtually Unlimited Size Authoring System	Yes	No	Size Limited by Publ
Easy to Update/Revise/ Expand	Yes	No	Must Republish
Cannot See Whole Work, Limited by Screen Size Hardware/Software	No	Yes	Can Hold Entire Work "In Hand"

Figure 5. Standard SmartBook Features

HyperCard® Stacks with Parts of Concept Map and Text at Botton

Buttons linking to Cards in Stack Including:

- **Introduction/Help**
- **STD Text**
- **Pop Up Windows**
- **To Map**
- **Map to Cards in Stack**
- **Glossary**
- **References**
- **Path List (not implemented)**

Figure 6. The STDs/ITS Architecture