Software Technology: Studies and SmartBook Prototypes

Towards the Reduction of Medical errors

Introduction

Health care providers in America, in general, are considered to be the best health care providers in the world. Skilled physicians, trained nurses, qualified administrators make it one of largest twenty industries in the United States. But recently, some reports on healthcare systems tarnish this image. **The Institute of Medicine (IOM)** report "To Err of Human" which was published in Nov. 1999 (Kohn et. al, 2000) pointed out a very important issue related to the health care system.

> **'Error caused by medical professionals' in the health care system are the focal point of that report, which has drawn attention at all levels. According to that report, somewhere between 44,000 and 98,000 people die in different American hospital in every year due to 'errors by medical professionals'.**

The IOM report also states that health care lags at least a decade behind aviation in safe-guarding consumers lives' and health. **The Veterans Affairs Department** the largest health care system in the country, counted almost 3000 errors -- along with some 700 deaths related to them -- within its health network between June 1997 and December 1998 (Nordenberg, 2000). All these reports point to the need that the health care system requires more attention to improve this precarious situation. (Kohen et. al, 2000, Nordenberg, 2000, Vincent et. al, 2000, Wilson et. al, 1995, Leap et. al, 1991).

Goal

The goal of our research work is to find out the " the human role" which have led to different adverse events or errors during the last 10 years in different American hospitals. We would also like to be able to make recommendations for how software information systems can be developed to reduce the frequency and consequence of theses errors, particularly those just due to "human error".

Terminology

We use the term "medical professionals" which includes physicians, pharmacists, nurses, and administrative personnel. In our research we have found that the incidence of error has included erroneous actions and decisions by all types of medical professionals at different stages.

Data Sources

To analyze "the human role" in a medical error we have used many diverse sources of medical informatics, and information science literature, including electronic database, MEDLINE, EMBASE, and EBSCO to search for cases of medical error from 1990-2000. We have also analysed some of the law suits, which were due to medical error. A number of research papers, focused on medical Information systems from the graduate students

of CIS 763 (Software Methodology) in the Fall 2001 semester at Brooklyn College, have served as seminal leads for further research.

Study Selection

Our study includes cases which occurred in different domains of medical error, as well as studies which evaluate the application of software technology to prevent those errors.

SmartBooks

Since 1993 the proliferation of the World Wide Web (WWW) has created a plethora of new opportunities for the delivery of electronic, distance learning systems. However, one might ask, "How many systems facilitated by the existence of the WWW have been proven and tested as sound educational tools?" Between 1988 and 1992 we developed a technology at the University of Maine for building what we called "SmartBooks". (Kopec and Wood, 1993, 1994), (Kopec, Brody, Shi, and Wood, 1991) , (Kopec, Wood, and Brody, 1991). The basis of this approach was the use of "concept mapping", which has been demonstrated to be a sound paradigm for learning and education. (Gowin and Novak, 1985). The ability to navigate in any direction does create the opportunity for the improved effectiveness of the learning process. The actual effectiveness is determined by each individual learner. The domain of application was education of college-age populations about sexually transmitted diseases (STD's), specifically, AIDS (Wood, 1992). The importance of developing an anonymous, correct, flexible, and up-to-date source of information and education about this killer disease does not need explanation. More recently, (1996) at the U.S. Coast Guard Academy in New London, CT. we applied the SmartBook methodology to develop an effective electronic system for educating about "Rules of the Road". All cadets at the Academy need to pass a course on Navigation where study of a book nearly 200 pages long is necessary. Cadets who used our "Rules of the Road SmartBook" responded quite favorably when asked to consider its effectiveness as a learning tool.

SmartBooks were developed in essentially four stages: 1) interviews with subject matter experts to develop an effective "concept map" for a domain (possibly involving a number of iterations over several months) 2) translation of the final concept map into the hypercard language on the Macintosh (later Toolbook for Windows was also used) 3) Implementation of a working SmartBook and 4) Testing and revision of the working system with undergraduate students.

Concept maps are a graphical form of knowledge representation whereby all the important information in a domain can be embedded in nodes (rectangular buttons or nodes in this system) and arcs (the lines connecting nodes). At any time during the use of the system a user can see how he/she arrived at where they are (the path taken through the SmartBook) and where it can lead to. This is indicated by a pictorial representation on the top of each card illustrating how the shaded circle (node) was reached and what circle(s) (nodes) it can lead to. Arrows without circles attached to them represent nodes which exist but are not shown in order to avoid cluttering the screen. These nodes can be found on subsequent screens. "General Text" refers to the node which is currently shaded in a graph on a visible screen.

The primary advantage of a SmartBook is flexibility and the fact that it can be developed for any domain using a sound educational methodology. It can be used and traversed in many ways. The order in which material to be learned is presented is the choice of the user. All information is represented in two forms: graphically and textually. Graphical information has been derived from a form of knowledge representation called *concept maps.* The structure of these maps can embellish the knowledge of experts in a domain. Typically any node (oval or button) 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. Table 1 (on the next page) summarizes the advantages of SmartBooks over traditional texts. As indicated in the Table, the one advantage of traditional texts over SmartBooks may be that the entire work may be held “in hand”.

In essence, the SmartBook represents a road map through any knowledge base. Transparency in form and function is fundamental to SmartBooks. In addition to existing pop up windows, there is the potential for linking to a glossary of terms, synonyms for key words, a retrace facility, expert advice, and video-based presentation of graphical information. As any good knowledge base, it is easy to modify, expand, and refine. Figure 1 (p4) indicates some of the standard SmartBook features.

Their effectiveness as a learning tool can easily be tested and evaluated. We can give pretests and post-tests evaluating subject matter knowledge. For example, performance of students in courses delivered with and without SmartBooks (which can reside on the web with a special course password) would be one way to measure their effectiveness. The SmartBooks themselves include a "Quiz” feature which allows us to test knowledge of any particular subtree of a learning path through the SmartBook. The quiz can refer learners back to the appropriate sections of the SmartBook where the relevant material is presented. There may also be a comprehensive exam which can cover the entire SmartBook. Students can receive feedback on their performance automatically from the system. Traces of nodes visited can also be helpful in evaluating learning using SmartBooks. During the past few months a prototype SmartBook for CPR with color coding and animation. features has been developed in Flash 4.0 (Katz, 2001).

We propose to: 1) further develop and refine the technology of SmartBooks with standardization of the additional features which may include, for example, color-coding of information and nodes traversed, three-dimensional representation of graphs, and animation of graphical information. 2) Prototype SmartBooks will be developed with these features to cover domains such as The Immune System, Headaches vs. Migraines, Anthrax, Smallpox, Diabetes, etc. 3) At a later stage of the research we hope to test the effective of the SmartBooks in reducing errors made by medical professionals.

Table 1: SmartBooks vs. Standard Texts

Smart Book		Standard Text
Advantages		
Concept Map Approach Multiple Expert Knowledge	**vs.**	**Author(s)' Conceptual Knowledge**
Flexible Order of Use	**vs.**	**Rigid, Fixed Order**
Any Combination of Graphical and Textual Knowledge	**vs.**	**Mostly Textual Knowledge**
Virtually Unlimited Size Authoring System	**vs.**	**Size Limited by Publisher**
Easy to Update/Revise/Expand	**vs.**	**Must Republish**
Automatic Testing, Recording, and Scoring	**vs.**	**Manual, Memory Work**
Disadvantage		
Cannot See Whole Work At Once	**vs.**	**Can Hold Entire Work "In Hand"**

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Figure 1: Standard SmartBook Features

The Pages of the Concept Map with Text at Bottom

Nodes or Buttons linking to Cards Including:

- **Introduction/Help**
- **Subject Domain Text**
- **Pop Up Windows**
- **To Map (overview)**
- **Map to Cards in Stack**
- **Glossary**
- **References**
- **Recording of Nodes Visited**
- **Self-Test : Quiz; Comprehensive Exam**

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