AC 2007-420: NEXT GENERATION OF TUTORIALS: FINDING TECHNICAL INFORMATION AT PURDUE

Megan Sapp, Purdue University

Michael Fosmire, Purdue University Libraries -- PHYS

Amy Van Epps, Purdue University

Bruce Harding, Purdue University

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Purdue University recently developed a multifaceted tutorial to provide just-in-time assistance for students seeking technical information. The tutorial incorporates an instructional, animated component that stresses the reasons why different kinds of technical information are important in an engineer's career. It also includes an expert system component, created with the open source program CLIPS, that allows the student to type in a question and receive a list of potential sources that could answer that question, with reasons why those sources might be relevant. By incorporating active and interactive elements, this tutorial will help students effectively fill their information needs whenever and wherever they are. This tutorial was created as part of an institutional grant to meet the needs of an introductory mechanical engineering technology design course that is famous for sending flocks of students to the library to find properties, standards, patents, and other technical information. The course also spawns intense loyalty of students that have completed the assignment, as they come back to campus to explain how they use their information skills on the job, and contribute new questions they have run across to the course. The components of the tutorial will be demonstrated, along with a synopsis of the assessment of its effectiveness. It's relevance to lifelong learning for students will also be discussed.

Introduction

Every April and November, the Siegesmund Engineering Library at Purdue University becomes extraordinarily busy for one week. The reason for this is that the Mechanical Engineering Technology 102 - Production Design and Specifications class is assigned an in-depth library research project. Over the years, the engineering library staff have come to both love and dread this one week. With anywhere from 50-100 students and a question database that challenges even the most experienced librarians, it is both an exhilarating time to practice our reference skills, as well as an exhausting experience.

Since the inception of the project, tools have been created to assist in guiding students to likely sources for answers to questions. Each semester, every section of students receives in-class instruction regarding types of sources and what types of information different sources contain. During the week of the assignment, the primary resource, an online bibliography, helps to ease the actual directing of students. However, the bibliography is not a great source for teaching students why they are looking at the sources they have been directed to find. The educational portion falls primarily to librarians and staff, and not even the best of reference librarians can give adequate information literacy instruction to an individual patron in the face of a line of 7-8 students who also need help.

In the fall of 2005, the librarians of the Siegesmund Engineering Library decided to write a grant to create an educational tool that would not only direct students to the appropriate sources, but would also give them an understanding of the kinds of sources available and what their uses are. The librarians wrote a grant for the Teaching and Learning with Technology (TLT) program

funded by Instructional Technology at Purdue (IT@P)[1]. The grant consists of two main pieces, an expert system to provide a first line of reference assistance directing students to appropriate resources, and an animated tutorial that educates students on the nature of the technical information sources that they might use for the assignment. The grant was funded for $14,520 directed towards paying time for engineering library and Mechanical Engineering Technology faculty to design the tool and student technology employees and IT@P staff to create the tool.

Since this online learning tool is concerned with the fundamental question of locating technical information, another goal of the project is to meet the needs of general users who don't choose or are unable to interact with the engineering library staff, for example, after scheduled reference hours or from remote locations.

Background on the Treasure Hunt assignment

This project developed as a way to increase the learning outcomes for the Mechanical Engineering Technology (MET) 102 Treasure Hunt assignment. The assignment has been ongoing since the mid-1980s[2]. It has grown and changed over time in terms of content, but fundamentally remains the same. The impetus for the MET 102 Treasure Hunt assignment began as a way to teach students to use a particular required text quickly and efficiently. The book, *Machinery's Handbook*, is an expansive 2500 page industrial tome on standards, fasteners, engineering materials, mechanics, machining, quality assurance, manufacturing processes, CNC (computer numerical control) and just about everything mechanical. It is the manufacturing practitioners' bible. MET 102 is the first of several classes requiring *Machinery's*. Currently, this class is still where students are expected to become skillful in the navigating the book. Unfortunately the book is not practical for assigned readings, since it is mostly charts, tables and other practitioner information.

During the same timeframe, a popular TV show, *The Paper Chase,* followed the exploits of Ivy League law school students learning lessons in law and life from venerable actor John Houseman as the cranky but wise law professor. In one episode, Houseman, telling the class that he was trying to bolster the students' knowledge of the library references they would use as practicing attorneys, assigned a weekend to answer a set of 100 obscure, very detailed questions spanning all reaches of the law. Because of the impossibly short timeframe, the class nearly rebelled until they realized that through teamwork they could divide the questions among the class and complete the assignment. They did, of course, and afterwards discovered that teamwork was one of the real lessons in the assignment.

That approach sparked the genesis of a project applying similar principles to topics in science, technology and engineering practice plus allied topics, as a way to encourage students to become more deeply familiar with *Machinery's*, their other texts and various other references. It has continually been expanded to encompass nearly every technical discipline and now heavily leverages resources of the worldwide web. In completing the project, it was envisioned that along the way students would learn to apply a good dose of creativity in finding sources and discover the value of teamwork as well. From the beginning, the intent was for the answers to become secondary to the process and then only as affirmation of the experience of the search.

The project was dubbed, "the Treasure Hunt," because of the 'treasured' knowledge to be gained from the project.

To reinforce this, grading of the questions is based on two parts. One-half credit is awarded for the correct answer, regardless of how it was obtained — no documentation required. The other half of the credit is earned from providing documentation from a published source to confirm the answer. If a standard is applicable, the source credit is split again between the documentation and the identification of the standard. Thus a less than fully documented answer, albeit correct with documentation, would still yield only partial credit if the student failed to recognize that the answer is actually derived from an applicable national or international standard.

Generation of questions for the Treasure Hunt

Students receive ten questions randomly generated from a list of about 1500. The database includes columns for question, answer, source and standard if applicable. A Visual Basic macro is used to randomly select questions for each student, resetting the random number generator after each question. Hence each student is presented with a unique set of questions.

Sample questions

- What was the date of issue (mm/dd/yy) and to whom was the first US patent issued for the safety pin?

- For a yet unidentified manufacturing process, you are asked to spec out 1000g of Woods Metal (Bi50%/Pb25%/Cd12.5%/Sn12.5%). Identify a vendor (name, address, phone, FAX, URL, etc.), current cost and precautions if any.

- What is the standard for water hardness testing of borax hand soap?

- What is the usual minimum yield point in psi, for SAE 950 Steel (0.5 dia.) as furnished by the mill?

- When using lock wires to secure bolted connections, what are the recommended type and diameter(s) of the wire?

- What is a gathering operation in forging?

- In 2002, when did Daylight Saving Time begin in Europe? Answer to be date and GMT.

Expert systems

Expert systems are used in many applications, particularly in business, to simulate the knowledge of an expert in a field and respond to the input of a user with suggestions based on this expert knowledge within a narrow, well-defined domain. A system is designed to provide an inexperienced user with information and assistance with a problem when an expert is unavailable.[3] Among the characteristics which make expert systems enticing is their modular

style, which leads to easy addition of new knowledge in the form of new rules or new facts/vocabulary.

Often expert systems are designed to ask a series of questions and navigate through the rules based on the answers received. In our situation the students were not doing a good job answering specific questions about their given problem or at gleaning bits of information from the context of the problem, so we wanted to have the expert system respond to the actual problems the students had been given instead of expecting the student to answer questions in dialog with the computer.

Expert systems in libraries are not new, but they have not gained wide recognition. Many of the applications that can be found have been created to assist users in determining which databases would be the best for them to search, given their particular information need. [4,5]

Development of the expert system

Development of an expert system includes several parts. The first is the knowledge acquisition step, which involves gathering all the bits of knowledge that need to be coded into the system so that the computer can make the logical recommendations that would match those of the expert. Once the information has been gathered, it needs to be coded into an expert system, often done using an expert system shell or application tool. The shell provides the framework and much of the programming and leaves the developer to enter the expert knowledge.

When faced with developing the knowledge base for the expert system, we started with the resources that were already in existence at Purdue's Engineering Library. The two primary resources that were readily available were the subject bibliography in use for the MET 102 assignment and an extensive collection of assignment questions developed over previous years by library staff. These sources provided a contextual framework for creating the results returned, the logic, and the thesauri components needed in the expert system.

One of the first decisions made about the expert system was that the existing bibliography would also be the results site for the expert system. The subject bibliography is the tool used to provide students a centrally localized gateway to resources appropriate for the MET 102 assignment. It began as a discipline-based directory using headings such as electrical engineering, materials science, business information, and chemical engineering. There is an ongoing process of review for this bibliography to reflect new questions recently added to the MET 102 database. During the review process in Spring 2005, a second directory based on questions topics was added. Headings such as engineering drawing/engineering design, tolerances, sizes/measurement/temperature, and fasteners were added. These categories correspond to a large percentage of questions in the MET 102 database. The disciplines that these question topics fell under were not always evident to our freshman participants. The question topics are simultaneously listed with the disciplines so that students have multiple ways of finding resources on their topics. By using the existing bibliography we chose to employ resources at hand that broadly pointed to groups of sources. Rather than pointing to one specific source (which would make the assignment too simple and would also be incredibly complex in terms of the results databases and the taxonomy leading to the specific results) the MET 102 expert

system would point to general categories that already existed, cutting down on initial work and allowing the librarians to create a more general logic system that would work for a variety of courses.

Historically, knowledge acquisition is the most difficult part of developing an expert system. In our particular application, the librarian is the expert who has the knowledge of where students should begin looking for the answers to their questions, based on words and other items, such as acronyms or trademark symbols, which indicate what type of information is needed. Since the librarians are also the developers of the system, the process became one of simply codifying collective knowledge of the reference collection and assignment questions for the computer programmers who were creating the system and its interface. Since the expert system was developed primarily to respond to questions for a particular assignment, the process of coding the knowledge began with reviewing the collection of possible questions and identifying all the terms and other items which the librarians and reference assistants use in determining the type of information resource that would be best suited to the given need.

The knowledge acquisition process began with the analysis of an existing question collection to create the thesauri used by the logic statements. Out of sheer necessity, Purdue's engineering librarians and staff have been collecting photocopies of assignment questions since the late 1980s. Since that time, the collection of photocopies has grown to a 3-inch thick manila folder that is entirely unorganized. Due to the need to track where answers were found and the need to train new and returning staff members on how and where to find answers, photocopying most question sets each semester has become consistent practice.

An analysis of these questions over time influenced the redesign of the MET 102 bibliography to include both disciplines and question topic types. The beginning of the expert system also started with an analysis of the questions, this time for important technical terms and key phrases that indicate the type of information asked for in the question. Five reference assistants and a librarian divided the large folder into five smaller ones. Each person was assigned specific question topics or subject categories. These thesauri topics were selected based on the current subject bibliography.

The thesauri that resulted created the backbone of the expert system. All together, 33 thesauri were created ranging in length from seven terms or symbols, to over 150 terms or symbols. Symbols such as $, and abbreviations such as mm, kPa and mfg were included on the lists because they often signal particular sources that should be consulted. A list of abbreviations, 72 items long, allow the expert system to "read" the question as input into the text box without requiring the students to guess what the abbreviation means and input incorrect explanations of the abbreviations.

Logic statements

We chose to build a rule-based expert system, a common form[3]. This type of system represents the knowledge as heuristics or "rules of thumb", those if–then statements generating the results list, and the facts, which in our case are lists of terms, which when used together identify a type of need. For example, density is a material property as is the hardness factor for a particular

metal; so, terms like density and hardness are in the list of material property terms. These terms then are referred to from the rules (logic statements), which may look something like:

IF [material property] and [wood] THEN materials

In the above statement, the sections in brackets indicate where the expert system must check the list of terms that may go in this part of the statement. If both sections of the IF statement return a match to the text of the input question, then there is a 100% match that the user should investigate the items in the materials list of resources.

The task of creating the logic statements fell to the coordinator of reference. As the coordinator of reference, the librarian used the questions frequently for training, tool creation, and ongoing addition of sources to the bibliography. With a working knowledge of the question collection, and a viewpoint colored by knowledge of what types of questions come up frequently, which are trickiest to solve, and specific problems students had in completing the assignment, the librarian tried to synthesize the majority of the questions in the assignment into the fewest possible statements that were logically correct, and based on the thesauri, would lead to the resources that were most likely to bring success to the student searcher.

The first step was to create at least one logic statement that incorporated each of the 33 thesauri. These statements were basic, looking something like:

IF [wood] THEN materials

Some of the thesauri were very closely linked. For instance, material properties and materials are extremely likely to be linked in a question, so a statement was written to connect the lists with a Boolean AND, giving a more targeted result for the searcher than either by itself.

Single words often serve as a clue to a source, but are modified by terms in the thesauri, so statements were written to reflect these situations. Physical qualities like size and the word "tolerance" almost always point to standards, so the statement:

IF [size/measurement/temperature] and "tolerance" THEN standards

were created. These statements combining single terms and one or more thesauri lists comprised the majority of the logic statements.

Finally a series of "random" statements had to be included in the list. These reflected questions to which there was no pattern, but that contained key words or phrases that signaled a direction towards finding a source. The librarians and staff members immediately recognize these questions by the key words. To package this knowledge a series of seemingly trivial questions were created. A typical example (if there is such a thing) is

IF "Persian red" THEN dictionary

by which statement the students who don't have the term "Persian red" in their vocabulary will still find the expert system useful.

At the completion of a list of 161 logic statements, a review of the statements was undertaken and it was determined that it was thorough enough to begin the programming of the expert system, with the understanding that once the system was working, a review would be made for statements that were redundant, or that were incorrect or insufficient due to words on the thesauri lists. It was also determined that the thesauri would be reviewed and fine-tuned after the expert system software was completed.

Programming the Expert System software

For development we found and began working with an open-source expert system application called CLIPS[6], which is written in C and is designed for portability and use on different operating systems. The program can also handle different types of programming paradigms: rule-based, object-oriented and procedural. This seemed a good match, as it would support our rule-based system requirement and is written in a language that would interface well with a web-front end, which is how we decided to make the application available to the students. Development work was done by the student programmers in IT@P, the campus department that funded the grant. After the first review of the application it appeared the logic was not functioning as expected. After our extensive testing and explanation of the logic we expected to see, the programmers determined CLIPS would not function as we desired and chose to program the application themselves.

The application is now written in C# and functions as anticipated, particularly for the rules with more than one part to the IF statement. The rules and lists of terms are all maintained in a database, which incorporates one of the best features of expert systems, the modularity of data and rules that makes updating and refining the system a fairly simple task.

The interface is now a Google™ style text box. The students will type in their questions as they are written on the assignment sheet given to them. This reflects the initial design decision to eliminate the requirement that the students pick out the keywords in the question.

The application provides output through a web site. The results currently show a list of sections from the subject bibliography, along with a relevancy ranking for each section. This gives the students an indication of where to start in an often-overwhelming list of sources. Each section is a hyperlink to the externally hosted subject bibliography, bringing students to the sources, but skipping the directory interface. The directory interface will still be available to students, but it is anticipated that it will take on far less importance to future classes.

One of our desired outputs from the expert system has yet to be realized, and that is presenting the information that was entered into the system with the terms that matched part of the rules highlighted. We feel that this would help instruct the students on the parts of the question that are providing information to the librarian, or the expert system, to help determine what type of sources they need to use. Creating this part of the application would also make our tutorial a "good expert system", which is defined as one that can explain its reasoning process in obtaining an answer or at least cite the sections of the knowledge base related to the conclusion reached.[8] (Alberico, 1990)

Animated Tutorial

Supplementing the expert system functionality of our learning object is an animated, multimedia tutorial. While the expert system provides students an interactive 'search' option for identifying useful information sources for their problems, we also understand that our users find information in different ways. The animated tutorial section responds to those users who like to 'browse'

rather than 'search' for answers. This tutorial provides a structure for the universe of technical information, so that students can see the big picture of how all of those resources fit together and how and when each one can be used.

The reason for creating this in an animated multimedia format is that it is seen as a best practice in tutorial construction. Dewald[7] identifies several characteristics of good library instruction that can be exported into an online environment. Among them, she discusses course-integration, active learning components, enabling collaboration, providing multimedia content, articulating clear objectives, and focusing on concepts and not just mechanics. Dewald[9] also discusses the key role interactivity plays in the success of online tutorials, especially the ability for users to choose their own path through the content at their own pace. As evidenced by the success of the Texas Information Literacy Tutorial, TILT[10] and its many descendents [11], Colorado State's Data Game[12], the creation of a shared repository for animated tutorials [13], and the development of a community of expertise in multimedia construction spearheaded by Markey[14,15], multimedia tutorials are continuing to be seen as important methods for getting information across to our current students.

In the development of the multimedia tutorial component, the designers considered the factors raised by Dewald[9], and attempted to integrate as many as possible in the tutorial construction. The theme of the animated tutorial is that, without proper understanding of technical information about a product or material, bad things can happen. In the course of the tutorial, a beleaguered robot on an assembly line is subjected to many dramatic indignities caused by the engineer's failure to check material properties, standards, intellectual property considerations, etc. The use of humor, explosions, and mean lawyers in black limos seeks to attract the attention of students while leaving them with indelible images to reinforce concepts.

The tutorial is written so that the user can sequentially 'tour' the different forms of technical information relevant to students, finding out what they are and what they are good for (and what happens when you don't take them into account). Alternatively, users can focus on the particular type of technical information they have questions about and just learn about that. While containing interesting splash screens and animations, the tutorial allows them to be skipped. This level of interactivity increases practicality, as well as the usability of the tutorial and lets the user bypass the frustration of seeing the same animation sequences repeatedly when they just want to access the content and links to the actual resources.
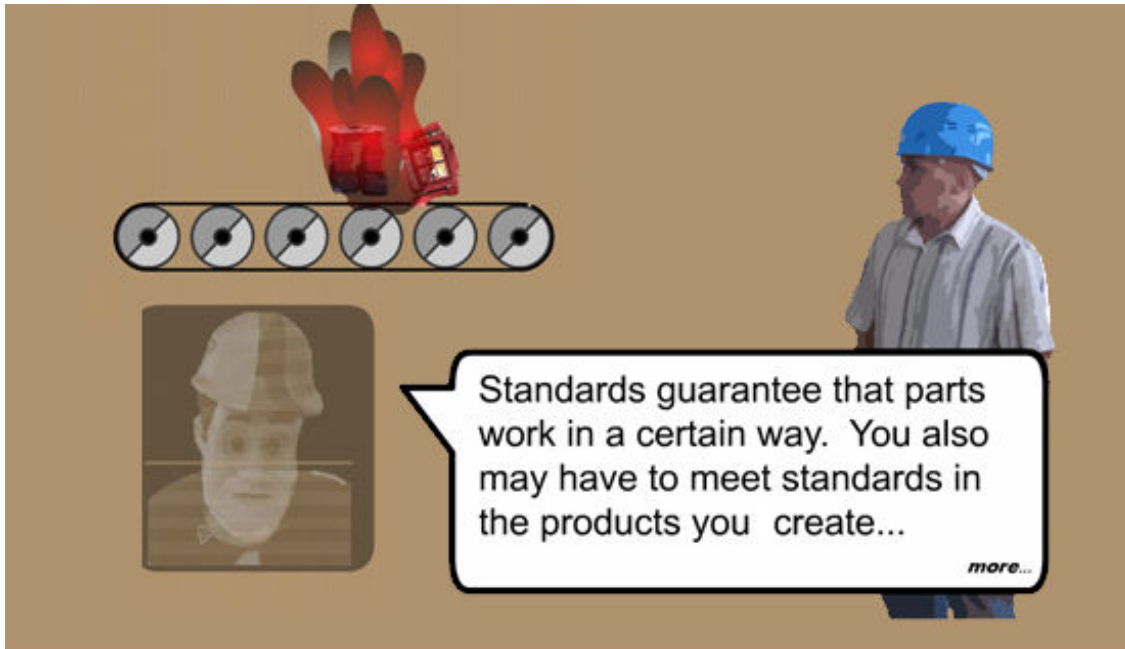
Figure 1: Our robot catches fire. The engineer is learning about standards from Purdue Pete (our mascot.)

Figure 2: The engineer is learning from Purdue Pete that checking standards for component materials will cut down on hazards.

The scope of the tutorial does not cover using any of the specific sources identified as relevant for the students. Partly, this is due to the focus of the tutorial on the concepts of what kinds of technical information are available, rather than on the mechanics of individual search interfaces (which are likely to change, often without notice). Purdue's CORE (Comprehensive Online Research Education) program (core.lib.purdue.edu), which is targeted toward the general undergraduate, covers general search strategies, so the designers did not feel it necessary to include those skills in this module. However, links to the relevant CORE module for those students with questions will be included.

The end result of the prime motivation of the tutorial component to this project, finding an appropriate resource for a technical information need, is the same as for the expert system. Indeed, the underlying resource list is the same for the animated tutorial and the expert system, so there really is an effect of browsing versus searching for the same information.

Conclusion

As stated before, the overriding goal of this project is the process of research and teamwork, not the answers. By completing the project, students experience the types of references available to them, both locally and worldwide. The tutorial and expert system are intended to give students additional instruction that it is difficult to supply in the environment of the "Treasure Hunt". We view this as a creative solution to encourage students to learn more about technical information, as well as streamlining the students' research processes. The expert system was chosen because it mirrors the reference interview process and allows students to gain the same underlying knowledge of technical information that the librarians and staff are also trying to convey. The tutorial provides an independent working environment for students to learn the big picture of technical information as well as be directed to subject-specific sources. The concept of a dual-sided educational tool works well for this assignment and gives the Purdue University Libraries and engineering and technology students of Purdue University another tool to gain self-directed knowledge.

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