Next Generation of Online Tutorials: Finding Technical Information at Purdue University

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Abstract - **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 engineers' career. It also includes an expert system, developed locally, that allows students to type a question and receive a list of types of resources that may be helpful sorted by relevancy. Each type of resource included links to a list of possible sources to answer the question entered. By incorporating active and interactive elements, this tutorial helps students effectively fill their information needs whenever and wherever they are. This tutorial was created as part of an instructional 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 spawns intense loyalty of students that have completed the assignment, as they come back to campus to explain how they use information skills on the job, and contribute new questions to the course. The tutorial components will be discussed, along with a synopsis of the assessment of its effectiveness.**

Index Terms – multimedia, tutorials, lifelong learning, e-learning

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 project known as "Treasure Hunt". 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, 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 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 how those sources could be useful. The librarians applied for a grant from the Teaching and Learning with Technology (TLT) program funded by Instructional Technology at Purdue (IT@P). [1] The grant consists of two 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 to help pay for the time of the engineering library and Mechanical Engineering Technology faculty to design the tool and student technology employees and IT@P staff to create the tool.

Because 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

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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 and/or new facts/vocabulary.

Often expert systems are designed to ask a series of questions and navigate through 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.

For the finding technical information expert system, the knowledge acquisition process began with the analysis of an existing collection of questions gathered by Purdue's engineering librarians and staff from student assignment sheets. The assignment questions were kept to track where answers were found and then used to train new and returning staff members on how and where to find answers. The question analysis helped create the thesauri of key terms which are used to help the librarians identify the type of question and the possible sources for answers. The thesauri that resulted create the collection of 'facts' that are the data used to interpret the system input.

Logic statements

We chose to build a common form of expert system, rule-based. [3] This type of system represents the knowledge as heuristics or "rules of thumb", which when written in English are if–then statements that generate a results list, and the facts, which in our case are lists of terms. When used together the rules and facts 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 braces 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 any part of 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 generation of the rules was also aided by analysis of the questions which had been kept over the years and knowledge and experience gained by librarians through many semesters of working with the students and observing where they have difficulties. Questions were initially developed to address each group of terms or thesaurus. From there additional questions were created to refine results and combine words from related lists. Finally statements were written to handle specific questions and keywords which were not covered in any of the thesauri, but which are known to use particular types of resources.

After initial programming and some significant changes based on testing, the expert system uses 139 logic statements. The thesauri were also reviewed and fine-tuned to better direct results.

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, which makes updating and refining the system a fairly simple task.

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

The application provides output directly below the search box on the initial page. The results show a list of sections from the subject bibliography used in previous semesters, 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 the 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]

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). Alternately, 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.

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, [16] 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.

RESULTS

Two semesters of data were gathered for students who took the class and went through the Treasure Hunt assignment in the same way as it has been for years, with the bibliography and librarians functioning as the primary guidance for students. This data functions as a large control set for testing the effectiveness of the online tools.

A pre-test and post-test were given to each of the students to assess their self-determined ability to find and use a variety of information sources. Students were asked to rate their ability on a 10 point Likert scale with 1 as low and 10 as high. The tests asked about the students’ ability to use the online library catalog to locate materials, determining when they would use different types of technical information and their ability to locate and use a variety of different types of material, including standards, patents, handbooks, codes, encyclopedias and dictionaries. The results for each question were analyzed using a repeated measures t-test to compare the responses of the same student in each set. The results, shown in Table I, indicate the students have a statistically significant, positive change in their ability ratings for finding and using most types of material.

For both semesters the smallest change in self-assessed ability was for locating and using dictionaries and encyclopedias. Most students are very confident in their understanding of these types of resources and how they work, and the changes indicated were not statistically significant.

TABLE I
T-SCORES FOR ALL MATERIAL TYPES; CONTROL SEMESTERS

Type of material	Spring 2006 t-scores (n=52)	Fall 2006 t-scores (n=36)
Library Catalog	5.816681	8.574979
When to use technical information	6.883795	7.235174
Standards	5.260486	6.60359
Handbooks	4.445442	4.916889
Patents	6.415348	5.748451
Codes	4.823047	5.541192
Encyclopedias	-0.25036	1.692071
Dictionaries	-0.94729	0.291111

Based on the data from the control groups it can be seen that the Treasure Hunt assignment serves the purpose of teaching the students about a variety of different resources available to them, what sorts of information can be found in each and how to use them.

The post-test also asked students to report their change in confidence when using a source, also rated on a 10 point Likert scale with 1 representing no change and 10 indicating significant change. When the change in confidence levels were analyzed for the Fall 2006 semester, using a one-sample t-test, all types of resources show statistically significant increases in confidence using the item, as seen in Table II. This includes encyclopedias and dictionaries, which receive almost no change in rated ability to use the sources, but the students' confidence in using these materials increased after completing the assignment.

TABLE II
CHANGE IN CONFIDENCE T-SCORES, FALL 2006

Type of Materials	t-scores (n=36)
Library catalog	12.38264
When to use technical information	10.35269
Standards	13.34311
Handbooks	9.578119
Patents	6.422024
Codes	7.863047
Encyclopedias	6.419471
Dictionaries	5.605828

We also tested for a correlation between the reported change in ability and the reported change in confidence for each of the types of resources the students may have used in completing the assignment. This was done using a Pearson correlation, which shows the degree of linear relationship between two variables. For Fall 2006, all types of material show a positive correlation between ability to use a source and confidence in using a source, but it varied in degree, as seen in Table III. As would be expected, the encyclopedias and dictionaries have a low correlation, reflecting the minimal reported change in ability but significant change in confidence when using the sources.

TABLE III
PEARSON CORRELATION, CHANGE IN CONFIDENCE

Type of Materials	Correlation Fall 2006
Library catalog	0.383009
When to use technical information	0.220141
Standards	0.332213
Handbooks	0.563591
Patents	0.440355
Codes	0.234801
Encyclopedias	0.125692
Dictionaries	0.086334

Spring semester 2007 marked the first use of the expert system and animated tutorial in assisting students with the assignment. The same pre and post tests were given to this group of students as with the two control semesters and the contents of the course and the assignment have not been changed.

The Spring 2007 data, shown in Table IV, indicate the same student reported changes in ability for before and after the assignment as the control semesters. All types of resources show a statistically significant, positive change in ability to use except encyclopedias and dictionaries. Similarly, the test for change in confidence for this semester also showed significant changes in confidence of use for all categories of materials.

TABLE IV
T-SCORES FOR ALL MATERIAL TYPES; SPRING 2007

Type of material	Spring 2007 t-scores (n=50)
Library Catalog	6.902311
When to use technical information	5.686069
Standards	7.382625
Handbooks	3.31599
Patents	5.008601
Codes	4.544838
Encyclopedias	0.992933
Dictionaries	-1.27273

The most interesting information to the authors is the comparison of the Spring 2007 data with the Fall 2006 data, to see if there is a difference which may be attributed to the use of the expert system and online tutorial. The post-test scores for each semester are compared using a between groups t-test. Table V shows no significant difference between the two semesters.

TABLE V
BETWEEN GROUPS T-TEST; FALL 2006 AND SPRING 2007

Type of material	Between Groups t-scores
Library Catalog	-0.925
When to use technical information	-0.74075
Standards	-1.05912
Handbooks	-0.25441
Patents	0.012309
Codes	-0.39745
Encyclopedias	0.366887
Dictionaries	0.15987

Although there was no statistical change in student abilities, the scores of the students on the assignment were also not markedly different than in previous semester. Thus, it is likely that the expert system has worked as expected and been used by students instead of consulting with the library staff, and a lack of change indicates a successful implementation. Table VI shows the variation in number of reference transactions per student during the Treasure Hunt time period. There is a clear reduction in number of questions during the Spring 2007 semester. While the MET 102 students are not the only ones asking questions during the assignment, they dominate the number of transactions and account for the noted fluctuation. The reduced number of reference transactions may be an indicator that the expert system and tutorial were being used, thus reducing the number of students asking for guidance from the library staff.

TABLE VI
NUMBER OF STUDENTS ENROLLED AND NUMBER OF REFERENCE TRANSACTIONS DURING THE ASSIGNMENT

Semester	Number of students	Number of transactions	Transactions per student
Spring 2006	90	546	6.1
Fall 2006	63	323	5.1
Spring 2007	80	295	3.7

Anecdotally, the students are placing keywords in the expert system instead of the full questions. The expert system still presents results, but does not fully help the student, since many of the keywords that help the experts figure out what information is being sought are being omitted by the student. The ability to identify the key points in a question is part of the learning process built into this Treasure Hunt assignment. Given that, we can not expect the expert system to take over the teaching role of the library staff, only to assist in initial guidance to possible sources for answers.

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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