SMARTTUTOR: COMBINING SMARTBOOKS ™ AND PEER TUTORS FOR MULTI-MEDIA ON-LINE INSTRUCTION

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Abstract -- *SmartTutor is a comprehensive web-based peer-tutoring service geared to the needs of urban commuter college students. The new system is based on SmartBooks, a, multi-media educational technology that was developed just prior to the emergence of the World Wide Web. This technology has provided a user-friendly, self-paced, easy to modify, software environment intended to serve the user's learning needs, particularly in an urban commuter college environment. A model for the student creation of the SmartTutor web site is discussed as well as the ongoing evaluation of the emerging software for the project. The assessment of the usefulness of the site is just beginning and its development is an ongoing process. We believe that consistent experimentation with iterative refinements will lead to an effective website for delivery of peer tutoring. In time, this approach will also lead to a more sophisticated and intelligent system*

Index Terms **–** *On-line tutoring, peer tutoring, Hypermedia/multi-media for learning and instruction, developing web-based instruction and learning, concept mapping, interface design, SmartBooks*

Introduction

Student failure rates in college computer science courses are more and more becoming recognized as a serious national problem. In a recent informal survey conducted by Mark Guzdial on the SIGCSE listserv, faculty from around the country reported that about 50% of students in their introductory courses in computer science either drop out or fail (SIGCSE, 2002). According to one respondent, publishers statistics indicates that there are about 65% fewer CS II books sold nationally than CS I books. There are several reasons usually advanced for this high attrition rate in introductory courses, but whatever the cause, many college administrations seeking new ways to avoid wasting resources. In the last ten years one of the most popular responses to student failure has been the development of various kinds of on-campus tutoring programs. As Kenneth

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Bruffee puts it in his recent seminal study of collaborative learning, there is "hardly a college or university now, from Berkeley to Brown, from Harvard to Hostos Community College" that could do without peer tutoring."

The Brooklyn College Learning Center has had a long history of providing effective on-site peer tutoring for an urban college campus in New York City. Brooklyn college is a four-year liberal arts institution whose students are a blend of many cultures and languages: 38% speak English as a second language, 70% receive financial aid and many are the first in their families to attend college. These students are often highly motivated but they need help to achieve their goals. At Brooklyn help is provided by trained undergraduate tutors who assist students in understanding course concepts and assignments**.** Each year about 4000 of the College's 15,000 students visit the Learning Center to work with their peers on assignments in writing, mathematics, science, and the twelve required core curriculum courses. Last year about 20% of the students in the introductory course in computer science sought help at the Learning Center, and these numbers are increasing as the college puts more pressure on the computer science department to do something about its high failure rates.

Brooklyn has been looking for ways to extend the supportive peer tutoring resources of the Learning Center. Budget constraints limit the number of tutoring staff that can be hired and the number of hours that the Learning Center can be open. Brooklyn's commuter students often lead extremely complicated lives—many have family and child care responsibilities and most work many hours to support their college education. Tutoring is often not available when these students have the most opportunity to use it—evenings and weekends. And tutors are themselves students with busy schedules. Brooklyn's students need additional help available at the times when they are free to address their coursework.

The solution to these problems at Brooklyn has been the development of an interactive website that offers information about on-campus Learning Center programs and selected tutoring services on-line[1]. On-line tutoring is not intended to replace peer tutoring, but to work hand in hand with it by creating customized out-of-class web-based instruction for students. Our new approach for offering on-line tutoring involves the use of SmartTutor, a multimedia, educational technology based on the SmartBooks system first developed more than a decade ago[2]. SmartTutor innovates in its use of the heuristic technique of concept mapping[3] designed to be flexible and facilitate the individual learning preferences of each student user. The user reinforces his/her understanding of new information by navigating through the web-based material. The system is designed to meet the needs of students who have different levels of understanding of course content. Of major importance in the development of the SmartTutor system is the input of peer tutors, students, faculty and advanced computer and information science majors.

Background

SmartBooks, a precursor to SmartTutor, is a generic, hypermedia-based educational technology which allows users to navigate through complex domain specific material in a non-linear fashion designed to be suitable for their own cognitive stages and learning approaches. The model has been used in the last decade for the development of prototypes of educational software for sexually transmitted diseases including AIDS[2b] and training materials in navigation for U.S. Coast Guard Academy Cadets[4]. The driving force of the SmartBook approach is the use of "concept mapping," which has been demonstrated to be a sound paradigm for learning and education[5][6]. Concept maps are a graphical form of knowledge representation whereby all the important information in a domain can be embedded in the form of nodes and links (connecting the nodes). In essence a concept map is a kind of table of contents, but instead of the usual linear list, the learner is presented with a chart or graph that displays the relationship of topics and subtopics in a field of knowledge. The learner selects topics of the concept map to go deeper along a path into a given subject (for example, in the AIDS SmartBook, the user can go from the topic "Signs and Symptoms" to either of two subtopics, "Clinical Observations" or "Lab Tests"). At any time during the use of the system a user can view how they arrived at where they are (the path taken through the SmartBook) and where it can lead. This is indicated by a pictorial representation on the top of each section illustrating how the shaded topic on the concept was reached and which topics it can lead to.

Unlike static conventional textbooks where the traversal is sequential, rigid and unch angeable, an advantage of a SmartBook is flexibility, the fact that it can be developed for any domain using a sound educational methodology. It can be used and explored i n many ways. [2a],[4]. The order in which material is covered is the choice of the user. In essence, the SmartBook represents a road map through a knowledge base. Transp arency in form and function is fundamental to SmartBooks. In addition to existing po p up windows, there is the potential for linking to a glossary of terms, synonyms for k ey words, a retrace facility, expert advice, and video-based presentation of graphical in formation. As any good knowledge base, it is easy to modify, expand, and refine.

SmartTutor

pplies all the useful, student-learner oriented features of SmartBooks in a web-based environment. We nning the design of SmartTutor for a number of domains which can be used to enhance the urriculum. Modules for courses in Computer Science, Biology, Mathematics, Physics,, and Social g constructed using essentially the same paradigm we have detailed above. The new technology access for the student at all times to the tutoring facility. It is intended to provide *all* students with st possible content, and to provide an alternate path for students who may otherwise be too intimidated

owledge a tutoring environment has about the domain in which it is presenting educational material, that ain-specific expertise the system has, the more effective it will be. For example, excellent baseball ow everything that needs to be known about the subtleties of the baseball environment, including the g fields, the idiosyncrasies of the players, etc. The same is true for effective educational environments. rich and deep domain knowledge and must be able to answer the follow-up questions of the learner in effective instruction. They must embody rich multimedia-based curricula, assimilated tutoring have the ability to assess the level of the learner. They must know how to test, evaluate, and improve of the learner. The aim of the SmartTutor system is to capture and mimic the knowledge and the d intuition of the effective teacher. In this case, the peer tutor working with faculty members and senior ce students provides the knowledge base.
mplementation of the SmartTutor system we have focused on a key gateway course for computer (this course has a 55% drop-out/failure rate). Aiming to reproduce the best qualities of one-on-one peer Tutor tries to predict and answer the most typical student questions by focusing on the most frequently opics, for example, control structures. The student, upon entering the CIS tutoring site, is presented map which graphically represents the relationships between basic course topics (Figure 1). The student er material on any of the topics on the concept map (students come for tutoring with different levels of dge). Once students have entered the system they can choose their own path through the material by o the concept map which records where they have visited. For example, they can access further material o" and then on "The *if* statement" and then back and see in the newly shaded portions of the map the isits.

t to note that traditional computer-based tutoring is designed to force the learner to go through a topic in lled, incremental steps that reflect the expert's control on the information. SmartTutor is far more he user multiple choices about how to move through the knowledge base. A SmartTutor concept map is o a textbook table of contents or even to a typical CAI menu. The test of a good concept map is whether ly find the instructional material that will answer their questions and that they can do so quickly and rch shows that if that is not the case, the user will often give up). It is sometimes difficult to predict t map will fail—only careful testing reveals problems. For example, for a recently developed support e, the tutors designed a menu that divided logical concepts into such fundamental categories as "AND en Operator, OR Operator," assuming that students would be able to access the information they needed. rst student who pretested the site failed to find what she wanted because her task was to identify the es of sample sentences ("The sun will shine or it will rain") rather than the other way around. The needed was available on the site, but she did not know how to locate it.

artTutor

hosen a category on the concept map, he enters a SmartTutor page. The page is designed to the selected topic and paths to related resources. For example, to further help clarify concepts, at query the database about keywords or visit rmation. An innovative feature of SmartTutor, now under development, is that students will be a self-test at any time, based on the particular subtree (path) of learning they have selected r site. The quiz can also refer learners back to the appropriate sections of SmartTutor where the sented.

e for loop (see Figure 2 below) DANNY IT IS IMPORTANT TO SHOW THE ACTUAL PAGE WITH ITS LINKS NOT THE EXCERPT WE HAVE NOW) is actually animated, enabling the e coding paradigm, watch real-time execution and modify the coding example. Since students have ving when a loop will terminate, the webpage provides both actual code and a flow diagram of the code. e C code is executed it is highlighted, and the relevant portion of the flow diagram lights up as well. choice of stepping through the flow diagram one statement at a time, or viewing an animated trace of cution of the code."the for loop.

mportant added feature, future plans call for SmartTutor to store and categorize students' most questions and to provide links to pages that answer these questions. On campus tutors often answer the ver and over again, but once online, answers will always be accessible. A student will be able to scan what other students have asked, and will be able to access the answers (just being aware of other ns can sometimes help clear up confusion.). The peer tutors are not equally qualified in their abilities, eceive better help than others, but with SmartTutor, only the best answers will be available to all. culty will also become more aware of the kinds of questions their students are asking.

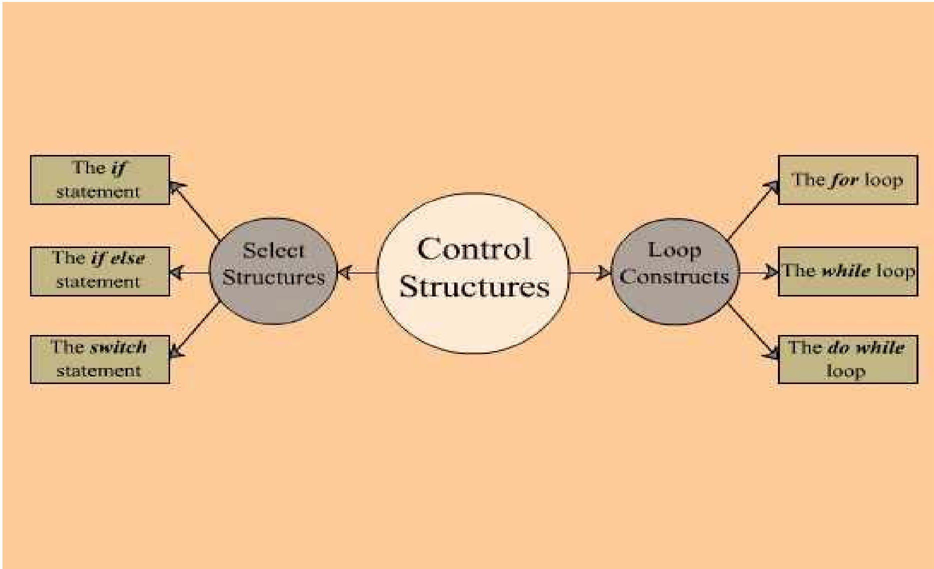

Figure `1:
The Control Structures MAP

```
int counter;
for (counter = 0; counter <= 5; counter++)
{
printf("Loop statements are executed");
}
printf("Statements after the loop");
```

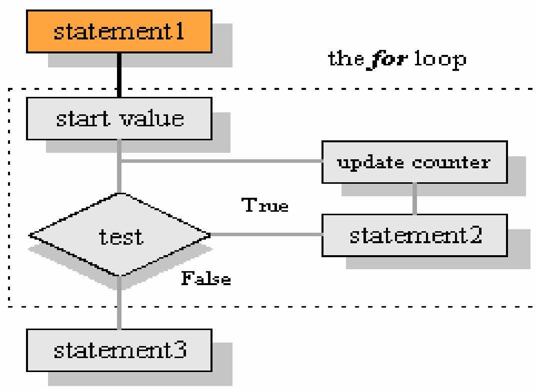

FIGURE 2

EXCERPT FROM THE FOR LOOP TUTORING WEBPA

e-mail Access To Tutors

Constructivist theory finds traditional models of computer assisted instruction inauthentic because the learning sequence is controlled by the facilitator and not the learner. Also, learning is not an individual enterprise but collaboratively constructed, so effective on-line instruction should provide venues for collaboration with peers. (Pearson and Gallagher 1983; Caverly 1997). SmartTutor will enable students to contact their tutors through e-mail—students will leave a request when they want a personal answer to a question and a tutor will answer within 24 hours. Future planning includes making tutors available on-line at a given time each week with flags on the home page to indicate that questions can be answered in real time. (For example, "a biology tutor is available at the SmartTutor chatroom Mondays and Wednes-days from 10-12 to answer your questions."). On-campus tutors often answer the same questions again and again, but with the new Learning Center system the most requested answers can be stored, categorized and made available to all. Also, not all peer tutors are equally qualified in their abilities so some students get better help than others, but with SmartTutor only the best answers will be posted, and also computer science faculty will become more aware of the kinds of questions their students are asking.

Developing SmartTutor Materials

The model that we are evolving to facilitate the addition of new SmartTutor domains, employs the pairing of an advanced computer and information science (CIS) undergraduate working on a senior project with a master (peer) tutor for the course. The peer tutor is responsible for identifying the key material that students request assistance with. Since additional material can always be added, the initial development focuses on the areas that students claim are most difficult. The CIS student then transforms the tutor's material into a concept map for the domain. The two work closely together to design the appearance and the content of the nodes within the domain. Implementation is the responsibility of the CIS student doing a senior project supervised by a CIS faculty member. New ways to carry out tutoring are discussed at group meetings and input is regularly solicited from the larger community at Brooklyn College.

It is important to note here that to prepare an effective SmartTutor system requires the input of a number of major college constituencies—in this case students, tutors, faculty and computer experts. The purpose of the Brooklyn College Learning Center web site is not to replace instructors but to assist students who are having trouble and need extra help. Peer tutors are considered the experts on student learning since they have had considerable experience in identifying the concepts that are giving students the most difficulty, but faculty have deeper understanding of course content. Early in the development of SmartTutor packages, peer tutors consult extensively with faculty. For example, a recent preparation of a concept map for the college’s core curriculum course in physics (required of all students) had to be modified when physics faculty disagreed with the tutors' analysis of how topics should be categorized. The faculty members suggested that inertia and kinematics be split into two separate sections. On the other hand, tutors were aware that students often have difficulty distinguishing between conservation of energy and conservation of momentum, so they decided to alter the original concept map to help students solve this problem. Then when advanced computer science students work on the SmartTutor system, decisions are made about formatting, basic design, associating information, and highlighting of key words that correspond to database entries, in addition to such decisions as whether to include animation and sound. And finally the packages must be tested by student users in order to identify potential strengths and problems.

At our online tutoring website, the basic web pages are programmed in HTML. We are using MySQL, an open source SQL database system, that the college had installed for use with Blackboard. Most interactive activities are implemented using the PERL scripting language. Also, database access from the webpages is carried out via PERL. Javascript and PHP are also used when necessary to provide animation and other multi-media features. Since Brooklyn College students do not usually own the newest or most advanced equipment, we are trying to use standardized technology on the website.

Future Development and Assessment

The Brooklyn College Learning Center project aims to: 1) design an on-line tutoring program that recreates the advantages of person-to-person tutoring and works hand-in-hand with on-site services; 2) create effective on-line tutoring strategies that support the learning needs of non-traditional urban students 3) make use of faculty, peer tutor and student input to design a program that reflects institutional needs 4) continually assess and revise the program so that it will be useful and usable.5) create a prototype that other institutions can use to develop on-line tutoring programs that suit their own needs.

Site usefulness is always a major concern**[7][8]**. According to Davis**[9]**, though lack of human friendliness can hinder user acceptance, perceived usefulness is not primarily about design choices— about cognitive understanding and retention: "No amount of ease of use can compensate for a system that doesn't do a useful task." The method we have refined in the past three years is for tutors and faculty to develop content and then informally show it to students in order to continually adjust and fi tune. Brooklyn College web-design experts (they have been from the fields of biology, health science and geology) have looked at the content to forecast problems before they occur. At a stage where the material seems ready, flyers are distributed to students in their classes, followed up by questionnaires and then focus groups. Questions concern whether the information relates to student problems, and whether overall construction, navigation and interface make sense. Our initial responses to the SmartTutor material have been informative.

During the stages of SmartTutor development there was considerable feedback from students and faculty, and this brought about changes in overall design. Colors (concept maps were too dark) and ty size were adjusted. There has been some discussion of the glossary (do we need it, what should be included), and of the self-tests (our SmartTutor tests are very sophisticated technically, but weak on th actual questions because tutors are inexperienced at creating exams). The most positive responses hav been to the animated run-throughs of sample codes. DANNY, MENDEL IS SHOWING THE MATERIAL TO STUDENTS AND TUTORS AND HE IS RECORDING THEIR RESPONSES—SO IF YOU VISIT HIM IN THE LEARNING CENTER WHERE HE IS TUTORING YOU CAN GET MUCH MORE ON FEEDBACK.

Our aim in creating SmartTutor is to give students the feeling that they are filling gaps in their knowledge, that they have a greater ability to move forward in a class, and that they have more understanding of how successful students approach difficult problems. If SmartTutor can provide these things then that would be a real mark of success. It is important that SmartTutor's effectiveness as a learning tool be carefully 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 the SmartTutor (which can reside on the web with a special course password) would be one way to measure their effectiveness. Traces of nodes visited can also be helpful in evaluating learning styles of the students using SmartTutors.

Evaluation will also examine whether students who use SmartTutor return to use it again, whether certain webpages seem to be more effective than other pages, whether the on-line program works hand in hand with on-site tutoring, whether students, tutors and faculty feel that the program sufficiently supports coursework, and, eventually, whether students who use the on-line system perform better in gateway courses than those who do not use tutoring services, or better than those who use only on-site tutoring services, or those who use a combination of both services. The SmartTutor system is designed to formulate a model for an on-line resource that will support students working on their own initiative and out of their own interest to integrate and synthesize knowledge and methodology outside the classroom. The model combines collaborative learning techniques (social interaction, access to peer tutors)

with SmartBooks' technological advances (individualized learning paths, coaching controlled by the learner) to create an integrated package for the student. While the goal of providing 24/7 tutoring for the core curriculum and other courses has not yet been fully achieved, much has been learned and the web site is viewed as an ongoing experiment that can only become more effective,comprehensive and useful with time.

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