

# CyberProf™ - An Intelligent Human-Computer Interface for Interactive Instruction on the World Wide Web.

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## ABSTRACT

Advances in computer technology and the human-computer interface have created a wealth of new opportunities for the development of computer-based instruction and intelligent tutoring systems. Unfortunately, much of the material currently available amounts to little more than "electronic books," in which learning is still accomplished by reading text and viewing two-dimensional images. This paper describes the features of CyberProf - an interactive, World Wide Web-based teaching system developed at the University of Illinois. Using CyberProf, instructors can create on-line lecture notes that include equations, animations, and graphics; write on-line interactive homework problems; communicate with students using CyberProf's Web-based conferencing system; survey students in order to receive feedback on course material; and record student grades in CyberProf's on-line gradebook. Students can review lecture notes 24 hours a day; complete homework problems on the Web and receive immediate intelligent feedback to their answers; use the conferencing system to post questions to their instructor, teaching assistants, and peers; and review their grades in the class at any time.

## KEYWORDS

Problem Set Editor

Assignment Maker

Gradebook

Network TA

## I. INTRODUCTION

For scientific instruction to become more effective and thereby meaningful to students, educators need to revise curricula and make use of new educational tools that allow students to interact productively with course material [1, 2]. We believe that such reforms are particularly needed in the physical and life sciences, mathematics, and engineering. Traditional methods of teaching -- lecture and demonstration by the instructor and relatively passive watching and listening by the students -- provide students few opportunities for active engagement with the subject matter. Students may complete a course with only a superficial understanding of essential concepts. They may not be able to apply course material to novel situations, to integrate discrete rules and concepts into a coherent whole, or to engage in abstraction, generalization, and inductive

thinking. Moreover, students often leave the classroom with a very static view of what are in reality very dynamic processes.

We believe that we can best help our students to achieve a meaningful and deep understanding of concepts in the sciences, mathematics and engineering by providing them with the resources and opportunity to engage in active and student-directed learning. We also believe that to enhance student learning we must investigate how students learn, how they interact with technology, and how learning may be optimized for students with diverse educational backgrounds (for example, underprepared, advanced, or minority students).

During the past three years, Dr. Alfred Hubler, Professor of Physics at the University of Illinois, in collaboration with educators in microbiology, chemistry, education, and theoretical and applied mechanics, has developed CyberProf, a robust World Wide Web-based system of teaching software (see <http://loner.ccsr.uiuc.edu/cyberprof/>).

CyberProf is a product of research at the forefront of nonlinear science and the human-computer interface. Students can use CyberProf to review lecture materials on demand; complete on-line quizzes and homework problems; review their grades and progress in the course; and asynchronously communicate with the instructor or teaching assistants via a Web-based bulletin board system. The CyberProf Web Server accepts responses to homework problems from students (in the form of graphs, algebraic expressions, drawings, and prose text), evaluates the information using tools and algorithms adapted from complex systems research, and returns specific and useful responses, even when student answers are ambiguous or only partially correct.

Dr. Hübler first tested a prototype of CyberProf in the Spring 1995 semester and anecdotal results from that first semester were overwhelmingly positive. By the Spring 1997 semester, 16 courses at the University of Illinois, and 20 remote institutions, were using CyberProf. The University of Illinois courses are primarily using CyberProf to deliver weekly, graded quizzes and as a forum to enhance instructor-student interactions and to promote student-student collaborations.

In this paper, we will describe features of the current CyberProf system. We will also discuss some enhancements under development within CyberProf.

## **II. CYBERPROF SYSTEM COMPONENTS**

### **A. Directory Structure: Password-Protected versus Free-Access**

#### **Material**

Files intended for use with CyberProf software are stored in one of two main directories, "public" or "protected." Whereas files in the public directory can be viewed as standard HTML documents by any Web browser, all files located within the protected directory cannot be accessed without the user submitting a valid login name and password. Gradebook scores, Problem Sets and Conferencing System postings are examples of password-protected materials restricted to students and instructors in the course. General non-interactive course materials, stored in the public directory, provide supplemental information about the instructors, links to password-protected material, dates and locations of exams, timetables for homework assignments, detailed lecture summaries and other resources specific to the course. Anyone with a Web browser can view such course information, whereas more sensitive materials remain password-protected.

## B. Interactive Problems

Students in biology, chemistry and physics complete interactive homework problems in order to reinforce course material. Affording students the opportunity to solve problems by applying what

FILE BROWSER    HOMEPAGE    ADMINISTRATION

CP VIEW    **PROBLEM SET EDITOR**    TEXT EDITOR    TRASH

File: *filename*      Folder: *directory structure*

*Instructor can view what student will see by clicking on this link*      *HTML editor--for users with extensive knowledge of HTML; allows user to customize the appearance of the question*

**Question 1**

EDIT/SAVE QUESTION

Enter the text before the question:

*This can be simply text or can include URLs of .gif or .jpg images. Simple HTML tags (e.g. line break, bold, italic) give question a good aesthetic appearance.*

Enter the correct keywords separated by a space:

*Can enter acceptable variables to correct answer, such as acceptable abbreviations.*

Enter the acceptable number of spelling errors in each keyword:

How many minutes would a student have on an exam for this question:

If the answer is correct, cheer the student and reinforce the right approach:

*e.g. "Congratulations!"*

Give a hint, if the student has no idea how to approach the problem.

*Hint buttons are immediately visible to a student next to the "check answer" box, so the student knows when there is help available.*

Provide help with equations etc. to get the correct answer:

*Help buttons cannot be seen by a student until the "Hint" button has been accessed. Help buttons are not required when using a Hint button, but are often useful.*

Enter the comment here. The comment goes between the input box and the response:

*This space allows the user to separate the cheer from the body of the question.*

shortanswer  
symbolic  
radio button  
multiple\_choice  
✓ singleword  
checkbox

SELECT the type:      Show response here: YES

DELETE QUESTION      INSERT PAGEBREAK      DONE



**Figure 1:** The Problem Set Editor Template. Using the Problem Set Editor template, educators with only basic HTML skills can generate "attractive" problem sets. This figure shows what the template looks like for a question requiring a single word answer. The layout of the template varies according to the question type selected.

they have learned in lectures and laboratories enables them to identify strengths and weaknesses in their understanding of course content.

A powerful feature of the CyberProf Problem Set Editor (see Figure 1) is its flexibility in accommodating a diversity of question types. Examination questions in large courses are often limited to the multiple choice format. Arguably a reasonable test of students' memorization of course content, the multiple choice format is less effective at testing the student's ability to apply and manipulate concepts. In CyberProf, the instructor can choose among radio button selectors which allow the student to choose one answer from a range of possibilities, checkboxes which allow the student to select multiple answers from among many options, symbolic responses for questions requiring numerical answers, single word and short answer responses where the student has to "fill-in-the-blank", as well as graphical responses where the student uses an interactive drawing tool to plot graphs which are compared to theoretical curves generated by the instructor.



a) Take a look at this [movie](#), and estimate the height of the jump of the killer whales. Please enter the height **H** in **meters**. If you need help click on the hint button. There is no penalty for using a hint or help.

*Hint button*


H =    *Check Answer button*

---



*Help button--only visible after Hint is accessed*


H =    **HINT:** The height of the jump is about 13 ft (13 foot). **ft** is the symbol for **foot**. The symbol for **meters** is **m**. At the bottom of this page and most other CyberProf homework sets you find an item called **Help on Units**. Please click on it and check it out before you proceed with this problem set.

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H =   **HINT:** The height of the jump is about 13 ft (13 foot). **ft** is the symbol for **foot**. The symbol for **meters** is **m**. At the bottom of this page and most other CyberProf homework sets you find an item called **Help on Units**. Please click on it and check it out before you proceed with this problem set. **HELP:** 1m equals 3.28ft. With this information you can calculate the height **h** in meters:  $h = 13 \text{ ft} * 1\text{m}/3.28\text{ft} = \dots$  Good luck!

---

H =    *A student can ask the system to attempt to discover the source of the error. This feature will be incorporated into future versions of CyberProf*

*Sorry, 20ft is not correct*  *Why?*

**Figure 2:** A Problem Illustrating the "Hint", "Help" and "Why?" Features of the Problem Set Editor.

The standard multiple choice format is also available via pull-down menus of choices. Problems requiring single word answers can be customized to accommodate a limited array of misspellings and variations on the correct answer (abbreviations, for example). This feature is particularly useful in scientific courses where many new technical terms and abbreviations are introduced.

In order to emulate the interaction between instructor and student, a system has been integrated into the problem set editor that allows the instructor to append "hints" to problems. A "hint" can be in the form of text, links to other information (appropriate lecture material, for example), figures, or animations. Hints are not displayed unless requested by the student, much the same as an instructor withholding information unless prompted for additional help by the student. Questions accompanied by hints are identified by a selectable button next to the "check answer" button at the end of the question (see Figure 2).

If the instructor wishes to provide still more information after the hint has been accessed, this can be accomplished by implementing the "help" function. "Help" is functionally identical to the hint tool, but help buttons only appear on the screen after the student has first accessed the hint for that question (see Figure 2).

Rather than simply responding to a correct answer by stating that the submitted response is correct, CyberProf encourages the use of positive reinforcement by permitting the instructor to customize the system's response to a correct answer submitted by a student. These responses can be textual, such as "Congratulations! That was a difficult question!" or links to supplemental information that the student may find interesting or useful (see Figure 1).

Another optional feature allows the student to see how many questions were answered correctly out of the total possible in that problem set. This function also calculates how much time it took to answer the questions, so that students can determine whether they have completed a problem in the time normally allotted to work a comparable problem on an examination. The number of attempts that a student can make on a particular question can be limited as well. This feature is useful when the problem set is to be graded as a course assignment.

### **C. Gradebook**

Once a question or set of questions has been answered by the student, the student's responses are posted to CyberProf's grading program, where the responses are checked against those provided by the instructor as correct. With CyberProf's Gradebook package, the students' scores are automatically uploaded from the Problem Sets into the Gradebook. If, for example, a student works a problem set with 10 possible points and answers 7 of those questions correctly, a grade of 7 is recorded in his or her personal Gradebook. The student may go back and try to answer the missed questions correctly, and the scores will be updated in the Gradebook as correct answers are received, provided the deadline has not been reached, nor the number of allowed attempts exceeded.

The CyberProf Gradebook also functions as a valuable tool for course administration and enhancement. An instructor in a multi-section course can use the Gradebook to set up course sections and enroll and drop students. Student progress can be monitored on the fly by tracking performance on Cyberprof homework assignments and thereby determining if the class has understood or is having difficulty with a particular concept. Instructors can review recorded grades in a variety of formats. All students' grades on a particular assignment might be viewed in simple list format, or as a graph of the grade distribution on that assignment. Other options include viewing a single student's grades on all the assignments in the course, or viewing all

students' grades on all assignments in table format. Students can review their own grades at any time. The Gradebook is password-protected and secure.

#### **D. Grading Software**

The CyberProf grading programs evaluate responses to multiple choice, checkbox, radio button, single word fill-in-the-blank, and short answer questions based on the instructor's input. The student is immediately informed as to whether an answer is correct or not. The grading software is also able to analyze symbolic answers to determine whether a response which does not correspond to the instructor's input is still correct. For example, if the solution to a problem involving a simple linear equation is 8, CyberProf would accept as correct not only 8, but also any numerical variant of 8. Thus students could input any of the following responses: "8", "10 - 2", "7 + 1", "80/10", "8 x 8/8", "64^(1/2)", or "2 + 3 + 1 + 1 + 1". The software also evaluates symbolic answers that include units, accepting nonstandard but equivalent expressions of units as well as either English or metric units. Thus, for a problem asking students to specify the force of gravity on earth (= 9.8 m/s<sup>2</sup>), CyberProf would evaluate all of the following responses as nonstandard but correct: "9.8 N/kg", "9.8 J/(kg x m)", and "32 ft/(s x s)".

Specialized grading packages are also being developed. Thus, chemistry professors may wish to use the organic nomenclature grading software. This grading software can evaluate the names of organic chemical compounds and provide intelligent feedback based on which kinds of errors students typically make on similar problems. For example, an error message could say that the alphabetical order of the substituents is wrong. Specialized grading packages which can analyze graphs and drawings are also being developed.

Although there are a number of Web-based educational environments capable of delivering graded quizzes, some of which also have the ability to incorporate "scaffolding" (the addition of "hint" and "help" statements) into problems, as far as we are aware, CyberProf is the only Web-based educational system capable of evaluating symbolic responses for sign errors and unit errors, as well as numerical errors. Thus, CyberProf can equate two answers that are mathematically equivalent but syntactically different. The specialized grading packages also allow for the analysis of graphs and drawings, which is not offered by similar Web-based educational products.

#### **E. Assignment Maker**

CyberProf's Assignment Maker is the starting point for setting many of the instructor preferences described elsewhere in this document. It is from the Assignment Maker that the instructor assigns point values for each question and arranges groups of questions into separate assignments such as homework problem sets, quizzes, or examinations (see Figures 3 and 4). The Assignment Maker allows the instructor to set deadlines for each of these assignment types, after which grades will only be uploaded to the Gradebook at a penalty (see Figure 4). Assignable late penalties range from 0 to 100 percent and can be set individually for each homework assignment, quiz, or exam.

The Assignment Maker also allows the instructor to take advantage of CyberProf's personalized random number generator to produce many versions of the same assignment (see Figure 4). The random number generator ensures that each student receives a randomly selected version of each problem, reducing the possibility of students' sharing answers while at the same time allowing motivated students to work multiple versions of the same problem types.

## Assignment Overview Page

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[Standard HTML Header](#) for assignment page

←
→

[Number of assignments](#) types such as Homework, Quizzes, Labs, Hourexams, Finalexam:

<a href="#">Assignment Type</a> (Quiz, Homework)	<a href="#">How many</a> assignments?	<a href="#">Name of each Assignment</a> (Quiz1, Quiz2) E = Edit
1: <input style="width: 80%;" type="text" value="Homework"/>	4 <input type="button" value="save"/>	1: <input style="width: 80%;" type="text" value="Homework 1"/> <input type="button" value="E"/> 2: <input style="width: 80%;" type="text" value="Homework 2"/> <input type="button" value="E"/> 3: <input style="width: 80%;" type="text" value="Homework 3"/> <input type="button" value="E"/> 4: <input style="width: 80%;" type="text" value="Homework 4"/> <input type="button" value="E"/>

[Standard HTML Footer](#) for assignment overview page (no changes necessary)

←
→

[What the students see \(/cyberprof/chemistry/102/assignments.html\).](#)

**Figure 3:** The Assignment Editor - Overview Page. The overview page of the Assignment Editor indicates the type (e.g., Homework, Quiz, Examination, etc.) and number of assignments within a particular course.

### Edit Homework1 Assignment Page

[Standard HTML header](#) and other text before the list of assignments, such as the general topic:

[Date/Duedate](#)    September    15    96    6:    00    am    [Late penalty in %](#)    20

[Number of tasks/questions:](#)    4   

<a href="#">descriptive name</a> <sup>1</sup>	<a href="#">filename (with version#)</a> <sup>2</sup>	<a href="#">question name(s)</a> <sup>3</sup>	<a href="#">credit</a>	<a href="#">color code</a> <sup>4</sup>
Metabolism	.../metabolism1 Found 5 version(s).	1	5	green
Cell Cycle	.../meiosis1 Found 5 version(s).	1,2	10	green
Cell Cycle	.../meiosis2 Found 1 version(s).	1	5	green
DNA Replication	.../DNA1 Found 3 version(s).	1,2,3	15	green
			=====	
			35	

Text after the list of assignments, such as an expl. of the color code, comments, and [standard HTML footer](#):

**Figure 4:** The Assignment Editor - Editing Page. This figure illustrates the layout of a typical assignment (in this case, Homework Set 1 which consists of 4 different problems).

1 *descriptive name* - the general title of the problem set (seen by the student). This name often relates to the relevant course material. Different problem sets can carry the same descriptive name.

2 *filename* - the directory structure and file name of the problem set (not seen by the student). CyberProf looks at the filename to determine the number of different versions of a particular problem set and automatically enters this value below the filename.

3 *question name* - the number of questions within a particular problem set.

4 *credit* - the total number of points assigned to a particular problem set.

5 *color code* - used to indicate the difficulty level or some other property of the problem set. An explanation of the color code is provided in the footer or header of the assignment page.

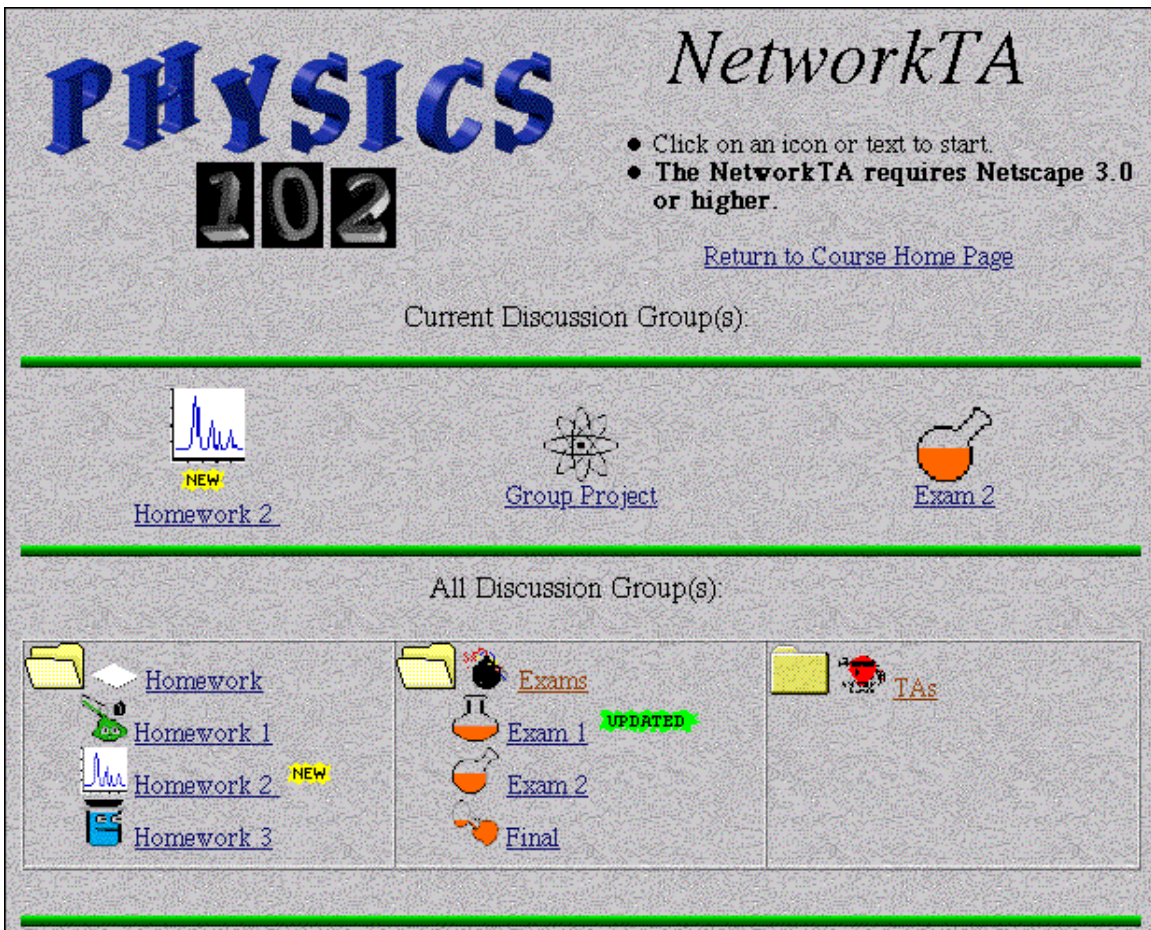
Within CyberProf, explanations of all of these terms can be obtained simply by clicking on the appropriate term.



## F. Network TA

In large classes, instructors' office hours represent the only opportunity for one-to-one interaction between students and their teachers. But office hours tend to be either underutilized by busy or timid students, or oversubscribed just prior to exams. Network TA, which was also developed by Dr. Alfred Hubler at the University of Illinois, is CyberProf's Web-based conferencing system that provides round-the-clock access to the instructor and TAs. A student can submit questions at any time, without disturbing the instructor or waiting until the next scheduled office hour by which time the question may have been forgotten.

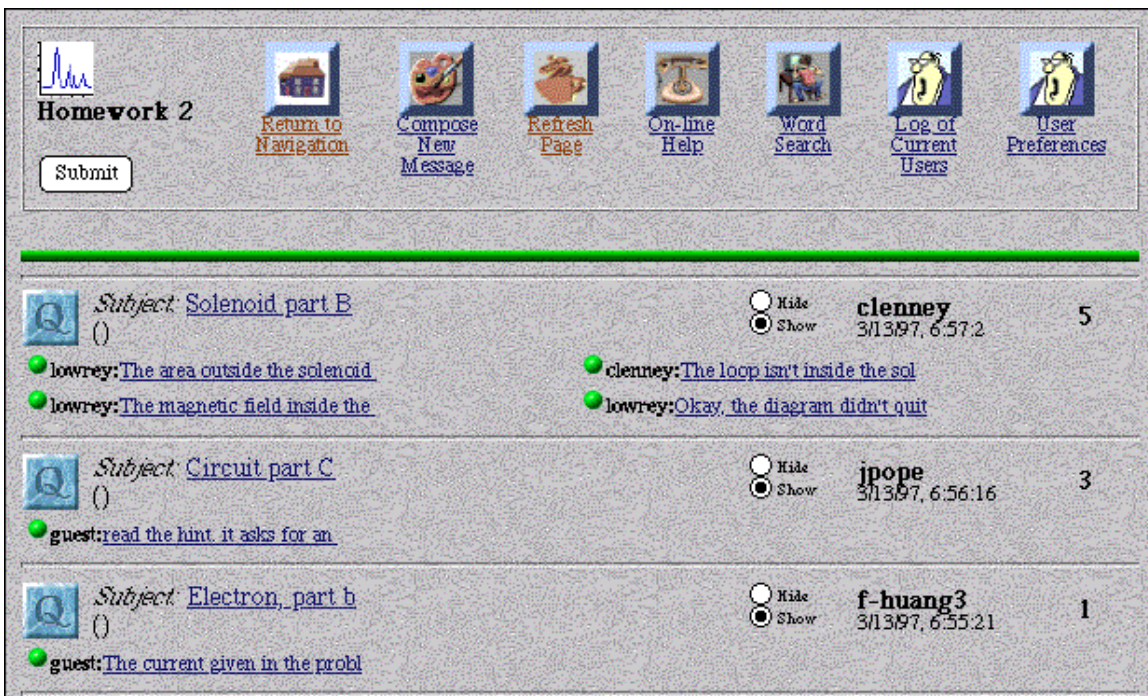
Within Network TA, separate discussion folders can be set up, by instructor preference, to deal with anticipated discussion topics. Each folder can contain any number of discussion groups. For example, a "Homework" folder may contain a different discussion group for each homework; a "Labs" folder, a different discussion group for each lab. If an interesting discussion starts up between the instructor or TA and a student or between two students, the instructor can draw attention to this discussion, hopefully encouraging other students to get involved, by moving the relevant group into the "Current Discussion Group" section at the top of the main conferencing page (see Figure 5).



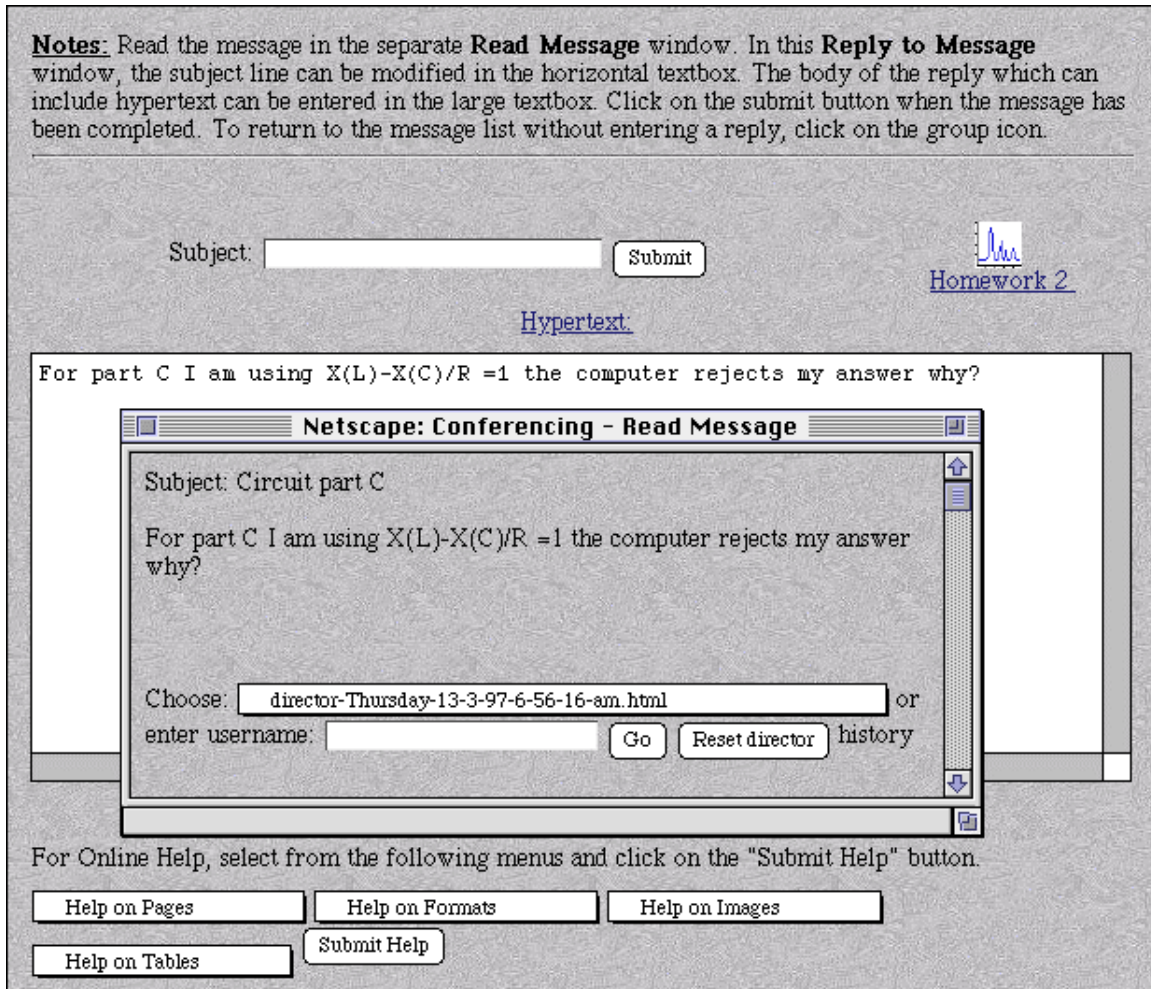
**Figure 5:** Network TA - Main Navigation Page. Related discussion groups are placed in a discussion folder. The "updated" and "new" tags indicate the presence of unread and unanswered messages, respectively.

To submit a question or comment to a particular discussion group, the student simply clicks on a "Compose New Message" button to open a HTML-independent text box (see Figure 6). Submissions to Network TA can be simple text or include figures or links to relevant information. To read a posting, the user simply clicks on the hypertext linked subject line. Since a reply box automatically opens behind each posting, as shown in Figure 7, if the user wishes to respond to the posting, a separate reply window does not have to be downloaded. Furthermore, unless the user chooses otherwise (by clicking on the "User Preferences" button and bypassing the default setting), the posting being responded to automatically appears in the reply box (see Figure 7). This option makes it easy for students to join an on-going ("threaded") discussion, even if there already have been numerous exchanges, since opening the last posting in a threaded discussion will download the entire discourse in a single window.

The number of submissions generated in large courses can be overwhelming to a student. Searching for new materials which may be distributed among many different discussion groups could be time consuming. In Network TA, a student is notified if new messages/questions have been submitted since his/her last login by the presence of an "updated" tag next to the relevant group as shown in Figure 5. Reading all of the questions within a group extinguishes the "updated" tag for that particular user. However, if there are unanswered questions in that group, the "updated" tag is replaced by a "new" tag which is not user-specific. Thus, the "new" tag disappears for every user when all of the questions have been answered, regardless of who answers them (instructor, TA, or another student). To save time, a student wishing to read messages on one particular topic only can also take advantage of Network TA's "wordsearch" feature (see Figure 6). This feature will scan a discussion group for messages containing the specified search word.











**Figure 6:** Network TA - Discussion Group Page. Replies to questions appear as hypertext links beneath the question. From this page, a user can read messages from other users, submit a new message, search the group for messages related to a particular topic, or check to see who else is online by clicking on the "Log of Current Users" button. The "User Preferences" button allows the user to customize the dimensions of the various message boxes to fit the user's monitor.




**Figure 7:** Network TA - "Read Message" and "Reply to Message" Windows. A "Reply to Message" window downloads behind each message. The message being replied to automatically appears in the reply box.

As shown in Figure 8, setting up the various discussion folders and groups is a relatively simple process. To set most of a group's attributes, the instructor simply selects from a number of options listed in pull-down menus. Most other features of the Network TA conferencing system can be as easily customized according to instructor preference.












## Director options

Click on "Director options" for explanation on using the director options. Select the option to change by clicking on its colored ball or hypertext link. You may need to resize this window.


**Main**
Add to Main



---


Name: 
Add New Item
Submit
Delete: 

Home folder name:  Order win folder:  Type:

Icon URL:  Icon size 1:  Icon size 2:

---




Name: 
Submit
Delete: 

Home folder name:  Order win folder:  Type:

Icon URL:  Icon size 1:  Icon size 2:

Starting active date:  Ending active date:

---




Name: 
Submit
Delete: 

Home folder name:  Order win folder:  Type:

Icon URL:  Icon size 1:  Icon size 2:

Starting active date:  Ending active date:

---





Name: 
Submit
Delete: 

Home folder name:  Order win folder:  Type:

Icon URL:  Icon size 1:  Icon size 2:

Starting active date:  Ending active date:




---



Name: 
Add New Item
Submit
Delete: 

Home folder name:  Order win folder:  Type:

Icon URL:  Icon size 1:  Icon size 2:

---



Name: 
Add New Item
Submit
Delete: 

Home folder name:  Order win folder:  Type:

Icon URL:  Icon size 1:  Icon size 2:

Figure 8: Network TA - Director Options Page, showing the template used to set the attributes of discussion folders and groups. Most other aspects of Network TA can also be customized from this page.

### III. TOOLS TO SUPPORT EVALUATION

CyberProf is a new teaching/learning environment and we rely very heavily on feedback from both faculty and students to monitor its effectiveness. The very fact that it is a digital environment affords opportunity for complete monitoring of every student's use and compilation of data. At present, CyberProf's evaluation tools include log file data (discussed in the next section) which can be analyzed by bonafide evaluators, on-line surveys which are filled out and submitted by students, and faculty feedback forms.

As CyberProf is being used by students and teachers in different fields of study, the on-line surveys can be tailored by the instructor to each course in order to determine how this technology can best be adapted to different purposes. A variety of question formats is available. The instructor can issue questions in the form of statements to which students respond by selecting from a range of choices (e.g., strongly agree, agree, no opinion, disagree, strongly disagree). Questions can also be written for which an answer is typed into a text box. The instructor can access a file of survey results which displays the responses in a variety of formats, such as bar graphs indicating the proportion of responses for each option in a question.

Anecdotal results from all of the courses currently using CyberProf have been very positive. The following statements represent a sampling of faculty (f) and student (s) feedback:

*"CyberProf results in time savings because quizzes are now presented and graded on-line" (f)*

*"CyberProf promotes student writing / interaction" (f)*

*"The load on my TAs is much smaller. I now usually have only one or two students in my office hours, but they still think I'm available." (f)*

*"CyberProf is an excellent Web application which provides good student support and feedback." (f)*

*"I found the Web-based tutorial sets to be more conducive to learning because of their interactive and visually oriented nature than all other study options.." (s)*

*"Overall, I think the Web offers an excellent and highly accessible medium through which students can get a lot of supplemental instruction on their own time schedules." (s)*

*"It (the Web-based tutorials) was the majority of what I did to prepare for the first two exams, on both of which I answered above ninety-five percent of the questions correctly.....I can truly say that I have learned more in this class than any other I have taken on this campus." (s)*

*"The Web site makes it easier to access the information in and about the course, and the supplemental materials help in the understanding of the material. I think that it is a worthwhile addition to any course and especially a large lecture course like this one." (s)*

*"I feel that CyberProf helped me prepare for the exam and gave me a better understanding of the lecture material." (s)*

*"I think it helps give a little bit more individuality to students and takes away the possible overwhelming feeling of a big course. For example, you can interact with the professor/TA with*

*ease and without fear (of calling, approaching, etc.). The professor/TA can get back to the student at his or her own convenience with a personal comment." (s)*

*"The Web site has provided me with easily accessible information that improved my understanding and deepened my interest in the course material." (s)*

*"The Web site gave a new twist to learning. I found studying not so time consuming or boring." (s)*

*"CyberProf helped me to prepare for the first exam and made sure that I understood important material that was covered in lecture." (s)*

*"The problem sets were extremely helpful in studying the material, especially before the test. I think that doing the problem sets was the main reason I did so well on the exam. Also, the lecture supplements were great because you could pay attention and listen during lecture instead of trying to write down every word." (s)*

Most of the courses using CyberProf have also reported increased lecture attendance, increased enrollment, and lower dropout rates. Since the goal of these courses is not to replace the traditional lecture with virtual lectures but, instead, to enhance the content of these traditional lectures with interesting interactive discussions, this is viewed as a positive result. By moving in-class tests, supplemental lecture material, and alternative explanations of difficult concepts to the CyberProf environment, instructors can dedicate more time to in-class discussions which spark students' enthusiasm for the course material and encourage collaborative learning. The increased enrollment and lecture attendance and lower dropout rates seen in these courses suggests a greater level of interest brought about by these more "active" lectures.

Preliminary data from courses in which the same final exam was used pre- and post- introduction of CyberProf into the course environment, suggest that academic performance has also improved, the most discernible difference being the lack of the "lower tail" in the final exam score distribution since the integration of CyberProf into the course (3). More rigorous evaluation data from courses in which multiple sections of the same course are taught with and without CyberProf are not yet available.

#### **IV. ENHANCED CYBERPROF**

Work is underway to expand upon the current capabilities of CyberProf and to integrate the separate components of the system in order to "scale up" CyberProf's effectiveness.

**Log File Data.** CyberProf generates huge amounts of log file data that document system performance, for example, server response times, system crashes, error messages, how long it takes individual parts of the program to run. A detailed performance analysis of these log file data is being conducted to identify unstable portions of the CyberProf driver, bottlenecks, incompatibilities, and the like. The information obtained will be used to optimize CyberProf for maximum speed and stability.

In addition to improving the performance of the CyberProf driver, the log file data can also be used to optimize student learning. For example, the information provided through hint and help buttons is based on the instructor's experience as to the most likely misunderstandings students

have with a particular concept. However, by mining the log files which Cyberprof generates for each problem set, it is possible to determine the most common errors students actually make, as well as the effectiveness of the current "hints" and "helps." By discovering how students tend to misunderstand concepts, it is possible to tailor the "hints," "helps," and other aspects of the courseware, to optimize learning.

**CyberEditor.** Materials to be stored in CyberProf's public directory ("read-only, non-interactive" material) can be generated independent of CyberProf using any one of a number of commercially available internet authoring tools (PageMill, FrontPage, etc.), which require no knowledge of HTML. Educators with only rudimentary HTML skills who wish to develop problem sets and other password-protected materials using CyberProf can also generate "attractive" course materials by taking advantage of the templates, such as the Problem Set Editor and Assignment Editor templates, as shown in Figures 1, 3 and 4.

Educators who author Web-based courseware or multimedia documents employ a variety of software packages, with different interfaces and varying levels of intercompatibility. In addition to an HTML editor, CyberProf includes a basic graphics editor (Webdraw), and an editor for creating and modifying line graphs (Webplot). These recent Java-based additions, Webdraw and Webplot, use model-based data compression to save information at a higher, more useful level. Thus, the drawings and graphs are being stored at the level of "hydrogen atom," rather than at the pixel level. This capability allows the system to analyze the drawings and to provide intelligent feedback quickly. This will help to reduce the frustration, felt by both instructors and students, caused by slow response times. In the future, CyberProf's HTML, Webdraw, and Webplot Editors will be integrated into a single authoring system that will allow users to edit any course material (lab, lecture, or homework) that includes graphics. This integrated authoring system will make it possible for instructors, especially those with little computer experience, to create Web-based courseware in any discipline quickly and efficiently.

Work is also underway to enhance CyberProf with the video capabilities of VOSAIC (Video Mosaic), a Web browser that supports the real time delivery of audio and video files across the Internet. Vosaic supports a new adaptive communication protocol (VDP) that increases the speed of data transmission by a factor of 44 over the standard TCP/IP protocols. The resulting software package will facilitate the creation of hypermedia course materials and problem sets that engage students' interests and accommodate a diversity of learning styles. Such engaging presentations would be impossible with a blackboard or an overhead projector.

**"Why?" Button** If a student enters an incorrect response in a CyberProf problem set, he or she can query the system so as to discover the source of the error by clicking on a "Why?" button (see Figure 2). When students answer numerical problems, CyberProf uses sophisticated software to analyse their responses for sign errors, unit errors and numerical errors. As discussed above, the system can detect alternate forms of correct responses -- including answers that are mathematically ambiguous or only partially correct -- and show students exactly how their answers might deviate from correct ones. Instant feedback permits students to rework problems immediately, rather than experiencing the delay of traditional grading methods. Currently, the order in which the system analyses a particular response is manually prioritized by the CyberProf developers. Features are being implemented to allow the system to determine the order in which this analysis is to be carried out.

## V. SUMMARY AND PROSPECT

Sparkling students' interest and enthusiasm presents a perennial challenge to educators. This is especially true in large courses where students have little opportunity for personal interactions with instructors. Course materials must be developed to accommodate students with varying backgrounds and different learning styles. Thus the challenge is to create a rich environment that provides a variety of opportunities for student engagement.

Previous online networked educational systems developed at the University of Illinois such as PLATO [4] and NovaNET [5] were partially successful, but somewhat limited by the technologies and methods of their time. Students could perform exercises online, receive instant feedback on their solutions, and have their grades automatically recorded. However, these systems were not capable of particularly sophisticated handling of student input nor were they able to take advantage of the enormous amount of information available on the Web. Furthermore, it was difficult to integrate lecture notes, labs, and homework into a cohesive package. CyberProf was conceived with the notion of addressing these shortcomings by synthesizing all of the functionalities of the above systems with the new technologies of the World Wide Web and a much more robust student/computer interface engine.

The primary pedagogical benefits provided by CyberProf include:

- **Provision of graded, interactive problem sets** where students apply the material learned in lectures and labs to answer practice assignments.
- **Provision of immediate help** in the form of hyperlinked materials which may be standard text, images, animations or other relevant materials.
- **Appeal to diverse learning styles** by use of hyperlinked materials that incorporate graphics, animation, video, and sound, in addition to standard text.
- **Improved interaction** between instructors and students - anytime, anyplace.

The feedback gathered from on-line surveys has been overwhelmingly positive and preliminary data suggest that students are also benefiting from the CyberProf environment in terms of academic performance.

By the Spring 1997 semester, 16 courses in the departments of Physics, Microbiology, Chemistry, Agriculture, Economics, Electrical Engineering, Bioengineering, and Theoretical and Applied Mechanics were using CyberProf on the University of Illinois campus. In addition, CyberProf is presently being used in two community colleges, four high schools, one middle school, and two 4-year schools (one international) and is being installed at 10 other universities (including Central University in Taiwan).

Although, to date, CyberProf has been used primarily in science courses, the software can support concepts and symbols from diverse fields, ranging from the hard sciences to economics to music.

### **Availability**

CyberProf is free to all non-profit academic clients. For contact information see the CyberProf homepage at: <http://loner.ccsr.uiuc.edu/cyberprof/>.



## REFERENCES

1. **L. C. McDermott**, Millikan Lecture 1990: What We Teach and What Is Learned—Closing the Gap, *Am. J. Phys.*, 1991, 59, 301-315.
2. **L. C. McDermott**, Guest Comment: How We Teach and How Students Learn—A Mismatch?, *Am. J. Phys.*, 1993, 61, 294-298.
3. **Hubler, A. and Assad, A.** "CyberProf: An Intelligent Human-Computer Interface for Asynchronous Widearea Training and Teaching." Paper Presented at the Fourth World Wide Web Conference, December 12-13, Boston, MA.
4. **Sherwood, B. and Stifle, J.** The PLATO IV Communications System, Urbana, IL, 1975. University of Illinois Computer-based Education Research Laboratory.
5. **Silver, D.**, NovaNET: Basic Skills Lessons for Middle School, High School, and Adult Basic Education Students, Urbana, IL, 1988. University of Illinois Computer-based Education Research Laboratory.

