

# AN INTERNET SITE FOR FRESHMAN CHEMISTRY

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## Abstract

Internet or web sites can store texts, articles, figures, computer simulations, multimedia segments, assignments, quiz and test questions, student records, discussion records and other materials. Information can be in the form of textbooks with the added flexibility of being hyper-linked for dynamic access. Because browsers are easily available, websites offer many benefits for educators and students. Websites have replaced posters, loudspeaker announcements, and notice boards.

I have developed a website for students at the University of Waterloo, and it has been in operation for a few years. Files for the website reside on a twin-CPU SUN Ultra Enterprises Unix server, but many pages have links to other internet sites. It can be accessed by anyone using a browser anywhere at any time, thus, it serves as a cyber office.

This website evolved from an earlier design of a Computer Assisted Chemistry Tutorial (CACT) system, which resided on a server of a local computer network of IBM PCs. Our students used CACT for several years before we adopted the internet technology. Thus, we call the web site Internet CACT, or simply CACT.

One of the important features for the Internet CACT is to conduct quizzes over the internet. Students have the choice of going to small group tutorials and write 5 class-room quizzes or writing 9 to 10 CACT quizzes over the Internet per term. During the Fall term (September-December, 1998), 650 of the 995 students registered in Freshman Chemistry I (CHEM120) have written 9 CACT quizzes each over the Internet site. During the Winter term (January-April), 390 of the 610 students registered in Freshman Chemistry II (CHEM123) have written 10 quizzes each over the Internet. Their marks were recorded on the same server. A locally developed program is used for this operation. While it is functioning, the website is constantly been maintained, developed, and updated.

A counter was placed in the CACT site during the Fall term of 1998. Usually, the numbers of access is about 20 per day. However, a few days before major tests and final examinations, the numbers of access were between 500 to 700 per day, usually at night. When the counter was in place, between 5 to 10 seconds was added to the time required for loading the menu. We have disabled the counter, for the convenience of students.

In this article I will share my experiences in implementation, design, development, operation, and maintenance, comment on the future outlook of using websites for teaching and learning, and will discuss our quiz design and operation. The CACT website address is <http://www.science.uwaterloo.ca/~cchieh/cact/cact.html>.

## 1. Introduction

Schools and universities stand at the forefront of science and technology. Students and teachers constantly look for new and exciting things to learn and do. Teaching without learning soon leads to boredom. The pleasure of learning multiplies if it is associated with teaching. Thus, the introduction of a new technology

almost immediately affects professors, teachers, and students in the universities, colleges, and schools.

Technologies such as radio, audio recorders, television, video recorders, etc. have greatly affected the learning and teaching profession, especially on the generations slightly before us. Some of us can only relate to the introduction of computers, and its effect on teaching and learning. However, we have to recognize that applications of any of these technologies to teaching are called **media teaching** or [media education](#). Computer and internet technologies affect teaching and learning more than other media before them in number of people involved.

When audio and video recorders were introduced, educators began to use them to store and deliver teaching materials. Some teachers feared that media teaching would replace them, but media teaching changed the nature of teachers' work. Furthermore, [TV and Film in media and teaching](#) has had a great impact on our society and on our life-time learning process.

When personal computers (PC) were introduced, many teachers rushed to employ them for storing and delivering teaching material. Again, some were afraid that computer aided instruction (CAI) would threaten the teachers' job security. Almost 20 years has passed since the PC came to the market place, and over the past 20 years, several generations of the PC have come and gone. A more recent event is the increase in the number of internet (web) sites. Abundant instructional aids are available from the Internet, for example, the *website for media teachers in the UK* (dead link removed).

[An Internet Site for Freshman Chemistry](#) has been developed and evolved for more than 15 years. At the start, this site was tested by a small group of students in the chemistry program on a local network of computers in one room. Then, it was placed on a campus-wide computer network for about 800 freshman chemistry students.

The popularity and the prospect of the Internet (for example see [The Future of the Internet as an Educational Medium](#))  compelled us to [convert the CACT into internet documents](#). During 1997 and 1998, both the DOS and the Internet versions of CACT were available. In the Fall of 1998, only the Internet version of CACT was maintained and supported. We are constantly improving it, and problems are dealt with as soon as possible. The CONFCHEM audience accesses the same site as our Freshman Chemistry students at the University of Waterloo.

Students have written [CACT quizzes](#) over the Internet CACT site for the past two terms. The experience is interesting and valuable for future improvement.

## 2. The Beginning of CACT

Science educators often ask when and how things start and why? Thus, let me start from the very beginning.

The introduction of personal computers (PC) in the early 1980s had a great impact on the educational profession, as had radio, movie, TV, and other media that were introduced before the PCs. During the early 1980s, the University of Waterloo received a donation of PCs from IBM. The Physics and the Computing Services Departments teamed up and developed a local network to provide computing for physics students. Partly because of my interest in the project, 8 PCs were allocated to the Chemistry Department to set up the same type of local network for Chemistry students. This photograph shows that first local network of personal



computers in one room.

The graphic capability of the PCs greatly tempted us to simulate chemical and physical phenomena. We wanted to show how systems respond to the driving force of change. For example, many of these programs were collected by the SERAPHIM project. However, information or instructions provided to students must be organized, and instructions are required to tell students how to use the simulations for learning and skill developing purposes.

The faculty members were very eager to become computer literate after the introduction of PCs. At a computer conference, I heard lectures on the hyperlink concept. That concept was later applied for the development of Hypercard. We were determined to make our students computer literate. Having the computers available in the Department, I designed a course to teach chemistry students to write software to solve chemical problems and handle chemical information. Some enthusiastic students, in particular Chris Reil and Adam Asworth, helped me in the development of a primitive browser for processing text files which had imbedded Script tags. We called these files Instructions. The browser is an important component of the early [Computer Aided Chemistry Tutorial](#) (CACT) system.

During those old days, we had a great pleasure in trying different things on the computer. The students and I have learned a great deal from each other. Both Chris and Adam have gone on to computer related careers since their graduations from the Chemistry Program.

### 3. Computer Aided Chemistry Tutorials

*Computer Assisted Chemistry Tutorials* (CACT) were instructions managed by a browser-like program called **Resource** written in the Quick Basic language. The CACT files resided in a server of local area network (LAN) of personal computers. Students accessed the CACT system from any workstations of the LAN in a disk operating system (DOS). The DOS CACT system was in operation between 1980s and 1998, but we began to convert the files into Internet documents in 1996, and placed them on the Internet in 1997. Students accessed either version in 1997-1998, but only the Internet CACT was maintained and supported by the Fall of 1998.

Both the DOS and Internet versions follow the same design, and the design of the DOS CACT is described in this section.

*Resource* starts by displaying a **Menu**, which is equivalent to the table of contents in a textbook. Each item on the Menu is linked to an **Instruction** file. A user moves the highlighted choice (base) from the Menu by using appropriate keys that are usually used to control the cursor movement. A user can move one item or 20 items at a time in either direction by typing an appropriate key.

Typing any key will move the choice one item at a time in the forward direction. By pressing the **Enter** key, the **Instruction file** linked to the highlighted (base) item of the Menu will be displayed. When a user depresses the Esc key, the Menu is displayed for the user to make another choice. At that time, we had to show students where the *Enter*, *Esc*, *PageUp*, *PageDown* and the *arrow keys* were on the keyboard, because most of them had not used a PC before.

At the start, the DOS CACT was a flexible system. Users had to keep track of the documents they have read and know what they need to study. In later years, the CACT automatically recorded a history for each student to help the user to keep track of his or her study. *My own CACT history* was the first item on the Menu, and the *History* showed the date and the title if and only if he or she had answered the Dialogue questions. This file resided in the users private account called *CACTHIST*, and the contents were updated each time.

Every subject on the Menu of the CACT

CACT		
<b>Menu</b> Acids <b>Bases</b> Catalysts Density...	Enter = > < = Esc	<b>Instruction</b> <b>Acids</b> An acid is a substance that dissociate into ... when dissolved in water ...

A CACT Subject



system has four potential components: *Instruction*, *Dialogue*, *Demonstration*, and *Quiz*. Unfortunately, the DOS based technology enables only one of these to be displayed at a time. By typing appropriate keys, the user can go from one component to another. All subjects have the *Instruction* and the *Dialogue*, but some have all four components.

The *Instruction* and *Dialogue* are handled by *Resource*, which is linked to *Demonstrations* via the Menu. *Quiz* is handled by a separate program to conduct tests and record marks. They all work together as a single system.

<p><b>Dialogue</b>          What is an acid?          What is HCl?          Why is HCl an acid?</p>	<p><b>Instruction</b>  <b>Acids</b>          An <b>acid</b> is a substance that dissociate into ... when dissolved in water ...</p>
<p><b>Demonstration</b></p> 	<p><b>Quiz</b>          Which is produced by an acid?          H<sub>3</sub>O<sup>+</sup>    H<sub>2</sub>O          OH<sup>-</sup>       ·OH</p>

The strategy for CACT may be applied to any subject or course. A considerable effort was required for preparing the content and we had a full implementation only for the the large first year chemistry courses.

When a resonable amount of content were implemented, we asked about 120 Chemistry-Major students to try the preliminary version. Then we released it to about 800 students who are taking the freshman chemistry courses. These students are from various programs in the Faculties of Mathematics, Health Studies, and Sciences. The engineers at the University of Waterloo offer their own version of a one-term freshman chemistry course, dealing with equilibrium and stoichiometry.

The CACT worked well with the local area network (LAN) called *JANet*, and University wide network systems called *WatStar* (DOS and Window 3.1 operating system), and later *Polaris* (Windows 95 being the default operating system).

Starting in 1997, students entering university did knew what DOS represented. To them, the Windows system is how computers should work. Changes to CACT were unavoidable and some possible changes were to:

- write a management system based on the Window system for CACT. Languages C++, Visual Basic and Java have been considered, and their potentials explored.
- write a CACT management system using a language for the UNIX operating system.
- adopt one of many **course development packages** or **teaching systems** as they call them for the CACT.
- take advantage of available browser technology.

The advantages and disadvantages of each of these possibilities have been carefully considered in view of our strength and resources.

Since web browsers have been distributed free of charge, and they have been readily available at the university work stations (computers), we decided to make the CACT available on the Internet. The [conversion](#) was underway in 1997. We tested it extensively with browsers available on the University computing facilities.

## 4. The Dialogue and Confidence Building Questions

The name *Computer Assisted Chemistry Tutorial* (CACT) implies the original intention of learning by working. After having studied a chemical theory or concept, the student apply it to solve problems. By then, students have acquired some skills, not just memorized some statements. The CACT is based on this pedagogical practice, and self testing is an important part. This part was called the *Dialogue* in the DOS

CACT, because students engaged in conversations with computers. Since the interactivity between computers and users over the Internet requires more time to implement, questions in the *Dialogue* become *Confidence Building Questions* in the Internet CACT.

## 4.1 The Dialogue

In the early DOS CACT, the self testing was done in the form of a *Dialogue* between a student and a computer. A *Dialogue* consisted of a series of questions, and the computer gave the user one at a time. Since programming a computer to process students' input is a difficult task, we used questions that require short answers. A complicated task is broken down to many questions, and students were asked to provide key answers in steps.

For each question, *answer-response* pairs were prepared. The computer gave a corresponding *response* to the student's *answer*. The responses pointed out some common mistakes used in deriving these *answers*. A *mark* was given to indicate the quality of the answers, but it was not recorded.

A student could answer a question as many times as he or she wanted. The purpose of the *Dialogue* is to build students confidence and to acquire skills by solving problems. Setting up *answer-response* pairs in the *Dialogue* was a very demanding task.

Some concepts or theories can be taught by asking a series of related questions. Some modules were made up this way.

We can also give a number of problems for a subject, each requires a different application of the same concept or theory.

In the early 1990s, students came to the computer room for the CACT. Watching them working on the problems was a rewarding experience, and students also directly interacted with me. After the network has expanded to campus wide with many computer rooms, and especially after having [converted to the Internet CACT](#), I miss the opportunity for direct human interactions.

Over the years, some students have use CACT extensively, and a few have even point out the errors and made suggestions to improve CACT. Jason Ekert a former student in the course, proof read the files after he completed these courses. Of course, I appreciate having the feedback very much, and some of them realize it.

## 4.2 Confidence Building Questions

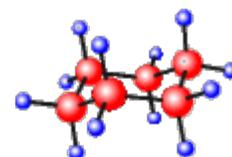
Questions in the *Dialogue* of the DOS version of CACT have become *Confidence Building Questions* of the Internet CACT site. Common browsers do not provide interactive *responses* to corresponding *answers* in the form of *Dialogue*. Java applet or other programs have to be implemented. We have not had the time to develop a Dialogue approach to the Internet version of CACT yet.

In the current version, we put all the questions together, and provide *hints*, *suggestions* or *considerations* as well as hidden *answers*. Over the past two years, we have tried various techniques in the *Confidence Building Questions*. On some pages, we specify the *skills* students acquired in solving these problems.

Rather than learning the chemistry directly from the computer screen, Many students print the web pages in the Internet CACT for their study.

Having the appropriate number of quality questions in a subject is important. We are constantly improving the *Confidence Building Questions* of the Internet CACT. Time and effort are required to read the pages and make changes. Thus, building a web site is a real *labour of love*.

One of the early intentions of *Computer Assisted Chemistry Tutorials* (CACT) was to provide computer **Demonstrations**, which could be simulations of chemical principles, visualization of chemical concepts, demonstrations of experiments, and illustrations of theories.



For simplicity, demonstrations were called *Demos* in the DOS version of CACT. We implemented selected topics, each had a *Demo* as an enhancement of our teaching. We did not intend to cover all the lecture material or course content.

## 5.1 Demos

The personal computers' ability to display vivid graphics in color has attracted many educators to write programs to demonstrate (*Demos* for short) chemical concepts and theories. We have also written a number such programs, which were organized for students to use in the DOS version of CACT, first for students in the Chemistry programs, and then for all freshman chemistry students.

The *Demos* used for the first term are listed in the Table here. Most *Demos* were written by me, in the Quick Basic language. The *Demos* were organized using the *Menu* like that shown on the right. Each *Demo* had its own *Instruction* and *Dialogue*. Few *Demos* were adopted from other sources, because of copyright and difficulties in their integration into CACT. Approximately the same number of *Demos* were written for the second term freshman chemistry, but for brevity, they are not given here.

The drawback of the DOS version of CACT was that the *Demo* and its *Instruction* could not appear on the same screen. This created some inconvenience for students, because they had to copy down the points in order to fully realize the benefit of the *Demo*. Having the *Instruction* and its *Demo* on the same screen would have been more convenient.

Demonstrations of term I	
Battery	Galvanic cell simulation
BondEL	Chemical bond length and energy
Conventn	Conventions used in CACT
EMWave	Electromagnetic radiation wave
Gaslaws	Gaslaws
HBond	Electron density of H-H bonds
Hybrid	Hybrid atomic orbitals
KinetGas	Gas kinetics
Limitn	Limiting and excess reagents
Molecule	User controlled molecular display
Orbital	Electron density of atomic orbital
PeriodTb	Electronic periodic tabel
PiBond	Electronic density of pi-bonding
QuantNum	Quantum numbers
Spectrum	Simulation of spectrum
TVP	The ideal gas law
VSEPR	VSEPR and molecular shapes

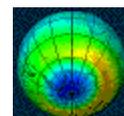
## 5.2 Loss of Demos in the Internet CACT

Because the *Demos* are written in Quiz Basic, they cannot be directly implemented in the Internet documents. If they were hyper-linked on the pages and the user clicks them, the users' computers will ask if they want to download them onto their computers. Such an arrangement is not practical for freshmen taking chemistry, and the *Demos* were not included in the Internet CACT. Thus, the *Demos* ceased to function in the Internet CACT, due to the change in technology. However, the *Demos* can still be used during lectures in classrooms with computer display facilities.

It is possible to rewrite the *Demos* in Java applets or Java scripts. However, due to time constraints, these have yet to be done.

## 5.3 Advantages of Internet CACT

Despite the loss of the *Demos*, [making](#) CACT available on the Internet offers many advantages over the DOS CACT:



Special chemical terms can be [hyperlinked](#) to related documents for further help.

- Diagrams, illustrations, and animated demonstrations (such as the ozone hole animation here) can be imbedded in the documents to make them more interesting.
- Audio files, video clips, Java Applets, and other presentations can be hyperlinked or imbedded to make the documents multimedia. Implementation of these features will, no doubt, be easier in future generation of browsers.
- The current html-type documents can easily be made to offer pleasant and attractive presentations.
- The browsers capability to search key words can be applied for enquiry type of approach for students.

Because computers are close to each other in our computer labs, we have not included any sound tracks, nor have we included any video demonstrations. These require much more effort to implement.

Key word searching is very useful for active learners, but most students are passive learners.

## 6. CACT Quizzes

Quizzes administered at regular intervals demand that students study according to a schedule that we have set for them. Thus, we traditionally have small group tutorials and quizzes. When the DOS CACT was in use, it offered students an opportunity to write quizzes administered by computers in a DOS environment. After CACT was made accessible on the Internet, students had the opportunity to write quizzes over the Internet.

In this section, I will review the traditional [Small Group Tutorials and Quizzes](#), the [DOS CACT Quizzes](#), and the [Internet CACT quizzes](#). I will share my [Experience with CACT Quizzes](#) to the extend of addressing issues in computerized quizzes in general. Furthermore, I will give reasons for our [Strategies for Quizzes](#).

### 6.1 Small Group Tutorial Quizzes

Freshman chemistry classes have increased over the years, and now the classes have approximately 200 students per lecture section. There are several lecture sections in the Science Faculty, totalling more than 1000 freshman chemistry students in the Fall term, and more than 700 in the Winter term. The Department used to give biweekly small-group tutorials to about 30 students, and that class size would have increased considerably had CACT quizzes not been available. At the end of each small-group tutorial, we administer a 15-minute written quiz. Students solve one problem per quiz. The quiz papers are collected and marked by tutors, and they are returned two weeks later. These tutorials are offered so that students can ask questions in a less formal atmosphere. Most students, however, attend them biweekly to write quizzes.

Writting quizzes has always been a part of our Freshman Chemistry courses, the [DOS CACT](#) and the [Internet CACT](#) administered quizzes are substitutes for written quizzes in the tutorials.

For the past many years, students have written five (5) quizzes by attending 5 small group tutorials or nine to ten computerized quizzes. During 1998-1999, more than 70% of the students opted to write the quizzes over the Internet.

### 6.2 DOS CACT Quizzes

During the 1980s, our local area network (LAN) of computers was only lightly used. Following several years of running the DOS CACT on the LAN, I implemented the computerized quizzes, which followed the [Dialogue](#) format. In the *Dialogue*, students could answer a question many times, and the marks were not recorded. In quizzes, marks were recorded.

Each CACT Quiz consists of 5 to 10 questions randomly chosen from a pool of questions. Marks were the same for all questions. Partial marks were awarded. Three question types have been used:

- multiple choice questions - The student enters a letter to indicate his or her choice,
- questions requiring short-answers - The student enters a keyword, symbol, or term,
- questions requiring numerical answers - The student must enter a numerical value.

The computer displays one question at a time, and there is no time limit within which to give an answer. As soon as an *answer* is entered, the computer reveals the mark earned for the question. For a correct answer, the computer returns with a thought provoking comment or question. For an incorrect answer, a hint is given.

Many years ago during a lecture, a student made a suggestion:

"Sir, we know the purpose of CACT Quizzes is to encourage us to learn, why don't you give us a second opportunity to give a correct answer for partial marks after we have seen the *Hint*?"

The class applauded and the strategy of quizzes was changed thereafter, partly also because I wanted students to read the *Hints* carefully. The *Hints* suggested a formula to use or a theory to apply, but the answers were not given. A student could answer a question  $n$  times, but the earned mark would be divided by  $n$ . We have not carried out research to see if such a strategy indeed led to more learning, but the number of requests to raise their quiz marks was drastically reduced.

At the end of a quiz, the mark earned for the quiz was displayed together with previous quiz marks for the students to review.

## 6.3 Internet CACT Quizzes

The [conversion](#) of the *Instruction* and *Dialogue* in the [DOS CACT](#) into Internet documents was completed early 1998. At this point, I wanted to begin *quizzes over the Internet* in the Fall term of 1998. Planning, exploring possible software, modifying, testing, and making up the *Internet CACT Quizzes* was my project for 1998.

After having explored several possibilities, I decided to modify a locally developed program called [WEBTEST.pl](#) for the *Internet CACT Quizzes*.

During the winter term of 1995, Nevil Bromley and Paul Snyder of the [Faculty Projects Group](#) at the [University of Waterloo](#) developed a preliminary version of the program [WEBTEST.pl](#). During 1997, there had been some limited testing and applications of the program, with very limited support provided by the [Information Systems and Technology \(IST\)](#).

Together with Wai Chun Li, a former Chemistry graduate working on his Computer Science degree at that time, we got a copy of WEBTEST.pl, and tested it. The question formats used for WEBTEST.pl are similar to those of the [DOS CACT Quizzes](#), but now students can point and click their choices when WEBTEST.pl is used to administer the quizzes. Questions requiring keywords and numerical values as answers are handled the same way as the [DOS CACT Quizzes](#).

The program WEBTEST.pl sends quiz marks to a *quiz master* in the form of an e-mail, and the *quiz master* has to extract the marks from these e-mails. Thus, students can write the quizzes any number of times. On the other hand, the DOS CACT Quizzes checked the student mark every time he or she started a quiz, and the mark earned during (not after) the quiz is immediately recorded. A student has only one chance to write a quiz. Once they start the quizzes, they have to finish them, because if they stop or turn the computer off, the marks they have earned at that time become their marks for those quizzes.

I decided to modify WEBTEST.pl so that I could incorporate the strategies and designs used for *DOS CACT Quizzes*, which have worked well. We have consulted many *Perl* experts about file handling students quiz marks. We eventually used a technique used in the DOS CACT Quizzes.

We have added an interesting and useful feature to the selection of questions from a pool of questions in our modified WEBTEST.pl. We divided the pool of questions into groups, and a definite number of questions can be chosen from each group to make up a quiz. This feature enables the questions to be grouped according to difficulty, topics, style, or type (multiple choice, numeric answers, key-word answers). Thus, several skills can and will be tested in a quiz.

Together, Wai Chun Li and I tested how the system behaved under various conditions. For example, we tested the program as if three *students* were writing a quiz at the same time. During the past year, we modified the program to accommodate the problems experienced by students.

During the Fall term (September-December, 1998), 650 of the 995 students registered in Freshman Chemistry I (CHEM120) wrote more than 7 quizzes each over the Internet CACT. During the Winter term (January-April), 350 of the 606 students registered in Freshman Chemistry II (CHEM123) have written 8 or more quizzes each. Seven and eight best quiz marks were used to derive an average for the two terms respectively.

April 5, 1999, was the last day of lectures for the Winter term. April 4 (Sunday) was set as the deadlines for two CACT Quizzes. As a result, more than 150 students tried to write their quizzes, and unfortunately, the Internet server went out of service. The system manager thought that heavy usage by students writing *Internet CACT Quizzes* that day might have contributed to the problem. In the future, deadlines shall be set during office hours on week days to avoid this problem recurring.

A special [CACT Quiz](#) has been set up for CONFCHEM participants, whose identity and marks are not checked or recorded.

## 6.4 Problems of Computerized Quizzes

Computerized quizzes can be given either under the supervision of a proctor in a computer room where the students write the quizzes or unsupervised, in which case, no proctor is present when a student writes a quiz. Students writing unsupervised quizzes over the the Internet can do so at any time from anywhere. Problems or issues for the two quiz types are different. Since the CACT Quizzes are unsupervised, the problems addressed here are for the unsupervised quizzes. These problems can be divided into computer related and people related categories:

### 6.4.1 Computer related problems

- Computers freeze (hung) during quizzes.
- Power failures (due to thunderstorm for example) during quizzes, or during a period students want to write quizzes.
- Failure of the Internet server, especially during the nights and on weekends.
- Internet connections interrupted during quizzes.
- Workstations in a computer network system may have security measures. For example, all the workstations in the University library restart themselves when no action from the keyboard or mouse is detected within three minutes. After restarted, Internet communication between the workstation and the Internet server is lost.
- After a set period, the Windows operating system activates a screen saver. Some students are unable to get back to the *Quiz* window after the screen saver had been activated during the quiz.

### 6.4.2 People related problems

- Students have claimed experiencing computer related problems, such as frozen computers, power failures, accidental computer reset (or turned off by other students), Internet connection interruption, *etc.*
- Students have claimed that they were incorrectly marked by the computers.

Students reported seeing several of their fellow students working together and helping each other during quizzes.

- Students claimed that they had written the quiz, but the computers failed to record their marks. Other students claimed that they were about to write the quiz, and found their quizzes written by others.
- Abilities to use computers vary from student to student. Some sophisticated computer users tried to beat the system, whereas some inexperienced students were simply frustrated by computers.
- Some years ago, I was sympathetic when a student claimed a computer froze-up during a quiz, and often allowed them to rewrite the quiz. This upset other students, who wrote to tell me about the cheating practices of some of their fellow students by simply turning off their computers and then complaining that the computer froze-up. No, policy is more important than a student's plea.
- Correspondence regarding CACT Quizzes have been collected on a web page called [Questions and Answers on Quizzes](#). Students were encouraged to read this page to help them avoid the common mishaps.

## 6.5 Strategies for CACT Quizzes

On the one hand, the quiz marks must count for something to encourage students to write the quizzes. On the other hand, the weight should be light enough not to make students greedy for (quiz) marks. The goal of CACT Quizzes is to encourage students to learn chemistry, not computer literacy. Only 10% of the final grade is allocated for Quiz marks. Despite the low weight, many students have argued for higher marks.

So far, students must complete the CACT Quizzes once they have started them. This policy prevents them from not submitting for marking unless they have acquired a good mark. On the other hand, the goal of CACT Quizzes is to tempt them to learn, and the WEBTEST.pl has just been changed so that when students get less than 50% in a quiz, they will be allowed to repeat the quizzes in the Fall of 1999. Larger question pools will be made to insure that different sets of questions will be given in all quizzes.

Because of computer related problems, one or two of the worst quiz marks have been ignored. If students are allowed to rewrite failed quizzes, allowing one worst mark to be ignored will be adequate.

Questions in a pool are divided into groups. Most of the time, they are grouped by topics or concepts in a learning unit. For each topic, we prepare a group of questions. One question from each group is chosen randomly to make up a quiz. Thus, all the topics are tested in a quiz, and no quiz will get too many questions from one topic.

In a separate file from the mark file, the *Internet CACT Quizzes* record the question numbers in the pool and students answers. Students' claims of incorrect marking by computer can be checked by instructors, who can change the record in the mark file.

## 6.6 Benefits of Internet CACT Quizzes

The educational value of *Internet CACT Quizzes* is hard to assess, but there are some benefits associated with them. Thus, developing tools for computerized quizzes is a worthwhile venture. For example, [Question Mark](#): is such a business venture to provide tools for computerizing quizzes, tests, assessments and surveys. Furthermore, the [San Jose State University](#) has set up [the Testing and Evaluation Department](#) to provide consulting services for test construction, survey construction, and data analysis to its own faculties.

Some well known institutions have adopted computerized examinations. In 1998, the [Educational Testing Service \(ETS\)](#) introduced computerized testing for TOEFL examinees in the United States, Canada, Latin America, Europe, the Middle East, Africa, Australia, and selected countries in Asia. Written tests are no longer available. In 1999, the Dental Aptitude Test (DAT) will also replace the written examination by [Computerized DAT](#). [The Computer-Based Graduate Record Examinations \(GRE\)](#) has already replaced its written tests.

The TOEFL, DAT and GRE tests are aimed at assessing a student's ability, rather than for educational purposes. These tests are supervised under controlled conditions. The unsupervised Internet CACT Quizzes are mainly aimed at enticing students to learn or study.

During the past two terms, about 70% of students taking freshman chemistry chose to write the Internet CACT quizzes. In our opinion, these quizzes offer many advantages:

- CACT Quizzes provide immediate score reporting and feedback to students to let them know their results. Poor marks serve as a warning of inadequate preparation.
- CACT Quizzes give hints or methods for problem solving to help them improve in areas where they need help.
- Once set up, the cost of increasing the number of computerized quizzes is very low compared to the cost of providing man power to set, supervise, and mark written quizzes.
- Computerized quizzes offers the possibility of using graphics, sound, video etc.
- Content and questions in *Internet CACT Quizzes* can be revised and changed easily *on the fly* in response to students needs.
- Internet CACT Quizzes are at least partially individualized, and all topics are tested.

A freshman chemistry student has a chance to practice writing a [CACT Quiz on measurements and units](#) over the Internet. This quiz mark is not counted. The same quiz is made available for the CONFCHEM participants. Participant's identity and mark are not kept. Feel free to give it a try.

## 7. Constructing the Internet CACT Site

Technology is constantly changing. A computer becomes obsolete in less than five years, and new versions of software appear almost annually. Within twenty years, the disk operating system (DOS) has given way to the Windows operating systems. Students, who have grown up with the Windows operating system, do not know what DOS stands for and [the DOS CACT](#) has become outdated.

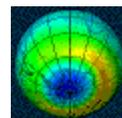
With no resources to hire programmers to write a CACT Management system for the Windows platform, I tried to learn Visual Basic (VB) hoping to use it to write a system. Before such a system took shape, my attention shifted to Java because many reports suggested it would be the language of the Internet.

At the same time, the functionality of Internet browsers has matured, and they are widely available because they are distributed free of charge. The Internet culture has taken root in the general public, and in particular among students.

### 7.1 The Internet Culture

The attainments and activities of any special period, place, or group of people can be called a **culture**. Today, the Internet is so popular that it has changed the way we learn, teach, and live. **The Internet** (broken link removed 5/01) has penetrated political, language, and religion barriers, and it plays a major part in our lives. Willingly or not, our lives are influenced by the [Internet culture](#). Future generations may call this period an *Internet age*, instead of [Internet culture](#), just as we have called past periods *bronze age*, *nuclear age*, *information age*, etc.

In 1969, [the Internet](#) started as a project by the Advanced Research Projects Agency (ARPA) to connect four major computers at universities in the south western US. Within months, many universities and government agencies have become connected to it. Soon, computer experts, scientists, and engineers used the Internet to communicate with each other. The expansion of Internet was rapid, though not to the extent of undergraduate students and the general public until the 1990s.



Popularities of personal computers, browsers, and Internet servers have brought the Internet culture to the public in the 1990s, compelling us to follow a trend of building *cyber-space offices* for students. Like radio,

television, fax, and telephone, the Internet has shrunk distances, making the world a truly *global village*. The constant availability of information from anywhere at any time on the Internet has made it unique, however.

Today, students know how to access information on the Internet, and making the [CACT system](#) available on the Internet is a sensible thing to do. The CACT strategy and functionality seem to have worked well over the years, so these ideas are retained in the [INTERNET SITE FOR FRESHMAN CHEMISTRY](#), or *Internet CACT*.

## 7.2 Web Construction

[The World Wide Web](#) (known as "WWW", "Web" or "W3") is the universe of network-accessible information, the embodiment of human knowledge. Internet sites are often called *web sites*. The word *web* is short and attractive, because it reflects the resemblance in structure between the Internet and a web. Thus, making an Internet site is a *web construction*.



Having spent more than 20 years using computers for crystallographic computations, I am familiar with the computer technology. However, web construction is still a new venture. In order to convert [the DOS CACT](#) into the [INTERNET SITE FOR FRESHMAN CHEMISTRY](#) I began the task by collecting the links to [web construction tools](#) on my Internet site for my own convenience.

Browsers can be used to edit or construct web pages, so can MS Word, WordPerfect, and other editors and word processors. However, I find it just as convenient to use a simple text editor for preparing the Internet documents. Files so created can be organized for easy access and their content can be revised easily.

Constructing a good web site requires more than knowing the HTML tags. Writing, page design, crafting, graphic design, questioning, *etc.*, are all parts of the web construction. Being able to excel in any one of these is a life-long learning process. Fortunately, we have learned some of these skills as teachers. However, unlike a textbook author, Internet authors work alone. Perhaps because writing is a struggle for me, I enjoy doing it. Unfortunately, proofreading my own writing is difficult. Some documents on the [INTERNET SITE FOR FRESHMAN CHEMISTRY](#) have been proofread by former students, and I do engage students to give feedback.

Since we are using a textbook, and I teach one of the 3 to 5 sections, the teaching team often decides that test topics must be in the textbook. Our team members are glad to have the CACT sites, and the [CACT Quiz](#) policy is a collective agreement.

We use the textbook notation and terms as our *standard*. However, computer screens and the software limit the type of symbols and notation we can use. Students seldom complain about the differences in notation and symbols of CACT and those of the textbook.

Lately, I have increased the number of links to other sites. Searching for the appropriate documents requires time. However, many sites have animated illustrations and simulations, which are prepared by experts. These sites may not be permanent, and changes to them will result in broken links.

Working in cyber space is fun, but spending too much time and effort, means neglected gardens, cluttered garages, messy kitchens, and untidy desktops.

## 8. CACT Content

The content of the [INTERNET SITE FOR FRESHMAN CHEMISTRY](#) is based on a Departmental decision made more than 15 years ago, but the teaching team chooses topics to emphasize and it adopts a suitable textbook. In 15 years, we have switched textbook a few times, but the content of CACT is prepared independent of the textbook. Actually, we present the topics in the order given in the [INTERNET SITE FOR FRESHMAN CHEMISTRY](#). Students, who have studied from this Internet site and mastered all the concepts

therein, will do well in all examinations. [The Distance and Continuing Education](#) branch of the University of Waterloo has looked at this site, and the manager is very interested in having this site offered as distance education courses.

Due to the large amount of information on the Internet, most Internet documents are short. Each page on the [INTERNET SITE FOR FRESHMAN CHEMISTRY](#) deals with one concept or theory so that it is short. In this approach, chemistry is broken down into many modules; each teaches a number of skills. Bits and bytes of chemical concepts are organized by the Menu to present a body of chemical common sense with some general themes.

Freshman chemistry is taught in two term courses: [Chem120](#) followed by [Chem123](#) for students in other than chemistry programs. For students in chemistry and biochemistry programs, the two parallel courses are Chem121 and Chem125. Their themes are:

- [Chem120/121](#)  
Properties of materials, stoichiometry, electronic structure of atoms, and chemical bonding.
- [Chem123/125](#)  
Intermolecular forces, states of matter, chemical reactions, chemical (acid/base and heterogeneous) equilibria, and electrochemistry.

Some high school graduates have already mastered some of the topics in Freshman Chemistry. Active learners can selectively study the pages of [INTERNET SITE FOR FRESHMAN CHEMISTRY](#). They may also use the questions to test their skills before reading the theory. There are some students, who passively follow the menu and the text, but cannot apply the theory or concept covered in these pages to solve slightly different problems.

Because the low achievers attract most of our attention, they tend to affect our perception of freshman chemistry students more than the high achievers. We often debate on reducing the number of topics and changing topics in freshman chemistry to deal with this group. We feel that we need more time to help them understand the concepts.

On the other hand, we have had many high achievers passing through these courses. They have no problem with the content. The Departmental decision to have separate courses for students in chemistry related programs and students in other programs was to teach according to their ability, but students in both streams have varying degrees of ability.

Students who have mastered concepts and skills expected of Freshman Chemistry in their high school years are given an opportunity to write an Early Examination to earn the credit. Every year, a few students get over 70% in the Early Examinations, and are given the opportunity to select another course for the term. More often, students accept only marks over 85%. If they get less than 80%, they write quizzes and examinations to get higher marks. Many of these students are competing for entrance to a professional school such as medical, dentistry, and optometry.

## 9. Internet CACT Future

As the [Internet culture](#) spreads, more and more professors, teachers, and organizations are constructing web sites for their courses, departments, and schools. The growth of educational material on the Internet is similar to the [growth of information on the Internet](#). They grow because many enthusiastic educators are constantly making information available on the Internet. The [number of Internet servers](#) has increased exponentially. [A count of Internet servers](#) shows a rapidly increasing rate on top of a huge number. To complicate the matter further, each server has many sub-servers and divisions. These days, students ask for the web addresses for the courses they are taking, and such requests will no doubt increase the number of web pages.

Life in cyber space is multidimensional, multicultural, cross discipline, and exciting. We enjoy each other's web pages. Once we have created a web site, we like to see

it grow and improve so that it becomes useful. Furthermore, we like the web site visitors to benefit. There is no boundary to limit improvement and growth. In the future, more Java scripts and Java applets, animations, demonstrations, and simulations will be added to make the web site more dynamic and interactive. Learning by doing leads to better comprehension and a higher degree of skill retention.



The [INTERNET SITE FOR FRESHMAN CHEMISTRY](#) is a web site for courses and this template provides a consistent way to communicate with students. Like any educational material, reactions from students are not uniform. Some students, who do not understand the chemical concepts, are further frustrated by the computer technology. They need help and guidance both on academic and on emotional matters. They need to be understood and handled with sensitivity.

On the other hand, some ex-students, who have used the system, tell me that they felt the CACT offers innovative material for them, and they think it has had some positive impact on their lives. While they are in the course, these students constitute the silent majority, because few have said much.

Statistics on students' reactions to the Internet CACT have yet to be collected. During the past two years, we were busy constructing and improving the site.

The [INTERNET SITE FOR FRESHMAN CHEMISTRY](#) has a workable framework, and there is room for making it more educational, attractive, flexible, resilient, and elegant. To date, the [INTERNET SITE FOR FRESHMAN CHEMISTRY](#) provides some educational functions. It too contributes to the [Internet culture](#) because it shapes the mindscape of students. Both culture and mindscape are hard to define, but they mutually affect and change each other. The [INTERNET SITE FOR FRESHMAN CHEMISTRY](#) must change accordingly with the culture over time.

More development work is needed to make the Internet CACT a good resource and a useful database for a chemist. Graphics, simulations, generation of problems, interactivity, peer discussion, indices, and the ability to accept enquiries are some of the desirable features to be implemented in the future. Even with limited support, effort will be made to improve over time to make the [INTERNET SITE FOR FRESHMAN CHEMISTRY](#) an interesting cyber space for freshman chemistry.



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