NDED LEARNING

Interactive online homework with LON-CAPA

Ray Batchelor
and Veselin Jungic

CAPA is a "Computer Assisted Personalized Approach" that has been in development since 1992 at Michigan State University. It has been used effectively at many institutions, including SFU, where it has been used in the departments of Chemistry and Physics since 1996. It is an assessment system based on the independent solving of randomly individualized homework problems, for marks, with immediate feedback and allowing multiple tries. This approach impels students to perform individually the kinds of problem-solving activities that are integral to science education.

In 2000, at MSU, the CAPA project merged with another project called LectureOnline to produce an entirely new, free, open source Learning Content Management and Assessment System with a distributed/shared Learning Object Repository. This system became known as The LearningOnline Network with CAPA or LON-CAPA. The browser-interfaced system is designed for maximum functionality and scalability, and appears to be a good choice for discovering and building on the simple but effective learning experiences that have become possible with today's technology. This development has been enhanced strongly by the organization and growth of the international user community of LON-CAPA developers, authors, and instructors. http://www.lon-capa.org/

In 2003, the principals of the LON-CAPA project at MSU won the ComputerWorld 21st Century Achievement Award in the Education & Academia Category. http://www.cwheroes.org/caa_4_a.asp

In 2001, Dr. Ray Batchelor (Chemistry) and Dr. Martin Siegert (Academic Computing Services) implemented LON-CAPA at SFU. The SFU Chemistry Department was the first department in the world to offer Chemistry courses using this system. In the SFU Chemistry department, LON-CAPA has now completely superseded CAPA. Evaluation surveys show that LON-CAPA has been received favourably by the majority of students. Recently, instructors in the departments of Mathematics and Physics at SFU have also been evaluating the system in active courses.

SFU Academic Computing Services houses and maintains the servers and provides system administration support for LON-CAPA. The full article attempts to demonstrate many of LON-CAPA's advantages, as well as some of the challenges it presents. The benefits of participation in its user community are also discussed.

Have you read... about Blended Learning?

The Node Learning Technology Network. (2001). *The Node's Guide to Blended Learning.* The Node Learning Technology Network.

This is a great introduction to blended learning, serving to give a practical overview and also including steps to getting started with blended learning.

Bates, A.W. & Poole, G. (2003). *Effective Teaching with Technology in Higher Education: Foundations for Success.* San Francisco, CA: Jossey-Bass Publishers.

This resource goes into some fundamentals of educational technology; design, development and delivery of courses that use technology; and the issue of change with regard to teaching with technology.

Both of these resources can be borrowed from the Learning & Instructional Development Centre's Resource Library (call 604-268-6570 for details).

The 3rd Annual Simon Fraser University Summer Institute

The 3rd Annual Simon Fraser University Summer Institute on eLearning in Higher Education was held at SFU's Burnaby campus from June 8 – 11, 2004. With a focus on intensive, hands-on workshops, the Summer Institute attracted instructors both from the SFU community and beyond. Some of the highlights included a keynote presentation by Tony Bates on "Why Universities Must Change: The Challenge of eLearning", workshops on wikis and blogs; video for eLearning; writing for the web; and building online course modules.

Online Interactive Homework with LON-CAPA

Ray Batchelor and Veselin Jungic

The main purpose of this article is to present our experience with running LON-CAPA at SFU. We will consider some of its advantages, as well as the challenges that we have faced in using this technology. At the same time, we hope to convey some impression of the LON-CAPA system and its interface through selected screen-shots. We also wish to share a summary of results from student evaluations that give a sense of how well the system has been perceived and accepted at SFU. We are enthusiastic about this particular system and about the possibilities for enhancing traditional courses with this, or similar, technologies. At the same time, we hope to present a balanced presentation that gives a reasonable indication of what to expect in the future.

The Rationale

It is generally accepted that extensive, independent problem-solving is a necessary component of learning the quantitative sciences. However, the manual grading of a large number of individual homework assignments is an extremely inefficient use of an instructor's time. Also, it is not as effective learning reinforcement as could be wished because of the usual lengthy time-delay (days or weeks) between performing the exercises and receiving any feedback.

Consider this example from SFU Mathematics: the Calculus Workshop at SFU serves three calculus courses with class sizes of between 200 and 700 students. During the fall semester, course instructors, the workshop coordinator, and teaching assistants face the problem of how to mark about 240,000 assignment questions in three months and get useful and timely feedback to the students.

Similar situations exist in lower-level Chemistry and Physics courses and, no doubt, in other disciplines as well.

The Solution

An effective solution to this problem has been in use in the departments of Chemistry and Physics at SFU since 1996, namely CAPA, or the Computer Assisted Personalized Approach. This assessment system, initially pre-www, was developed at Michigan State University (MSU) from 1992 until 2000. It was conceived based on the notion of learning through independent solving of randomly individualized homework problems, for marks, with immediate feedback and allowing multiple attempts. Basically, it made use of the power of computers and the internet to provide homework that impels students to perform individually the kinds of problem-solving activities that have always been integral to science education. It evolved into an elegant system with a student browser interface, an instructor X-interface, and many tools for analysis of the data logged.

More recently, many other systems (commercial or otherwise) have been developed. For example, the publisher-owned system PHGradeAssist (Prentice Hall) has been used in the department of Mathematics. It is now common, and to be expected, that publishers of science textbooks will provide such tools. However, this is usually at an additional cost to the students. Furthermore, individual instructors sacrifice some degree of flexibility and independence in the use of these proprietary systems. It is our experience that the PHGradeAssist servers' location outside SFU sometimes causes registration and communication problems. Also, since students' data are stored on those servers, there are possible problems with privacy issues. It would appear to be preferable to maintain a high level of local or individual control of the learning and assessment content used. Based on this idea, Maplesoft has developed an online assessment tool called Maple TA that combines commercial and locally controlled approaches.

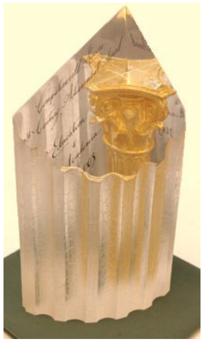
Online Interactive Homework with LON-CAPA

The Learning*Online* Network with CAPA

In 2001, the leaders of the CAPA project and of another project at MSU, called "Lecture Online," joined forces to produce an entirely new, open source, freeware system: the Learning Content Management and Assessment System (LCMAS) with a shared, distributed Learning Object Repository (LOR). This system became known as the LearningOnline Network with CAPA, or LON-CAPA. This entirely browser-interfaced system is designed for maximum functionality and scalability. It appears to be a good choice for discovering the simple but effective learning experiences that have become possible with today's technology.

The Learning*Online* Network with CAPA

With National Sciences Foundation (NSF) support, the leaders also initiated the international LON-CAPA user-community of developers, authors and instructors. This is manifested in annual winter conferences held at various locations in the U.S., as well as summer workshops at MSU. Extensive documentation, several mail lists, and online developer and user communication tools are all accessible through http://www.lon-capa.org. In 2004, the Annual Conference was held at George Washington University, Washington, D.C., on January 22-24. The theme of the conference was "Exchanging and Sharing Educational Resources."



For a relatively recent, independent, comparative review of LON-CAPA and other course management systems, see http://www.edutools.info/course/.

In 2003, the LON-CAPA project at MSU won the Computerworld 21st Century Achievement Award in the Education and Academia Category.

LON-CAPA at SFU

At SFU, Dr. Ray Batchelor initiated and now coordinates the implementation of LON-CAPA for the Chemistry department, which was the first in the world to use this system in Chemistry courses. The first LON-CAPA server at SFU was installed in May 2001 and the first course supported by LON-CAPA was offered in the fall of that year. The Chemistry department now has three load-sharing computers, dedicated to serving LON-CAPA, which run the latest stable release of the software. In the Chemistry department, LON-CAPA has now superseded CAPA. Currently, this involves six lower-level courses with 1100 course enrollments expected in the Fall 2004 semester. Evaluation surveys in Chemistry indicate that LON-CAPA has been received favourably by a large majority of students. Recently, instructors in the departments of Mathematics and Physics have also been evaluating this system in active courses.

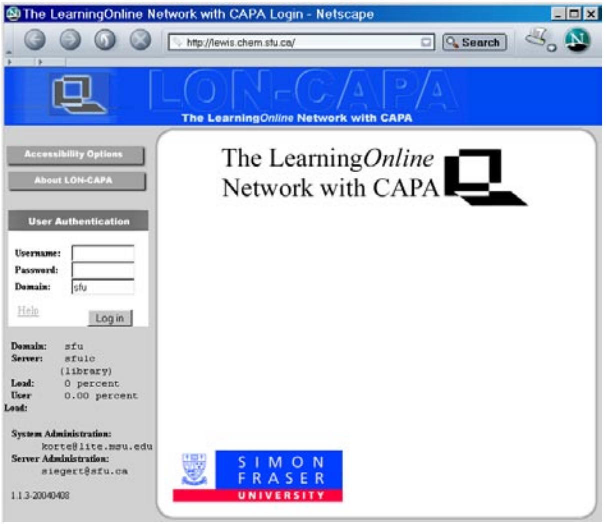


Figure 1. Log-in Screen.

Online Interactive Homework with LON-CAPA

SFU Academic Computing Services supports the installation of the LON-CAPA systems at SFU; it also houses and maintains the servers. Dr. Martin Siegert of ACS is the systems administrator and also a contributor to the LON-CAPA code base. The principal developers at MSU have provided extensive support. Such support continues and is a glowing example for open source development.

On Feb 11, 2004, Dr. Gerd Kortemeyer from MSU, the principal investigator in the LON-CAPA project, gave a keynote presentation at SFU at the invitation of the Learning Management Systems Search Committee. This presentation can be viewed in streaming video at http://www.sfu.ca/lidc/LMSSC/keynote.htm.

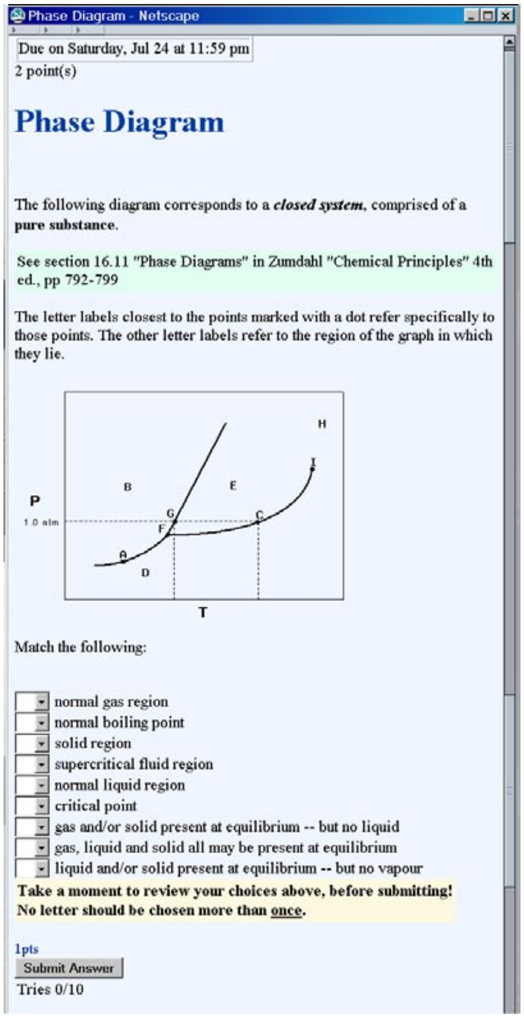


Figure 2. Randomly Labeled Image with Option Response Question.

The Benefits

There are many interrelated advantages arising from the rich diversity of features of the LON-CAPA system. Some of these are as follows

- Every student receives problems, which, while alike in concept to those of the other students, contain different parameters, quantities or expressions. In large measure, this has the effect of forcing each student to do his or her own work.

  This pseudo-random diversification of problems can be carried out to any degree, ranging from identical problems right down to those that are completely different for every student.

- These problems are viewable as files and answerable online through the web browser. They can include such components as images or integrated scientific plots, rendered on-the-fly from algorithmically generated variable parameters and displaying pre-positioned randomized labels (Figure 2).

- The system supports mathematical typesetting throughout (LaTeX inside XML) – formulas are rendered on-the-fly, and can be algorithmically modified through the use of variables inside formulas.

  Individual problems or entire problem sets can be automatically reproduced (via LaTeX) as pdf files in a compact printout format, convenient for taking away from the computer to work on. (Figure 3.)

- Responses, submitted online, can be of various types: textual (simple string or essay), numerical (with or without scientific units, defined tolerance ranges, and significant figures), multi-dimensional symbolic math expressions, or various types of mouse-click selections such as radiobuttons, drop-lists, and also defined ‘active areas’ of images. (Figure 4.)

Online Interactive Homework with LON-CAPA

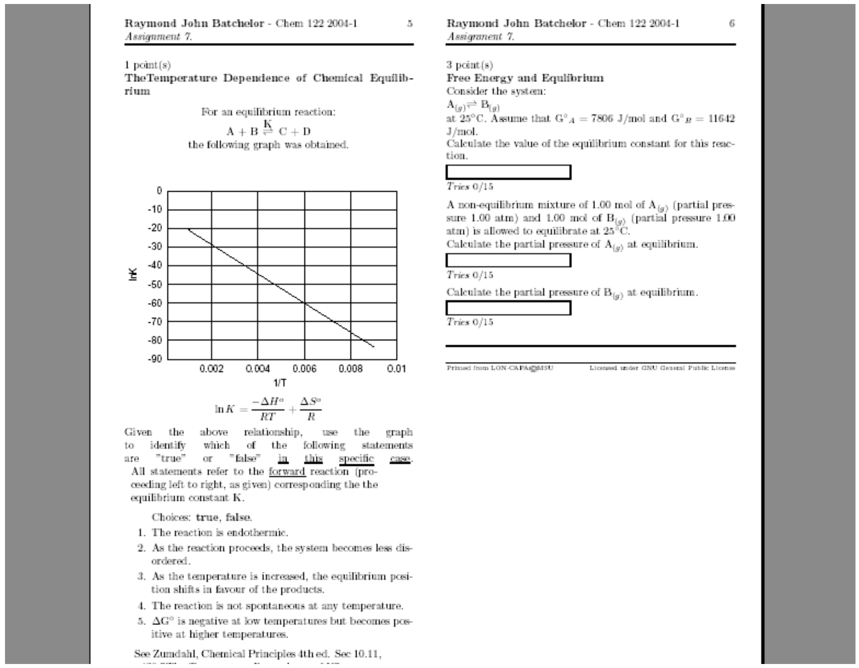


Figure 3. PDF-viewer screen-shot of a page from a problem set, showing an individually generated plot.

- The students receive immediate feedback of varying types depending upon their submissions and are allowed the opportunity to retry up to a defined number of attempts, with or without penalty. The feedback can be of the default types provided by the system, but can also be instructor/author-programmed to satisfy specific, anticipated, or commonly recurring situations. The ultimate object in every case is to lead the student to discover his/her own independent solution.

- All submissions are saved and automatically graded for assigned credit – an important motivational aspect.

- Students can work on their own schedule, within prescribed date limits.

- Instructors can post short, multiple, weekly assignments to ensure that students keep pace with the course.

- Both individual and class progress can be monitored and analyzed while the work is in progress.

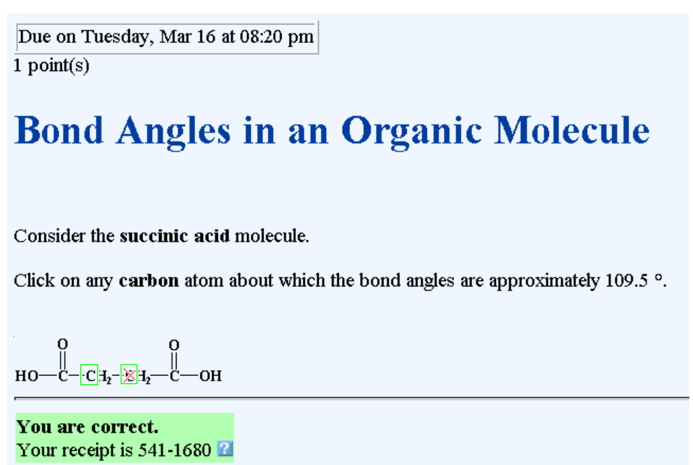


Figure 4. A Simple Click-on-the-image Problem.

Online Interactive Homework with LON-CAPA

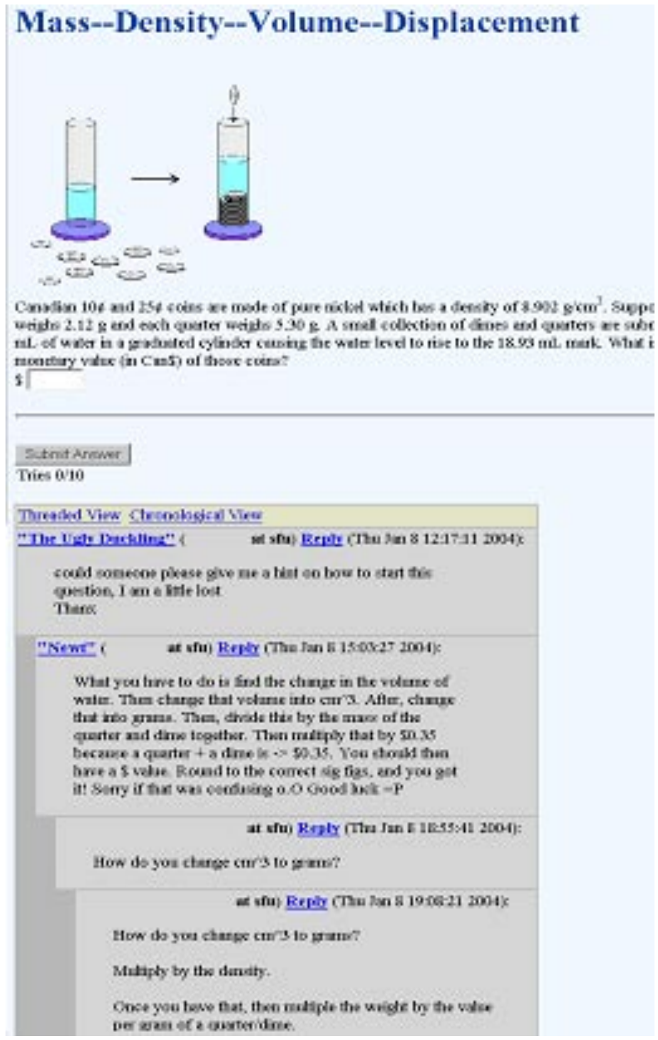


Figure 5. A Simple Numerical Problem with Threaded Asynchronous Discussion.

- Asynchronous or synchronous communication options (student-instructor or student-student),as well as instructor-moderated, full-class, asynchronous discussion threads for every resourceupported. Active bilateral participation by students in such a forum provides a strong reinforcement of the concepts learned and tested: those who teach also learn, and learn well. (Figure 5.)

- Using this system, it is relatively easy to assign a large number of problems to a large class and still provide individual feedback and grading.

- The creation of the interactive problems (or other learning objects) is made easy, for non-programmer instructors, through a graphical interface in which numerous template problems are provided upon which to base their own. (Figure 6.)

- More advanced authors can include their own scripts to produce whatever degree of responsiveness or interactivity they envisage.

- Individual resources can be published into the distributed/shared learning object repository, subject to distribution restrictions prescribed by the author. This permits both widespread and limited sharing and reuse of the resources.

Online Interactive Homework with LON-CAPA

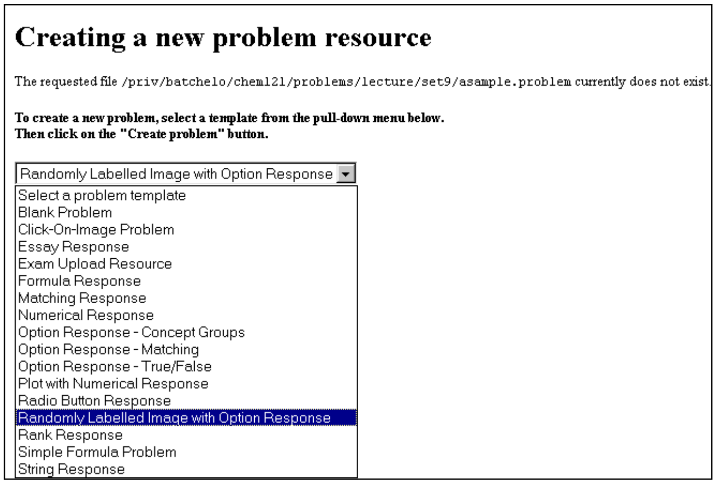


Figure 6. Problem Editor Drop-list of Current Templates.

- Compound resources, which are effectively pre-assembled sequences of more fine-grained resources, can be created and also published so that every aspect of the instructors' preparation of course material can be preserved and reused. Ultimately, a single resource, or sequence, corresponding to an entire course or program, is created and used to deliver the material to the students in a particular course or class.

- Instructors wishing to reuse such resources (either their own or another's) can select at which degree of granularity they wish to reconstruct the previous work. That is, they can create and use their own original fine-grained resources; import previously published individual questions, texts, images, or other media into their own course sequences; or import and modify entire sequences of resources optionally. Thus, instructors can refocus their efforts on improving their resources, thereby responding globally and enduringly to issues raised by individual students.

- Usage statistics and user evaluations are accumulated and summarized in the meta-data, or catalogue information for each and every published resource. The recycling of such information produces (through laws of natural selection) well-tested and reviewed resources that can thus be reused with a high degree of confidence: safety in numbers!

- Such well-tested resources set a standard which all future instructors and tutors should attain or exceed.

- Finally, but most importantly, the use of this system makes the instructor a participant in the extended community or Network of user/developers. Users can choose to provide content for reuse, feedback, or even program development for the system infrastructure to any degree. This networked approach to development results in a robust system and repository created by and for the end-users, thus ensuring that it will continue to meet our individual and collective instructional needs.

Online Interactive Homework with LON-CAPA

Name
Domain - author (Hosted Authors)
Domain - BCHS (Bear Creek High School)
Domain - brookscole (Brooks Cole Publisher)
Domain - brs (Beaverton Rural Schools)
Domain - bsu (Ball State University)
Domain - cmich (Central Michigan University)
Domain - csm (Colorado School Of Mines)
Domain - elps (East Lansing Public Schools)
Domain - fit (Florida Institute of Technology)
Domain - fsu (Florida State University)
Domain - fsuK12 (Florida State University - K12)
Domain - fvl (Fowlerville High School)
Domain - glps (Grand Ledge Public Schools)
Domain - gwu (George Washington University)
Domain - huji (Hebrew Universty of Jerusalem)
Domain - ifusp (Universidade de Sao Paulo)
Domain - lsd (Lansing School District)
Domain - mio (Mio Schools)
Domain - montana (Montana State University)
Domain - msu (Michigan State University)
Domain - msudemo (Demo Machine)
Domain - nagoya (Nagoya University)
Domain - nau (Northern Arizona University)
Domain - ndsu (North Dakota State University)
Domain - nsdl (NSDL Gateway)
Domain - ohiou (Ohio University)
Domain - physnet (Physnet MSU)
Domain - portland (Portland Public Schools)
Domain - redford (Redford Union Schools)
Domain - rhs (Roosevelt High School Wyandotte)
Domain - sc (University of South Carolina)
Domain - Selwyn (Selwyn High School)
Domain - sfu (Simon Fraser University)
Domain - sunysb (SUNY Stony Brook)
Domain - tmcc (Truckee Meadows Community College)
Domain - ucf (University of Central Florida)
Domain - ucsc (University of California, Santa Cruz)
Domain - udel (University of Delaware)
Domain - unihalle (Universitaet Halle)
Domain - uwsp (University of Wisconsin - Stevens Point)
Domain - waverly (Waverly Community Schools)
Domain - wmston (Williamston Community Schools)
Domain - wscc (Westshore Community College)

Figure 7. Above is a recent screen-shot showing the production cluster of domains (or institutions) from which published resources may be retrieved and reused.

Online Interactive Homework with LON-CAPA

LON-CAPA 2003, Reno Nevada
"Community Through Quality and Sustainability"

The Challenges

- While automatic grading eliminates a large and ongoing instructor task, the flip side is that it does require the large initial task of preparing, or authoring and coding, all the necessary interactive resources. This can be a very time-consuming exercise indeed, if every resource must be an original creation. However, unlike marking, this can be a one-time task if the resources created are readily and practically re-usable. Sharing resources with other author-instructors can further reduce the preparation time for a course. LON-CAPA resources, coded in such a way as to be highly randomized in their content and mode of presentation, have a high degree of re-usability. That is, they can be used for many different students in more than one class before ALL of the possible answers are widely known and disseminated among the students. Even then, there is still an ongoing need, not only to continue to create new resources, but to evolve the existing resources to be more robust and effective in producing positive learning outcomes.

- This raises the question: how does one minimize cheating or mitigate its effect? It is found that the same kinds of technology that allow us to provide online learning content to the students is also used by students (and others) to obtain and disseminate answers. For example, the use of asynchronous communication tools such as bulletin board websites has been popular. This problem is certainly not at all unique to online assessment. The same possibilities for cheating exist regardless of whether online homework or traditional homework is used. The main difference is that when an online homework system is used cheating comes to our attention more quickly. Automatically-graded responses are generally of such a simple nature that the detection and prevention of "copying" is difficult or impossible.

  We do not believe an adequate response to this challenge can be purely technological. However, we can suggest several things that can be done to mitigate the potential impact of cheating and strengthen positive learning outcomes. Finding the right pedagogical balance may require some thought and effort on the part of the instructors. This underlines the need for a blended use of technology and traditional methods.

Online Interactive Homework with LON-CAPA

The first line of defense is not to place too high a portion of the final grade on the interactive online homework. The higher the overall weighting of the homework, the more attractive cheating becomes.

Ideally, when permitting multiple attempts (under which the majority of students can eventually attain most answers) the best situation is one in which the learning becomes its own reward; in such an ideal situation, no marks need be assigned. However, experience shows that placing no marks at all on the homework can result in a very small percentage of the students actually completing (or even attempting) the work. The desired balance is one in which the credit assigned to the homework must be sufficient to motivate learners to do the work, yet it must also leave sufficient weight on the exams, in order that the perceived benefit of actually learning outweighs the perceived benefit of easy marks obtained without learning. It is hard to say what this balance may be in any given situation. One suggestion is to assign not more than about ten percent of the grade to the homework. At the same time, the reasons for this must be made clear to the students, right from the outset. One should stress that the negative effect on their final grades from poor exam performances as a consequence of cheating on the learning process (i.e. homework) may significantly outweigh the small positive effect on their grades from illicitly obtaining homework points. Encouragement of a positive learning attitude is necessary.

Another way to potentially reduce the amount of online (or offline) cheating is to provide a legitimate avenue for students to discuss their work with their peers in a moderated forum. Many instructors have made good use of the Caucus conferencing system at SFU for this purpose. We have found that while the moderating presence of the instructor may be necessary in such a forum particularly for large classes, this task need not become onerous.

The LON-CAPA system takes this strategy to its logical limit by allowing the instructor to make every homework problem or learning resource an individual discussion board for the class. This intimate association of the class discussion with the actual homework web page already produces a large degree of community responsibility toward the learning process. In such a setup, we found that very few instances of abuse of this tool occurred. In those instances where students succumbed to the temptation to "paste in" exact questions and answers without explanation, a simple cautionary mailing to the individual was sufficient to prevent a re-occurrence. In any event, the system allows for the instructor to simply and quickly hide or delete any postings or even to remove the participation privileges of any individual student, if necessary.

In the course navigation screen, all resources having new discussion postings are flagged, so that the moderator or course coordinator can quickly scan the active homework pages and respond as best fits each situation, with regard to either course policy or learning content. In general, we have found it best for the instructor to participate in the actual discussions rarely, or else to contribute in such a way as to encourage students to participate actively. Rather than intervene in the discussion, it is often best for the instructor to modify the actual homework resource so that it automatically addresses the learning issue. In this way, the reusable resource is improved for the benefit not only of the current class, but of all future users.

- Another interesting way to impel individual students to do their own work, and learn from it, is to create homework problems that are not only highly diversified from one student to the next, but are also presented in such a way that students need to describe the problem in some detail in order to exchange help. This can be aided to some extent by the use of more graphical representations of problems rather than by simply diversifying words and numbers.

Online Interactive Homework with LON-CAPA

- One criticism of automatic homework systems is that they do not allow for students to develop their solutions rationally but are more or less "boxed-in" by an "all right" or "all wrong" solution status. This need not be the case if the problems are broken down into component steps. Programming conditional hints or other system responses into such multi-part resources can make this an exercise in discovery and thus more attractive and conducive to active learning. This seems to be an instructional challenge that is well worth taking up. It should be fun for both the students and the instructors.

  The development of such conditionally responsive and complex resources may involve a great deal of work in planning, coding, and testing. This is where the advantage of publication in the LON-CAPA distributed/shared Learning Object Repository can really show its power. An individual author/developer can concentrate his or her efforts on perfecting or enhancing specific resources, while at the same time re-using resources created by others on the network to flesh-out his or her course. For this to happen successfully, a large body of well-reviewed published content must already exist. Thanks to the dedicated efforts of the early adopters of LON-CAPA, this state has already been attained in the areas of secondary and lower-level post-secondary Physics and Chemistry, and also in certain sub-disciplines of Biology and Mathematics.

- The homework should not always be difficult. Good judgment as to the overall degree of difficulty of the homework should strike a balance between problems that are just sufficiently challenging to evoke discovery readily and those which are more testing –"more carrot and less stick." The inclusion of appropriate hints and text references should provide the learners with all the tools necessary to make the discoveries they need to succeed.

- Another challenge is to make more use of new media in online course components. LON-CAPA aims to support many mime-types aside from the usual html or xml files, including movies, sound bites, and applets or files requiring plug-ins or helper applications. Since large numbers of students work and are graded online through their browser interface and the apache web-server, in the short term it may continue to be important to mind bandwidth when creating and deploying new media resources within the course management system. This should become easier in time.

- What about the long-term sustainability of initiatives based upon LON-CAPA? The decade-long record of success, and the current degree of recognition this system has achieved, attests to the ability and commitment of its principal developers. However, institutions need to recognize that even such effective and popular open source projects still need local financial support. The LON-CAPA project at MSU receives major support both internally (approx. US $250,000 annually) and by grants from the National Sciences Foundation (NSF) and other foundations. As one of two major Course Management Systems used at MSU, LON-CAPA is included in their long-term technology plan. With around 13,000 course enrollments/semester in LON-CAPA currently at MSU, it would appear that the internal support at that institution will be ongoing.

  At SFU, the Chemistry Department has committed significant resources to our local installations and to content development. The present cluster of three servers at SFU is sufficient for the needs of one department, but further resources will be required if LON-CAPA is to be more widely used.

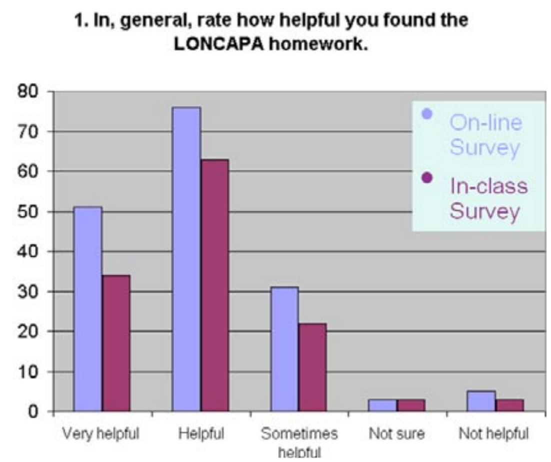
We feel that these challenges should be approached positively. Increased use of online assessment and course management technology seems to be inevitable in our future, regardless of our personal current view of its immediate impact.

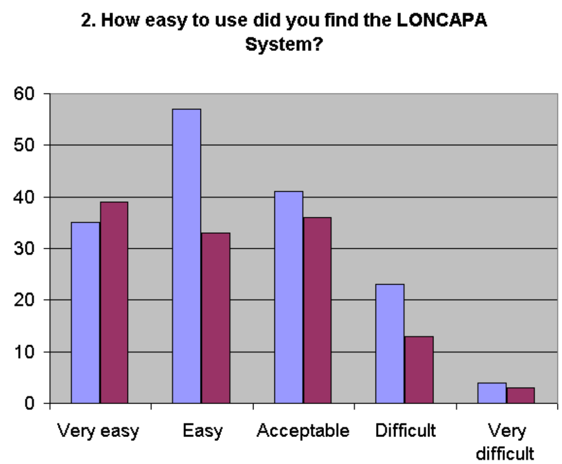
Online Interactive Homework with LON-CAPA

Evaluations

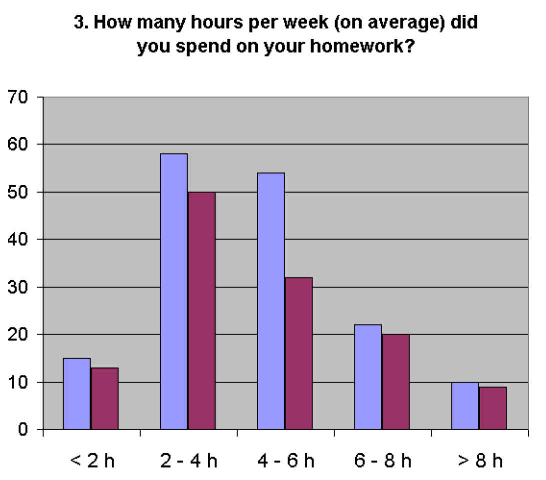
The function of having fine-grained control of the learning pathway helps combat the defocusing effect of "information overload," which could be a natural consequence of depending too much on a "search-engine" or "surfing" approach to learning. Getting information is clearly no longer a problem. The problem is in the filtering and selecting of, and focusing on, specific knowledge or concepts, and in guaranteeing that the learner achieves a respectable level of comprehension or competence. This is the role of the instructor, be he/she "real" or "virtual." Students need and appreciate this direction.

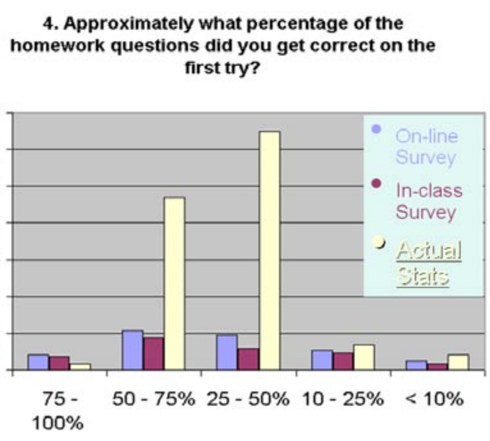
Here are the results of some student evaluation surveys conducted both in-class and on-line in Chemistry 120 and 121 in December 2003.





The total number of voluntary respondents corresponds to a little less than half the actual enrollment. However, for the on-line respondents, it is found that their average course grade is within one percentage point of the average for the entire class. There is a barely perceptible correlation between the response to question 1, above, and the course grade. Therefore, not only the good students alone found the homework helpful.





Online Interactive Homework with LON-CAPA

The responses to question 4 show that students perceive their degree of first-time success to be somewhat higher than the actual. We do not believe this necessarily represents any difference between respondents and non-respondents, but is more likely simply a matter of perception. This reasoning is supported by the fact that more people thought they had correctly answered more than 75% of the questions on the first try than was the actual case.

The survey asked for general comments. The responses can be loosely summarized as follows: 70% favourable; 25% neutral; 5% unfavourable.

One student commented: "I think that in general, the LONCAPA homework was very great and interesting. The students really learned a lot from doing them and they were very helpful. They really reinforced what we learned in class and they also helped us prepare for our exams. However, it would be even great if occasionally, there would be less questions on the LONCAPA homework."

The following specific question was also asked.

"If you could change one thing about the LONCAPA homework, what would that be?"

The responses fall mainly into the following categories:

a) 30% would change very little or nothing.
b) 25% want easier questions and/or more like the exams.
c) 15% would like more hints, conditional hints and text references.
d) 10% asked for more tries.
e) 7% wanted to change due dates in different ways.
f) 5% commented on technical problems with their browser or ISP.
g) 4% expressed dislike for questions in which several different things must be correctly identified simultaneously.
h) 3% want the marks/effort ratio to be greater.

We feel that points (c) and (g) are well worth addressing. The LON-CAPA system offers many options for creative improvements in these areas.

Conclusion

Published studies have indicated that the use of CAPA has resulted in positive learning outcomes. It has been observed that online assignments help students improve their exam performance. [1, 2] One study states: "We have demonstrated that networked tools can complement traditional teaching methods to enhance learning and improve efficiency while establishing and maintaining high performance standards. Motivated students have clearly benefited as they have taken advantage of the learning opportunities made possible by this technology." [2] At SFU, application of similar methodology in our use of LON-CAPA may underlie the local success of this system. As early adopters of this system, we are well placed to benefit from the continued evolution of this technology.

(Footnotes)

[1] Kashy, D. A., Albertelli, G., Kashy, E. & Thoennessen, M. (2001). Teaching with ALN Technology: Benefits and Costs. Journal of Engineering Education, 90, 499-506.

[2] Kashy, E., Thoennessen, M., Tsai, Y., Davis, N. E., & Albertelli, G. (2000). "Melding NetworkTechnology with Traditional Teaching: Enhanced Achievement in a 500-Student Course." In David G. Brown (Ed.), "Interactive Learning: Vignettes from America's Most Wired Campuses (p.51)." Boston: Anker Publishing Company.