

# A Web-Based Object Technology Course Database

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## Abstract

A Web-based database<sup>1</sup> of course materials in object technology is being developed. Its goal is to allow instructors at different institutions to share independently developed materials and to develop new materials jointly. This database comprises programming assignments, test questions, and lectures downloaded (with permission) from the Websites of courses in object technology at universities around the world. The site is searchable by classification or full-text string for problems on particular topics. Currently, the database contains 32 programming assignments, 67 other homework problems, 25 tests, and more than 150 lectures. The software was originally developed for a computer architecture course database. Its use for object technology demonstrates that it is applicable to other academic fields as well. A Java application has been developed to fetch this material over the web, separate homework assignments and tests into individual problems, and store them in the database. Instructors can also obtain accounts that will allow them to load their questions directly.

This project has been developed in conjunction with the WebAssign project for on-line homework submission and grading. Where the format permits, test questions can be automatically graded. The software for building the database is usable for constructing databases in almost any academic field.

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## 1. Introduction

The World-Wide Web owes its existence to the Internet, whose original constituents were mainly universities. So it is only natural that the Web should abound with educational materials. As universities scramble to put courses on line, they are in effect creating a large distributed database of course materials, organized in an ad hoc manner, with varying degrees of incompleteness. Filtering this information and storing it in a central database based on relevant academic fields, will allow instructors to search, locate and retrieve material they are interested in.

Today, most course materials in all academic fields are produced with wordprocessors or other document-formatting systems. This fact, combined with the increasing number of Web-based courses, clearly indicates that there is enough material on line to cover many academic fields.

*Education engineering:* Centuries ago, all kinds of manufactured goods—shoes, furniture, carriages—were made to order for the local customer. Manufacturing is no longer done that way ... but education is. “Handcrafting of courses” is expensive, and it is a major reason why the cost of education has been increasing faster than inflation. It makes little sense to have scores of highly trained researchers spending their time devising lab exercises or test questions over the same material, semester after semester. Rather they should be spending their time solving open problems or advancing the frontiers of technology and their teaching hours should be spent more with students and less on preparation.

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This suggests the notion of “education engineering”—developing methodologies and tools to create educational materials more quickly and in greater volume, and disseminate them without loss of quality to the increasing numbers of students seeking a technologically up-to-date education. Distance education and Internet delivery are successfully attacking the dissemination of course materials. This research attacks the problem of creating them.

## 2. WebAssign

The software [GGSG 98] for the Object Technology Course Database is built on top of WebAssign [TMB 98], a Web-based multimedia exam and homework-grading system developed at NCSU using Sybase 11 and a Sun Ultra 2.1 server. This allows us to share the database format and Web accessibility of the physics database. Although it shares software with WebAssign, our course databases, including the Object Technology database, are totally separate from the physics database.

It has been very advantageous to team up with an existing on-line testing system. It has freed us from the need to do database programming, and thus permitted us to bring up a small system with only a few thousand dollars of internal funding. Eventually it will allow the problems in the database to be used for quizzes administered over the Web and graded automatically, although at present, few problems in the database have objective answers that permit automatic grading.

## 3. How Information Is Submitted

Currently, material may be submitted to the Object Technology Course database in three ways.

- Instructors can e-mail their questions using attachments. The attachments are then translated into WebAssign format and

inserted into the database. This operation is performed manually for the time being.

- Instructors who have their own accounts (called “tutor” accounts, because they were originally designed for tutors in WebAssign courses) can log in the database and create their own questions.
- Questions can be loaded semiautomatically from course Websites using a Java application that we have recently developed. The application takes a wildcard URL and a set of editing instructions. It will search the URLs for all problems, labs, lectures, etc. that match the editing expression and download them to the local machine as separate files. It can fetch solutions to problems from separate URLs (since instructors often produce separate question and answer handouts). The application will then divide the handouts into separate files for each question, and upload them to the WebAssign database. The application will process information in either HTML or ASCII formats. So when other formats are submitted (MS Word, PDF, etc.) a converter is used to translate the file to HTML before processing.

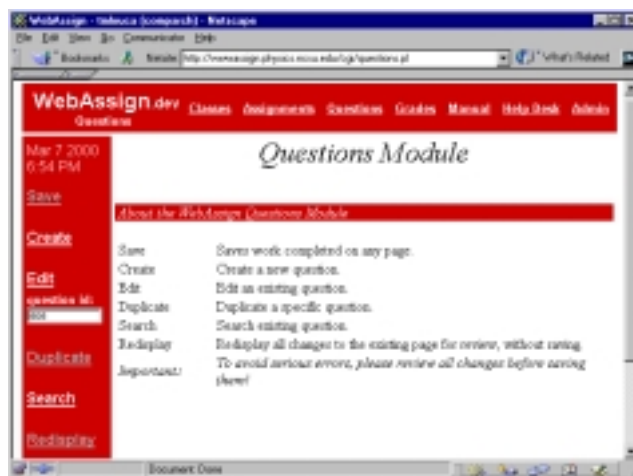


Figure 1: Question module

The application also provides management utilities like maintaining contact and portfolio information for each instructor, checking course

Websites for new material, and keeping local copies of each downloaded homework or lecture. Each problem in the database contains both a link to the “original source”—the Web page from which it was taken, and a link to the local copy. The “original source” link is used to see the problem in the context of the assignment from which it was taken; for example, maybe a common set of assumptions apply to all problems in a problem set. The “local copy” link serves as a backup for the original source in case the original source is moved or removed after the end of the term when the course is taught.

The “original source” link also provides a way to access the most recent version of a problem. For example, if an instructor assigns homework and then discovers an error, (s)he may update the handout on the Web. The “original source” link will access the current version. Also, the application periodically goes back to each URL to check for new versions of problems and replaces the old version of these problems in the database. Both of these mechanisms help keep the database up to date.

#### 4. How Information Is Accessed

To enter the database, go to <http://www.assign.physics.ncsu.edu/comparch>, and log in. You will be directed to the questions page (Figure 1), which contains links to the search, edit/duplicate, and creation functions of the database. These operate as follows:

- *Search:* Questions in the database have codes that distinguish between a “programming” assignment and a “lecture”. You may retrieve all programming assignments by filling in the Code field with the characters “programming” (see Figure 2). You may also perform a text search on all questions or answers by typing in your search string into the question or answer field. Search results can be reported in either short (Figure 3) or full (Figure 4) form.

- *Edit/Duplicate:* The user can invoke the Edit function on one of the questions retrieved in a search. The person listed as the author of the question can edit the question and save it back. You can also create your own version of the question by using the Duplicate command, and editing the duplicated question.
- *Create:* This function allows instructors to directly feed their problems and answers into the database. The format can be either ASCII or HTML; most HTML tags are supported. A special utility is available to import images and insert them as links in the questions. Instructors can also fill in some information fields used to document the questions (Figure 5).



Figure 2: Search screen

#### 5. Progress to Date

In its first month, nine instructors contributed material to the Object Technology Course Database, and four more promised to do so in the near future. This contribution rate is encouraging, because the most challenging part of assembling the Computer Architecture database

has been obtaining submissions from enough instructors. At this writing, 34 programming assignments, 67 other homework problems, 25 tests, about 80 sample Java programs, and more than 150 lectures have been submitted. Java and Smalltalk are the best represented programming languages, although some C++ and Eiffel material is also included.

Though most of the material so far has been contributed by faculty at research institutions, there is great potential for expanding the database by promoting it to instructors at undergraduate colleges and universities. When the Computer Architecture database was demonstrated at the 2000 SIGCSE conference, dozens of instructors expressed interest in using it. With most institutions now using o-o languages in their introductory programming sequence, demand for reusable o-o materials should be even higher.



Figure 3: Search results (short)

## 6. Related work

The IMS project devises a standard that identifies educational material on the Web by the use of certain tags. WebAssign plans to incorporate those tags into the database material automatically when it is inserted.

Other efforts concerning sharing course material on the web include Steve Beaty's [Beat 97] Website <http://lamar.colostate.edu/~beaty/> containing links to other online courses. The author of this paper has compiled a list of course Websites in object technology for the 1999 OOPSLA Educators' Symposium; it can be found at <http://www4.ncsu.edu/~efg/oo-courses.html>. Currently, it contains pointers to 98 course Websites.

However, a list of course Websites is of limited utility. In order to find anything, an instructor has to surf to several sites. Material is stored in a variety of different formats, including word-processor formats that require files to be downloaded before being read. The work required in finding appropriate problems is much greater than in a dedicated database. User surveys bear out this observation. Users of an earlier annotated version of the author's list of o-o course Websites [Gehr 97] were asked whether that list was more useful than a searchable database of test questions and programming responses would be. Their average response was 2.93 on a scale of 1 to 5, with 5 being "strongly agree" and 1 "strongly disagree". Thus, on balance, users thought that a database would be more useful. On the other hand, when users of the Computer Architecture Course Database were asked whether the database was *more* useful than a list of Websites for courses similar to the one(s) they taught, a plurality of them (7) strongly agreed, with the average response (of 18 respondents) being 4.22 on the scale of 1 to 5. Thus, both users exposed to a list of Websites and users exposed to a searchable database thought the database was more useful.

In addition to WebAssign, there are dozens of other Web-based assessment and testing systems [Bonh 99]. Though such systems are not the focus of this paper, it bears noting that at least one of them, the CAPA system (<http://www.pa.msu.edu:80/edu/CAPA>) has been collecting a repository of problems by CAPA users at different institutions. This approach

differs from ours in two important ways: First, our software is designed to import problems from arbitrary Web pages rather than limiting its



Figure 4: Search result (full)

reach to problems designed for a particular Web-based testing system. Although a closed system might build up a formidable repository of problems for introductory courses, it is doubtful whether this approach could ever capture a sufficient number of problems for advanced courses on new areas of technology. Second, when CAPA imports external problems, they must be converted to the CAPA language. Our system is designed to translate material automatically—though at this stage of development, some hand-massaging of the generated HTML code is often needed.

## 7. A note on intellectual property

The problems included in the database are the intellectual property of their authors. Thus, we must be careful not to include problems without permission, for example, problems taken from textbooks. All contributors to the database are required to sign a letter stating:

This letter is to confirm that all questions, answers and other materials I have submitted to your Object Technology course database are original, and not

drawn from any textbook or other copyrighted source.

While you are welcome to use and distribute this information via your database, I reserve the right as author to reuse this material in the future.

In effect, this grants the database a nonexclusive right to use submissions on a royalty-free basis. In addition, to protect the intellectual property of the authors and make sure that the material in the database is only used for teaching purposes, the following disclaimer appears in the login page of the database.

"The authors of the material in this database grant authorized users of this database permission to reuse it for educational purposes in their own courses. Any further republication of the material requires the express consent of each author whose intellectual property is being reused."



Figure 5: Create question screen

## 8. Conclusion

A Web-based course database is an idea whose time has come. First, rising student enrollments<sup>2</sup> in computing and other areas of technology are increasing the demands on faculty time. Second,

the increasing pace of technological change is creating a need for more up-to-date courses. Third, instructors are placing more and more of their materials on the World-Wide Web. Fourth, the trend toward distance education is increasing the demand for course materials to be available in a form that can be served over the Web. Finally, the public is demanding that more attention be devoted to good teaching. Our approach is semiautomatically to collect course materials already on the Web into a single database. This will greatly enhance the availability of good, up-to-date materials to instructors around the world.

Benefits will accrue to both students and faculty. Students will be able to learn from better-thought-out problems over more recent material. Students will have more good problems to practice on, which will help many of them to improve their understanding. Faculty will be able to design better courses in less time. They will have a greater chance to identify colleagues at other institutions who share their interests and teaching style, and thus a greater opportunity to collaborate on course development and delivery. Finally, as the need diminishes to spend large amounts of time on course preparation, faculty and students will be able to spend more time working with each other, to the benefit of both.

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<sup>2</sup> NCSU's Computer Science enrollment is up 50% from 1994-99, and among undergraduates, Computer Engineering majors now outnumber Electrical Engineering majors.