Creating and Utilizing Online Assignments in a Calculus Class

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Abstract

The aims of this paper are to present some of the findings about the creation and utilization of online assignments and choice of support software for several calculus classes at Simon Fraser University (SFU) by considering the needs and perspectives of the instructors, students, and administrators. The term online assignment is used for a set of problems that are posted, submitted, graded, and recorded electronically through a course learning management system (LMS) of choice. The purpose of this note is to contribute to the discussion about a common question detected among research papers on the theme of online assignments; how can technology be used in teaching so that students benefit the most? Questions are provided to guide an instructor in choosing online assignment problems, and a list of necessary skills is supplied for an instructor to be able to deal effectively with this pedagogical tool.

Introduction

The Department of Mathematics at SFU decided to introduce online assignments for its science/engineering calculus course sequence in the summer semester 2003 and subsequently for the social science calculus course sequence in the fall semester 2004. The main reasons for this were: to provide consistent and on-going feedback on homework assignments for students in large first year calculus classes, to ensure that students practice concepts and skills sufficiently, and to reduce the high costs of handling paper assignments. Similar observations and moves to online assignments have been documented especially for physics courses [BDB03, D07] in the past decade and only lately for mathematics courses [SCX06, SS06, YHR08, LG09].

Managing Online Assignments

There are a number of educational software systems that support online assignments. Some of the software is commercial while some is open source. It has become standard for publishing companies to accompany their calculus and other math and science textbooks with software that supports online assignments. For example, the software called PHGradeAssist accompanies the book *Calculus* by C. Henry Edwards and David E. Penney developed by Prentice Hall. Another example is the software package called WebAssign, originally developed by North Caroline State University that accompanies the book *Calculus Early Transcendentals* by J. Stewart published by Brooks/Cole. There are also commercial companies that offer as part of their courseware packages to create questions or use existing question banks for online assignments such as Lyryx Learning based in Calgary, AB, and Maplesoft in Waterloo, ON. In addition, many commercial learning management systems like WebCT come with capabilities of creating online quizzes. Two examples of open source software are LON-CAPA developed by Michigan State University, and WebWorK, which originated at the University of Rochester Department of Mathematics.

Basic features of the existing software packages that enable online assignments include: a browser-based interface, question banks, various types of questions, parametrically generated questions, automatically graded assignments, an electronic grade book, and communication tools. The question banks may be provided or purchased as is the case with software that accompany textbooks, or shared as it is the case with all open source software. Almost all packages allow instructors to create their own questions. The questions might be multiple-choice, true/false, fill-in-the-blank with a formula, numerical value, string answer, or open-ended. Communication tools usually include chat rooms, a discussion board, and an internal mailing system.

It is our experience that an instructor preparing a set of problems for an online assignment faces the same challenges regardless of whether questions are created from scratch, or modified or chosen from an open source or commercial question bank.

- How can we choose online assignment questions that would best complement other elements of the course

such as lectures, readings, paper assignments, and exams?

- Which types of online questions are best suited for the learning of various mathematical concepts and skills?
- Which types of online questions are the most appropriate for testing complex mathematical ideas?
- Can online questions be used to communicate mathematical ideas, i.e. be used to introduce new concepts that have not been seen in the lecture or the textbook?
- To what degree should online assignments be used as a drillmaster?
- Are the provided online questions suitable for all teaching and learning styles?
- How can we mimic online what we observed with paper assignments in our workshops, i.e. support discussion among students for the purpose of learning?
- How can we avoid cheating?

In our opinion, question banks are limited and cannot provide a resource adequately to address all of the above questions. However, these question banks do provide a platform to get started in the creation of online assignments. Publishing companies are paying more and more attention to this piece of the courseware and generally speaking their products are of a high quality. It is important to notice that commercial systems like PH Grade Assist or Maple T.A. allow users to create new or modify already existing problems. It may be the wish of many conscientious instructors to create problems themselves, but this is tied to investing much time and energy in the creation of questions, dealing with the time-consuming task of testing the questions and getting feedback from the students to improve their purpose, and needing a strong support by the administration for the creation and implementation of this new pedagogical tool.

During the five years of working first with a commercial question bank and then switching to an open source question bank, where we have been using and contributing to shared question banks, we have come to the conclusions that regardless of whether online questions are chosen or created the instructor must utelize this pedagogy with a whole new attitude and set of skills as listed below.

- Flexibility of Product: The questions are not tied to a particular textbook or a specific course. They are easy to change and to adjust to meet the needs of the instructor or the course. For example, a question created at SFU for the Introduction To Analysis course has been used in an algebra course at the Jerusalem College of Engineering (Jerusalem, Israel), a calculus course at Selwyn House School (Montreal, Canada), and a linear algebra course at the University of Applied Sciences (Braunschweig/Wolfenbuettel, Germany).
- Flexibility on part of the Instructor: The ambiguous use of terminology can create a stumbling block for students and even instructors. For example, not everybody agrees that a local extremum of a function might happen at the end point of an interval. Or, what one instructor calls “a critical number” another instructor might call “a critical point”. However, with an open mind these minor inconsistencies can be explained away or dealt with effectively.
- Looking ahead: When choosing a question from a shared question bank the instructor must be much more careful. Testing a few versions of the question is a must! A common problem with shared question banks is that a question might be created in an early release of the software and might not work properly in the newest version.
- Reaching out to students: By creating appropriate questions the instructor makes first year university students read the textbook in detail and regularly. For example, students might be asked to match parts of definitions and theorems from a given textbook section.
- Creativity: In creating questions for online assignments instructors can truly unleash their imagination. For example, a single problem might contain various types of questions: multiple choice, drop-down box, fill-in-blanks, formula and numerical responses. All this might be accompanied with dynamic plots and supported with hints that match most common mistakes.
- Community building: In our experience this happens at two levels, namely locally when a group of instructors from the same institution builds resources that the members of the group can use in their teaching, and globally, as in the example provided in “Flexibility of Product”.
- Self-Enrichment: Instructors can avoid having become routine and bored over the years by making changes in the way that we teach, by learning a new software, by creating new learning resources for students, and by reaching out to students by using a new medium for learning.

SFU Experience

Simon Fraser University was the first university in Canada to use PH Grade Assist, an online

assessment tool developed by Prentice Hall, in teaching calculus classes. The tool was used from the summer semester 2003 until the summer semester 2004 for assignments in the science/engineering calculus course sequence. The initial idea was to simply put weekly assignments for the three courses online and let the system do everything else, collecting assignments, grading, and recording grades. All the instructors had to do was to create an online course and to assign questions straight from the textbook. Students, who beforehand had to register into the system and enroll in the course via a code provided with the textbook, would get one of the parametrically generated versions of the assigned question. Codes increased the price of the textbook packages. There was a possibility of purchasing codes separately in case a student had a used textbook.

This approach was extremely convenient for the instructors and meant no extra cost for the department. The onus of the work was on part of the students. However, soon it became clear that the teaching and learning were disconnected because the instructors' choice of questions was limited by the medium with no questions of the type "prove," "graph," or "give an example," and students' answers were constrained by the medium. In particular, they did not gain any experience with writing down their answers similar to their exams. At the end of this first try of the fall semester 2003 a survey was conducted, where students were asked to compare their experiences with online assignments and paper assignments for understanding, quality, and enjoyment. The 409 responses are summarized in Table 1. The survey results showed that with the complete switch to online assignments, the Department did not achieve its main goals.

	Online assignments better	Same	Paper assignments better
Understanding the material	16%	34%	50%
Quality of your work	13%	29%	58%
Enjoyment of the subject	22%	33%	45%

Table 1

The next step was to use a combination of paper and pencil as well as online assignments which, this time, allowed students multiple attempts to get a correct answer. Still there were three extremely sensitive issues that had to be resolved to the students', the instructors', and the department's satisfaction, namely the increased cost of the textbook package due to the codes required to register into the online assignment system, the lack of variety of mathematical questions, and students being forced to share their personal data with an entity that was not part of Simon Fraser University.

These challenges lead to the decision that, starting in the fall semester 2004, the Department of Mathematics would switch to LON-CAPA. At SFU, both the Department of Chemistry and the Department Physics had used LON-CAPA successfully since 1998. The use of LON-CAPA comes with no cost for SFU students and the access to LON-CAPA is automatically granted to all students enrolled in courses that use this system. LON-CAPA is an open source freeware web-based course management system featuring content sharing and content reusability, creation and grading of randomized homework, quizzes or exams, assessment analysis, porting content, one source/multiple targets, cross-institutional network, clicker device support, and much more. As of the spring semester 2008 there were 121,038 problems in the LON-CAPA shared content repository. The repository has been steadily growing since its inception in 1993 supporting various disciplines such as physics, chemistry, biology, mathematics, and more from over 70 participating institutions worldwide [LNC09].

In the fall semester of 2004, the Department of Mathematics offered its first LON-CAPA supported course, Calculus I for Social Sciences. By the fall semester 2008 seven calculus courses were supported by the system with five instructors involved in creating problems and managing courses.

One of the most beneficial aspects of LON-CAPA is its DISCUSSION TOOL. We have found that students use the electronic board extensively to discuss posted problems with each other. Since each student has a different variation of the problem, students need to analyze the problem and explain to each other what steps were needed to solve it. The instructors were quite elated about this outcome as the students were using more mathematical language than the instructors thought possible. Additionally, they were teaching each other the necessary concepts and skills. However, every now and then students were stuck with a particular problem or misguided help was given from other students and the instructors saw the need for assigning TA hours to the supervision and aid of the discussion board. This proved to be very effective and only costs about 40 TA hours per semester.

Paper and Pencil vs. Online Assignments

We propose that in math classes paper and pencil and online assignments should be used in conjunction. In our view of teaching math classes the main role of paper assignments is to give students experience of writing mathematics. As Kevin P. Lee states in [L0x], "You should not confuse writing mathematics with "showing your work". (…) Rather, you will be writing to demonstrate how well you understand mathematical ideas and concepts. So a page of computations without any writing or explanation contains no math." Secondly, paper assignments allow instructors to ask students to prove a statement, to demonstrate their problem solving skills, to graph a function, or to give an example or a counterexample for a particular mathematical phenomenon. An added benefit of paper assignments is that they give teaching assistants an opportunity to practice marking students' papers.

In our experience the most valuable feature of online assignments is that the medium allows the instructor to reach each student in the class at their will. For example, an online assignment that is due before the *second* lecture in the semester makes students do the coursework from day *one*. In our classes we use short multiple online assignments that are often closely related to class lectures and definitions, theorems, and examples from the textbook. Many of these problems were offered as multiple choice, true or false, and matching questions rather than in the fashion of back-of-the-chapter-exercises. Assignments are due before the next lecture and in this way students have to go through the course material after the lecture in which the material is covered. In a survey that was conducted in a Calculus I class in Fall 2006 semester 230 students were asked to respond to the statement, "To complete online assignments I had to read the textbook and lecture notes regularly." Only 3% of students strongly disagreed with the statement and 83% of the surveyed students agreed or strongly agreed with it.

We also use online assignments as a drillmaster. For example, as an assignment question we post a dozen limits divided in groups of three with one submission per group. We anticipate mistakes that students might make and we create hints accordingly. Multiple tries were allowed.

Research shows that online assignments help students manage their time better. See, for example, [D07]. Our experience is that online assignments also might cause substantial frustration for some students. In our surveys, students list as sources of frustration: entering answers in an acceptable form, internet malfunction, lack of hints, ambiguous wording, several multiple choice questions with a single submission, programming bugs in questions, and misuse of the discussion board. Regardless of these occasional complaints, it seems that the majority of students appreciate online assignments. In our Fall 2006 survey 82% of students agreed or strongly agreed with the statement "Online assignments helped me to learn the course material better."

As a conclusion we finish this note with a comment by an anonymous student from Calculus I class in Fall 2006, "I believe that the short online assignments definitely changed my homework experience. It forces the user to read the directions and follow them to the letter. The unequivocally ruthless marker (the computer) definitely enhanced my ability to be meticulous."

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