1. Background & Outline

In 2011-2012 I received via the CTFD a Microsoft Impact Grant to create online homework problems for Math 411, Abstract Algebra. I completed that project, classroom-tested the problems, and gained many good insights during the monthly Impact Fellows meetings. My plan is to release these to the public; before I do that, over the summer I showed my project to several colleagues from UConn and Cornell for feedbacks. They liked what I did; they also made several suggestions (see Section 2 for comments and explanation):

(1) Add more routine problems;
(2) Have multiple problems of each given type;
(3) Include complete solution for every problem (the current system already provide the answer for every problem).

My database is for the open-source WebWork system, funded in part by the NSF and the Mathematical Association of America. I showed my project to the WebWork administrators and they were very interested; they also very supportive of my plan to apply for NSF funding to develop similar online homework database for other upper-level undergraduate classes, specifically number theory (Math 471) and discrete mathematics (Math 455). These three classes (411 has an annual enrollment of 60-100 students; 455: 50-60; 471: 35-70) are taken by graduate-school bounded math majors, math majors in the computing track, and math majors in the teaching track (411 and 471 are parts of the Massachusetts teacher licensure requirements). We also have a large number of CS and engineering majors who are interested in the applications to electronic communications. This mix of students makes the teaching rewarding (we can showcase the power of abstract mathematics and we can illustrate difficult concepts using concrete examples) and at the same time challenging (how to motivate difficult concepts to applications-oriented audience and students in teaching track). Using online homework, I can break down a theoretical problem into multiple steps and help students ease into and get instant feedback on the abstract materials. Based on CTFD evaluations done in connection with the Impact Grant, students like this system and find it helpful in learning the material.

I would like to apply for a CTFD Grant for Professional Development in Teaching to implement (1)-(3) above and use the finished product as a demo for a NSF grant application to develop in additional open-source online homework database for other mathematical courses.

2. Comments, and Plan of Attack

Let me address each of (1)-(3) and explain how I plan to implement these.

(1): In my Impact Grant proposal, I emphasized that my database is not a collection of simple multiple-choice questions; instead, each problem highlights one (sometimes a few!) salient feature of the material, and students should carefully think through each problem and view the whole problem set collectively in conjunction with the lectures. I believe I have accomplished that. At the same time, there is a good case to be made of having more routine problems, and
fortunately that is (much) easy to do; I already have a collection of such problems and they are easy to code.

(2): When I created my initial database, I classroom-tested it on my class of 30 students, and it worked out well. But as my colleagues pointed out, when we use this in a large and/or multi-section class, instructors need to be able to pick problems from a large database so as to avoid duplication and to be able to create e.g. exam reviews. This can be done by tweaking existing problems and is not difficult to implement.

(3): Currently about 1/3 of the problems have complete solutions; my idea was that students would work out the solution of the rest based on the ones that are provided. But as my colleagues reminded me, solution keys are most helpful to the students who have the most difficulty with the problems in the first place! Furthermore, having solution keys to 1/3 of the problems limits the instructor’s flexibility in creating her own problem sets.

I can readily work out the solution of every problem; it would take me a couple of months to flush them out such a way that the student programmer can code them.

In summary, my plan for the CTFD grant is to carry out (1)-(3) completely for Math 411; specifically, I will

(i) carry out the mathematical preparation during the spring semester,
(ii) hire a student programmer to code the problems,
(iii) submit this to WebWork (the open-source system underlying my database), and
(iv) use that as a demonstration/showcase for an NSF grant to develop similar online homework system for Math 455 and Math 471.

I already addressed (i) earlier in this section, and I have been in contact with the WebWork administrators so I know what I need to do for (iii). My research is currently supported by NSF, so I am familiar with the application process with (iv). And my experience with the Impact Grant taught me a very important lesson in connection with (ii): It is much more efficient and productive to hire a strong programmer, even someone not at all familiar with the mathematics, than to work with a strong math major with limited programming experience.

Note: (iv) is of course contingent upon NSF’s funding priority; if its 2013-2014 budget does not include online homework development then I will try again the year after. This of course has no impact on (iii).

3. Timeframe, Assessment and Budget

**Timeframe:** I will carry out the mathematical preparation in Spring 2013, and I will work with a student programmer either in the summer or in Fall 2013. I give myself some flexibility there because strong programmers are not easy to come by, and my experience taught me that it is better to wait until the fall if necessary than to work with an inexperienced programmer.

**Budget:** $3000 to hire a student programmer.

**Assessment:** If I receive the CTFD, I will ask the department to let me teach Math 411, either in Fall 2013 or Spring 2014 (it is offered both semesters) so I can classroom-test the database. I will conduct anonymous, written surveys, once about one-month into the semester (to use the feedback to fine-tune the system as needed), and once more at the end of the semester. I will ask the CTFD for advice in preparing these surveys and for analyzing the responses.

As I pointed out in the first section, students’ performance in Math 411 tend to fall into groups depending on their majors/tracks. It would be interesting to see if more extensive use of online homework could help close the performance gap between the different groups; I definitely need guidance from the CTFD to devise appropriate metrics for such assessment.