Enriching Student's Online Homework Experience in Pre-Calculus Courses: Hints and Cognitive Supports

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Abstract: As part of reforming our Pre-Calculus courses, we realized that reforms to instruction needed to be accompanied by reforms to the homework. We utilized the online homework system WeBWorK but recognized our students wanted more support on missed questions. WebWorK "hints" provided us an avenue to ask students leading questions to prompt thinking over procedures. Preliminary data show many students are using these hints and the hints are working as intended. We plan to expand hints beyond our Pre-Calculus courses. The open source nature of WeBWorK provides an opportunity for hints to be implemented on a wide scale.

The Department of Mathematics at the University of Nebraska-Lincoln (UNL) in the midst of reforming high-enrollment (first-year) mathematics courses. The reforms include implementing an active learning model for instruction; common activities, exams and lesson plans; and a blended course format using the WeBWorK online homework system to supplement in-class instruction and activities.

The reform efforts began in fall 2012, and the first attempts prompted much more extensive involvement by faculty and a more comprehensive research study. The extra support of instruction and additional data allowed us to both experience greater success and better understand the positive contributors to the success. While the levels of success have increased substantially (from 62% to 80%), there is still room for improvement. During focus group interviews of students in fall 2014, the biggest complaint students had is the way the online homework system works.

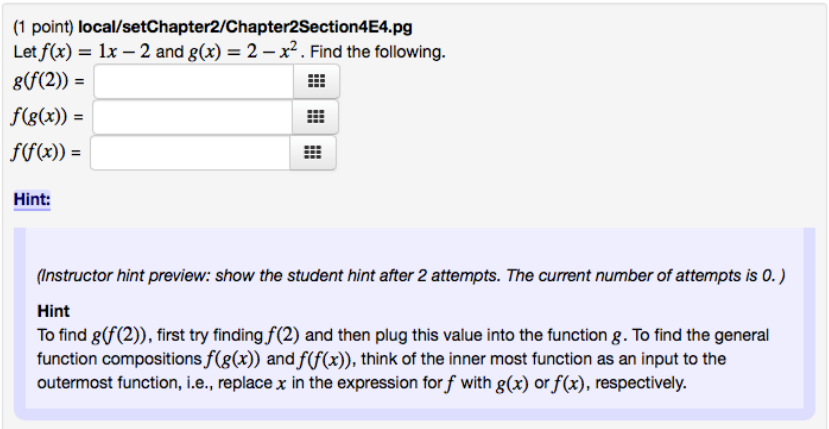
In 2005, Hauk and Segalla conducted an extensive study of student perceptions of web-based homework using the WeBWorK online homework system. They found

> as a facilitator for engaging in mathematical self-regulation WeBWorK is involved only as a monitor for correctness…the web based tool does some monitoring but the responsibility for metacognitive control (response to the monitoring), problem-solving heuristics, and the impact of mathematical beliefs rests on the student. (p. 241)

Thus, while an effective tool, WeBWorK lacks in a key aspect of the triadic reciprocity proposed by Bandura (1986) and modified by mathematics educators (e.g., Cohen, Raudenbush, & Ball, 2002). WeBWorK lacks the environmental interaction with a subject expert to provide the cognitive apprenticeship. This project aims to improve these interactions through direct modification of elements of the triadic reciprocity within our courses. Specifically, we attempted to improve interactions between the students and the mathematics content (WeBWorK), the students and the teachers (instructors, learning assistants and tutors), and the teachers and the mathematics content, all within the UNL context.

This poster will talk about the collection of modifications to the WeBWorK system and problems.

One benefit of online homework is that students are given immediate feedback regarding the correctness of their answer, and are allowed multiple attempts, on the exact same problem, to get a correct answer. One problematic aspect of this type of system is minor errors are treated the same as more egregious errors. Additionally, knowing an answer is incorrect almost never helps a student determine how to correctly complete a problem. Hauk and Segalla (2005) quote students as having reported "I prefer getting feedback from the professor because he could help me understand what I did wrong" (p. 244).



Thus, we attempted to leverage a new WeBWorK "Hint" feature. Our hypothesis was that using the "Hint" button would provide students with focused questions to prompt higher-order thinking about problems the student has answered incorrectly. In the figure, the hint button only

works after the student has attempted the problem and input an incorrect answer. The hint also involves more than just showing students and example problem but leverages the questioning one might expect from an actual instructor.

In social cognitive theory, people are said to learn from their social environment. According to Schunk (2004), learning can occur vicariously through engagement with electronic materials. Adding a feature that allows a hint to be given will further enhance the interaction students have with the electronic materials on WeBWorK. We note that while some online homework environments (such as MyMathLab) offer hints in the form of similar problems worked out correctly, our hints are in the form of questions designed to help students think about common errors related to each particular problem. Providing student with "cookie cutter" examples increases the likelihood students will try to learn through memorizing procedures, rather than reinforce our active learning philosophy that students need to learn through higher-order thinking and making sense of mathematical problems.

After creating the hints in the summer of 2015, students were given the opportunity to use the hints in the fall of 2015. We surveyed students about their use of WeBWorK hints and recorded results from 274 students (27% response rate). Among those surveyed, 84% reported accessing the hints at least once, with responses evenly split among "more than once a week", "less than once a week" and "a few times a semester". We further asked students to report on the usefulness of the hints. Students reported "sometimes (42%)" or "rarely (37%)" finding the hints helpful. We did not find this surprising since the students accessing the hints were already stuck on the problem and may have needed more help than a few questions could provide. In fact, only 12% of the respondents stated that they never found the hints helpful. Nine percent of the respondents reported "usually" finding the hints helpful. We claim this supports the goal of creating a hint that prompts higher order thinking instead of walking students through procedures. Students often want to be walked through a procedure, and see anything short of this as unhelpful. Therefore, we do not expect students to identify the hints as "always" helpful. Our hints are designed to maintain the cognitive demand of the questions while also helping students to clear up any common misunderstandings. We thus view a successful hint as one in which some students find the hint helpful but not every student found the hint satisfactory.

All indications show that in our university online homework is here to stay. Further research needs to be conducted into how to support students most effectively. We have found the hints to be a valuable resource in supporting student thinking and plan to extend the use of hints into other courses beyond our Pre-Calculus courses. Due to the open nature of WeBWorK, other instructors using WeBWorK homework can also make our hints available to their students.

References

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