AN ANNOTATION TOOL DESIGNED TO INTERFACE WITH WEBWORK: INTERPRETTING STUDENTS' WRITTEN WORK

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We present how we are using tablets with an open-source online homework system to collect students' written work to calculus problems. The new whiteboard feature captures all student written work in real time. An annotation tool has also been incorporated into the system. Through this tool, we are examining how students solve chain rule problems and what actions they take to correct their mistakes. At this poster, we will allow users to try out the annotation tool and provide results of how we have used it to date.

Key words: calculus, chain rule, online homework, collaborative methods

The collection of student work through online assessment systems is popular for many courses in mathematics. Such systems provide opportunities for students to practice problems and receive immediate feedback on correctness of their answers. However, with enhancements to such systems, both students and teachers could receive feedback on students' understanding of a concept through investigation of their solutions as well as the final answers to the problems. We will demonstrate the use of such enhancements to the open-source system WeBWorK. The enhancements included the creation of a whiteboard area in which students can provide their solutions to the problems (Figure 1) and an annotation system for researchers/instructors.

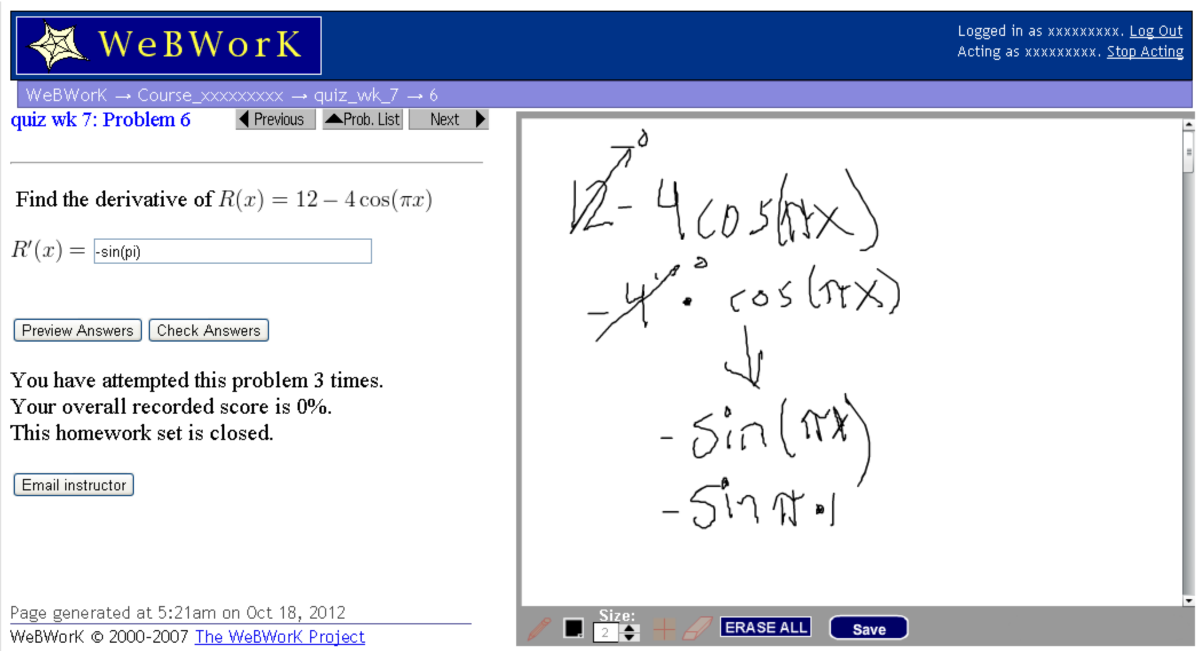
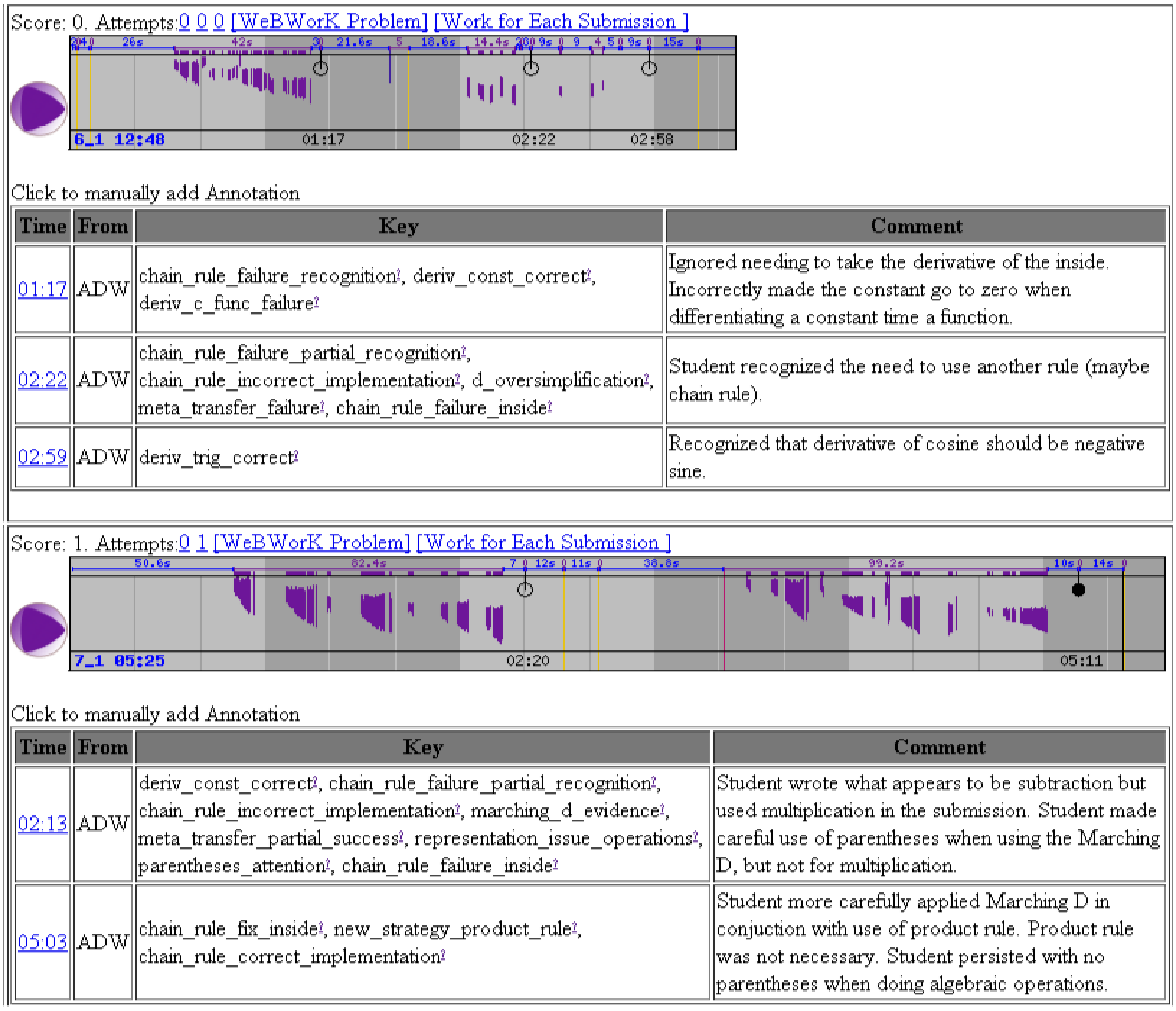


Figure 1: Example of student whiteboard area in WeBWorK

Success in calculus can be linked to students' understanding of the concept of function (Carlson, 1998; Carlson, Oehrtman, & Engelke, 2010; Engelke, 2007). While there is fairly extensive literature about student understanding of function, there is little that focuses explicitly on student understanding of function composition. Being able to work with functions in different contexts is particularly problematic for students, especially when dealing with function composition (Engelke, Oehrtman, & Carlson, 2005). One of the critical units where this concept is foundational to calculus is the chain rule and its applications. As such, we chose to study students' understanding of calculus concepts and problems which are closely related to function composition such as the chain rule, related rates, and optimization. We are seeking evidence of how and what students transfer from classroom experience to online activities.

Student work on calculus quizzes was collected via the whiteboard interface in WeBWorK. This data was analyzed using the newly created coding feature of the WeBWorK system which allows one to create keys and descriptions of student work. (See Figure 2) This feature was designed to allow researchers to apply open and axial coding procedures as described by Strauss and Corbin (1990).



Score: 0. Attempts:0 0 0 [WeBWorK Problem] [Work for Each Submission]

6_1 12:48 01:17 02:22 02:58

Click to manually add Annotation

Time	From	Key	Comment
01:17	ADW	chain_rule_failure_recognition, deriv_const_correct, deriv_c_func_failure	Ignored needing to take the derivative of the inside. Incorrectly made the constant go to zero when differentiating a constant time a function.
02:22	ADW	chain_rule_failure_partial_recognition, chain_rule_incorrect_implementation, d_oversimplification, meta_transfer_failure, chain_rule_failure_inside	Student recognized the need to use another rule (maybe chain rule).
02:59	ADW	deriv_trig_correct	Recognized that derivative of cosine should be negative sine.

Score: 1. Attempts:0 1 [WeBWorK Problem] [Work for Each Submission]

7_1 05:25 02:20 05:11

Click to manually add Annotation

Time	From	Key	Comment
02:13	ADW	deriv_const_correct, chain_rule_failure_partial_recognition, chain_rule_incorrect_implementation, marching_d_evidence, meta_transfer_partial_success, representation_issue_operations, parentheses_attention, chain_rule_failure_inside	Student wrote what appears to be subtraction but used multiplication in the submission. Student made careful use of parentheses when using the Marching D, but not for multiplication.
05:03	ADW	chain_rule_fix_inside, new_strategy_product_rule, chain_rule_correct_implementation	Student more carefully applied Marching D in conjuction with use of product rule. Product rule was not necessary. Student persisted with no parentheses when doing algebraic operations.

Figure 2: Student work map and associated codes

We met via the internet to explore how the coding tool facilitated our research goals. In the first session the researchers spent 71 minutes examining 3 minutes of student work. The first student was chosen because they had used all three attempts for entering a solution, but had not successfully solved the problem. Each line of the student's written work was discussed and analyzed resulting in multiple keys being created. The following week, the researchers met again and analyzed the work of a second student. For this meeting, a student was chosen who had only used two attempts and successfully solved the problem. This student was chosen because they had made errors (some similar to the first student), but had successfully corrected the errors. We anticipated some overlap of the codes we created for the errors but also the creation of new codes to identify actions taken to correct those errors. Our second coding session lasted about 50 minutes covering again about 3 minutes of student problem solving time.

We will share how the system collects data, facilitates coding, our data, and our coding. Examples from 16 codes will be shared to highlight what we learned in this process. Participants are invited to try the coding system. We are curious to know how others might envision using these tools.

References

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