

Peer Learning through Student Grading in Classroom Learning Partner

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6.UAP Thesis

1. Introduction

Peer learning has been proven to be an important learning tool in improving student engagement and helping students retain more information in the classroom (e.g., Bransford et. al. 1999, Mazur 1977). Studies have shown that peer assessment can lead to benefits as much as or even greater than those from teacher assessment (Topping <year>), In addition, effective and timely feedback, from both teachers and students, is widely acknowledged to be an important method for improving learning (e.g., Black and Wiliam 1998, Bransford 1999). This UAP combines peer learning with peer feedback by adding support for these features to a classroom interaction system called Classroom Learning Partner, whose goal is to facilitate communication and feedback in the classroom.

2. Background

2.1 Background Overview

Classroom Learning Partner (CLP) is a tablet-PC-based classroom interaction system first developed by Dr. Kimberle Koile and her research group for use in undergraduate computer science classes (Koile et. al 2007a, Koile et. al 2007b). More Recently, Dr Koile's group has been using in the *INK-12: Interactive Ink Inscriptions in K-12* project to investigate the role of pen-based written technology in K-12 classrooms.

2.2 INK-12 Project Background

In the NSF-funded project *INK-12: Interactive Ink Inscriptions in K-12*, we have been investigating the role that pen-based wireless technology could play in 4th and 8th grade science and math. We have thus far conducted tablet computing trials in five schools—in four 4th and three 8th grade classrooms.

The technology used in the trials consists of a set of tablet computers running a software system called Classroom Learning Partner (CLP), developed by Kimberle Koile's research group. CLP is built on top of a wireless presentation system called Classroom Presenter, and like Classroom Presenter, it embodies a “presentation slide” metaphor for classroom interaction: A teacher creates a lesson as a series of slides, e.g., a la Powerpoint. In the classroom, the teacher and students all have tablets on which the lesson is running; the lesson is also projected publicly on a screen at the front of the classroom. The teacher can annotate a displayed slide by using the tablet's stylus to create “digital ink”, which, by way of a wireless network, is then visible on the students' and public screens. Just as the teacher can send “digital ink” to students, students can

send “digital ink” to the teacher. Classroom Presenter, and CLP, use this communication channel as a way for students to send the teacher handwritten “digital ink” answers to in-class exercises.

The teacher then can select some, or all, of those answers to display anonymously on the public screen and discuss with the class. The teacher has the option to “link” student machines to her machine, meaning that the teacher controls which slide is visible on the student machines. The alternative is to let the students freely navigate through all the slides in the lesson.

Kimberle Koile and Andee Rubin, January, 2008

2.2 Classroom Learning Partner

Classroom Learning Partner makes use of one of the great benefits of computing over traditional pencil and paper: Wireless networking supports the type of quick communication between the student and teacher that is not possible in a traditional classroom. Building the peer grading and feedback tools as extensions of Classroom Learning Partner takes advantage of this existing functionality. Students can instantly submit solutions to problems to the teacher. If students decide that they want to change or alter their answer to a problem, they do not have to ask for their original solution back as they would if they had submitted it on paper. Instead, they can simply erase their old solution on their tablet, submit the new one, and the teacher will get that updated solution.

In a traditional classroom, displaying student answers is somewhat tricky to do. If the teacher waits long enough to make an overhead-projector-transparency or handouts of student answers, the students may have long-forgotten the problem by then. If the teacher wants to show student answers immediately, right after the students have turned them in, she can copy that

student's work onto the chalkboard or she could pass around the student's for everyone to see. Neither one of these methods is ideal, as they take up valuable class time. In addition, some students prefer to have their work discussed anonymously; walking to the blackboard disallows this possibility.

CLP greatly facilitates sharing and discussion of student work: Because the teacher can instantaneously receive students' submissions, the teacher can also instantaneously display those submissions for the rest of the class to view. Thanks to the speed of the network and the ability to pass around questions and solutions through the network, displaying student solutions can be achieved in ways that are impossible in a traditional classroom.

3. Peer Learning

Peer assessment, the act of exchanging solutions and having students grade other students' work, is a staple of many classes. Teachers often ask students to grade each others essays in English classes, for example. While this activity takes time, teachers and researchers agree that the exercise can improve student learning. Peer grading exposes students to other, novel ideas while honing their reviewing skills so that when they return to their own work, they will have a stronger sense of what to change and what to keep.

Peer assessment has often been utilized a lot at the high school and college level. A little more than a decade ago, the paper Keith Topping (Topping ...) began quantifying the effects of have students assess each other on various forms of activities. Not only did the peer assessments, in the form of marks, tests, and grades, have an overall positive effect on student achievement, the research showed that those effects were as good as if not better than under teacher

assessment. However, the paper limited its studies to students of higher learning and had not yet extensively explored peer assessment using computer technologies.

For my UAP I added peer assessment to CLP, merging peer assessment with the networking capabilities that make Classroom Learning Partner so useful. I implemented the peer assessment functionality through a straightforward interface and through solid back-end engineering to ensure that the process of distributing and grading student work is easily controlled. Allowing the teacher to control when and how student answers get swapped are important steps in the process. In my implementation, the teacher can control the various stages of answer-swapping, finally dictating when a graded problem is sent back to the original owner.

4. Challenges and Benefits

4.1 Challenges

Peer grading requires several assumptions that tend to be taken for granted in the traditional classroom.

Challenge 1

In the classroom, teachers can simply ask students to swap papers with their neighbors when it comes time to peer grade an assignment. Using software, how can we get students to "swap papers"? In addition, how can you ensure that the students are not being randomly asked to grade assignments, and then in some cases a student is asked to grade his own solution?

Design Choice 1

CLP's startup procedure prompts students to log in by choosing their name from a classroom list, which is provided to the program before startup. While this login process can help identify which machines correspond to which students, it cannot resolve where students are sitting geographically within a classroom. Thus, the peer-grading functionality for CLP abandons any kind of solution swapping that might be based on where students are sitting.

Instead, the proposed CLP solution exchanges student solutions as if everybody "passed their papers to the virtual student on their left". The program shuffles all of the solutions and gives student i 's solution to student $i+1$, and so on, until it gives the last student's solution to the first student. This design choice doubles as a guarantee that if you have more than one student submission, then nobody will get his or her own answer to grade.

Challenge 2

In the classroom, teachers can visually monitor that everybody has exchanged papers. If students were allowed to transfer their answers directly to each other via the peer-to-peer network, there would be no way for the teacher to confirm that everyone had switched papers.

Design Choice 2

The existing CLP software could already handle students submitting their solutions to the teacher. In order to cut down on development time as well as place more control into the teacher's hands, the peer-grading functionality takes advantage of this functionality. The teacher has copies of everybody's initial solution, displayed in a very intuitive filmstrip-like window.

The teacher can click through these initial submissions, and when the teacher deems it is appropriate, he or she can click a "shuffle" button that sends each student somebody else's solution to grade. This approach solves the challenge of figuring out whether or not students have swapped papers. As an added bonus, the teacher also controls the timing of the swapping, giving him or her more control over the peer grading process.

Challenge 3

In the classroom, teachers can ask students to swap their papers back. Once again, teachers can visually check that the students are passing their papers back. Using software, how could the teacher ensure that graders were returning their papers to the students whose work they graded? Just as importantly, how could the teacher guarantee that the original student received his or her graded answer and not some other student's? Peer grading loses much of its value if the graded solution is not returned to the original owner. The software needs a method for ensuring the return delivery to the correct student.

Design Choice 3

The peer grading functionality once again defers control to the teacher. Just like the initial submissions, the teacher can easily view the graded submissions in another filmstrip-like window. From the graded submissions, the teacher can click the return-to-original-student button, which uses the metadata from the slides to figure out which student should receive each graded slide. The metadata contains the addresses of the student machines; using these addresses, the return-to-original function will properly sort through which solution belonged to which student and send that answer back to that student.

4.2 Benefits

Technology can not only meet the challenges posed by a traditional classroom pencil-and-paper peer grading method, but it also can have added benefits.

Traditional Classroom Scenario 1

When a student has turned in an answer to the teacher, he or she cannot go back and change it. By the time the answer is in the teacher's hands, it is set in stone, even if the student thought of a better way to tackle the problem.

Software Benefit 1

By using digital submissions instead of paper submissions, the copy of the answer that is being passed back in forth is just that—a copy. If a student has already turned in an answer, the student can still modify his or her answer and turn in another one, and another one after that. In this fashion, CLP maintains a history of a student's problem-solving for a particular problem. The peer grading system assumes that the latest submission by a student is his or her best answer and uses that submission in its shuffle step. Similarly, when the students are being returned their graded problem, they see the most recently graded one if the grader submitted multiple graded problems.

Traditional Classroom Scenario 2

In the classroom, it is often simple to distinguish a problem-solver's handwriting from a grader's handwriting—the original student problem-solver probably wrote in the answer section, while the graders probably leave their comments around the answer section, possibly in a different color pen. While handwriting and color characteristics could be used in CLP, merely relying on these differences would not be using the computer tablets to their full potential. Instead, we propose the following functionality.

Software Benefit 2

Using the student history bar, implemented by Brandon Pung, also during the Spring 2010 6.UAP term, we can distinguish between iterations of the same problem. The student's initial submission, for example, is placed into the history bar for viewing. If a student's computer receives that submission graded by another student, it will be placed next to that original, initial, ungraded submission. If a student receives another student's solution to grade, that will show up as a new item in the history bar so that it doesn't overwrite the original student's solution. This functionality allows the students to be able to refer back to their old answers in any situation, whether they are using their solutions in order to grade somebody else's answer or if they just want to refresh their memory about the problem. Finally, if the student receives his or her own solution back graded, that solution will show up as its own item in the history bar.

Because each slide has its own history bar, and we're assuming for this discussion that there is one problem per slide (though there need not be), the student can easily manage all of the different iterations of his or her solution. In the traditional classroom setting, students couldn't have had their own solution in front of them while grading somebody else's unless they explicitly copied their answers somewhere else before swapping. Using software, their old answers could be easily stored and pulled up for viewing at a later time.

Software Benefit 3

As stated, CLP allows for any sort of slides, student submissions as well as teacher original slides, to be displayed on a projector. Because the peer-graded submissions are represented as slides as well, they can be viewed easily on a projector as well, fostering class-wide discussion of alternate methods for solving, and grading, problems.

5. Implementation

The implementation was done over about a one and a half month period, with the bulk of the work occurring over one particularly intense week. Many Red Bulls died to make peer grading possible in Classroom Learning Partner.

In CLP, the slides of the teacher and the student are synced up through a gateway computer that acts as a server that can distribute the teacher's lesson slides to all parties. When the teacher program and the student program wish to communicate, only the slide's "overlay" is sent, in order to minimize network traffic. The overlay contains the pen strokes consisting of the student's work and answers, as well as the student machine's ID and various other tidbits of information necessary to identify the sender. The first thing that had to be accomplished was adding a way to keep track of whose answer is being sent across the network. To do this, I changed the Slide Overlay such that it kept track of all the users that have ever sent that particular overlay. In that way, the original student who first answered the question will always be the first in this previous-user list.

Another benefit of the previous-user list was allowing the teacher to sort between the different student responses stages. Each particular overlay that was being sent across the network not only corresponded to one particular slide in the teacher's presentation but also to a particular stage of the peer grading process. To present an easy-to-use interface for the teacher, I separate the different iterations of peer grading for each slide. The first iteration—the initial students' answers—is grouped as one slide deck for each slide. This first iteration can be reached by clicking on a tab next to the corresponding slide in the presentation. The next iteration—the answers graded by other students—are also grouped together and can be accessed by clicking on

a second tab directly below the other tab. To group the iterations in this manner, I checked the number of users on the previous-user list to find out what stage the overlay was in. Afterwards, depending on what version the slide was, the slide was sorted into the appropriate deck. [This isn't clear; is there a single overlay object that you have to locate in the list of slides?]

As stated in the design choices, the student answers are shuffled amongst the students by passing each submission to the next student in the deck and giving the last student's submission to the first student. I programmed a button that, when clicked, would perform this operation and send each slide out to a different student to be graded. I also programmed the return operation, which works by sorting the slides based on their iteration, as described in the previous paragraph.

One unexpected difficulty I ran into was guaranteeing that only the most up-to-date submissions for each student were used. While testing the function myself, that scenario did not come to mind at first. Upon further consideration, the function should readily be able to handle multiple submissions for the same problem by a single student and deal with it accordingly. In the design choices above, I noted that I decided to take the latest submission only, assuming that the most recent answer is the one the student meant for the teacher to receive.

Integrating the selection of the latest submission with sending only that latest submission to the next student in line was a bit tricky, and I came up with an algorithm to solve the problem. The algorithm takes a working slide deck, which is essentially an array from which I can retrieve all the overlays for a particular iteration of the peer grading process. It creates two different hash sets, one to keep track of all the students whose latest slide has been sent, and one to keep track of all the students who have been sent a slide to grade. In the first iteration through the deck, I find the latest slide of the student whose slide is at the beginning of the deck, and I send this slide

to the student whose slide is at the end of the deck. Afterwards, I add the first student to the set of all students who have already sent their latest slide, and I add the last student to the set of all students who have been sent a slide. Then, starting from the end of the slide deck, I iterate through all of the slides to find another student that hasn't sent his or her yet (by checking against the set). Then, during each iteration, I also iterate through all the slides starting from the beginning of the deck and find the next student who hasn't sent his or her slide yet. Once a match is found, I send that student's overlay to the other student, add their names to the respective sets, and continue the algorithm to completion. The algorithm guarantees that as long as there are at least two students in the classroom, everybody will get a slide to grade, and everybody will have had their latest submission sent out to be graded by another student.

6. Walkthrough

This section illustrates the use of CLP's peer grading system by presenting a series of screen shots. Students submit an answer to the teacher; the teacher shuffles the answers so that each student gets another student's answer to grade; the students submit the graded answers to the teacher; the teacher sends the graded answers back to the student whose answer was graded.

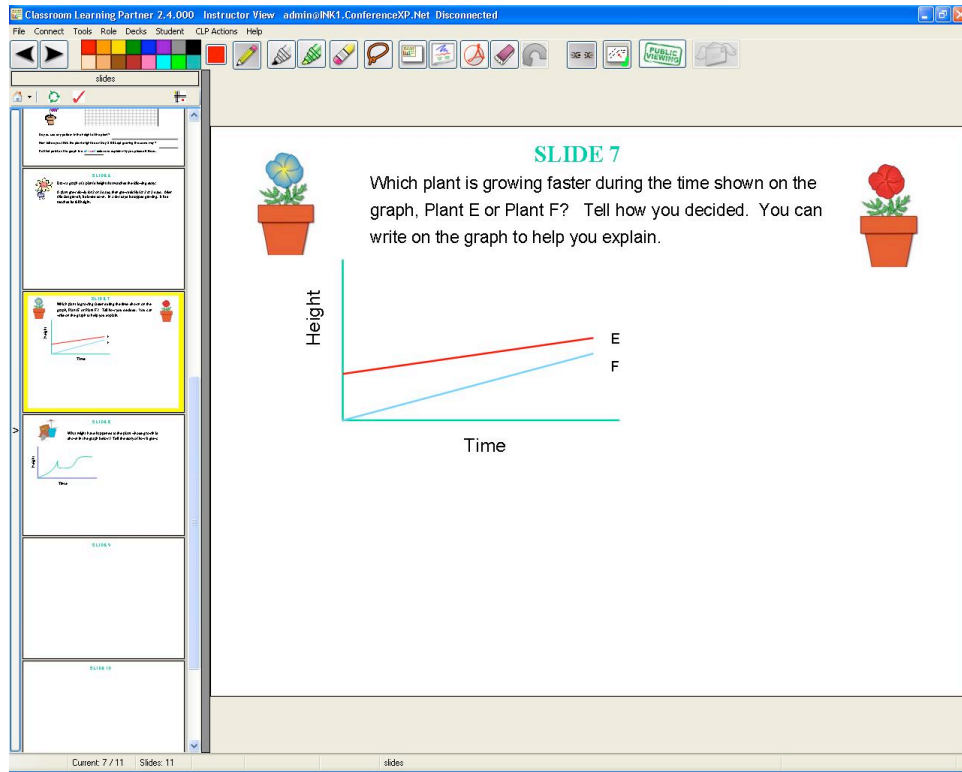


Figure 1: Teacher view of a slide

The teacher's program can link with the student programs, forcing students to be viewing the same slide; alternatively, the teacher can allow the students to freely navigate through the slides.

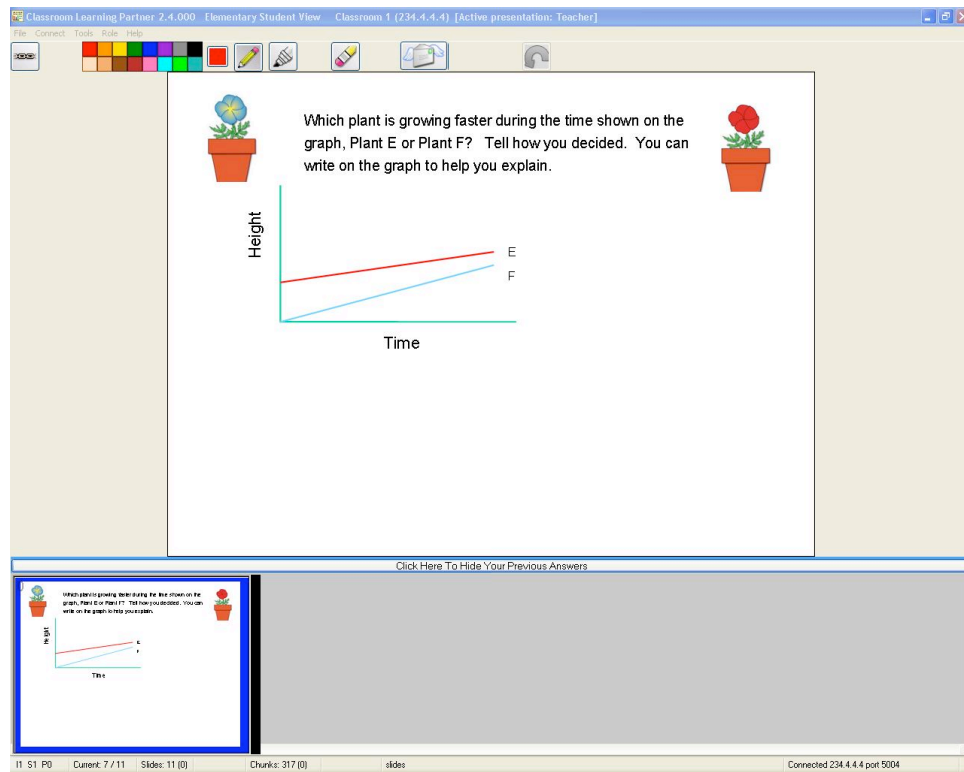


Figure 2: Student view of that slide with Submission History bar at the bottom

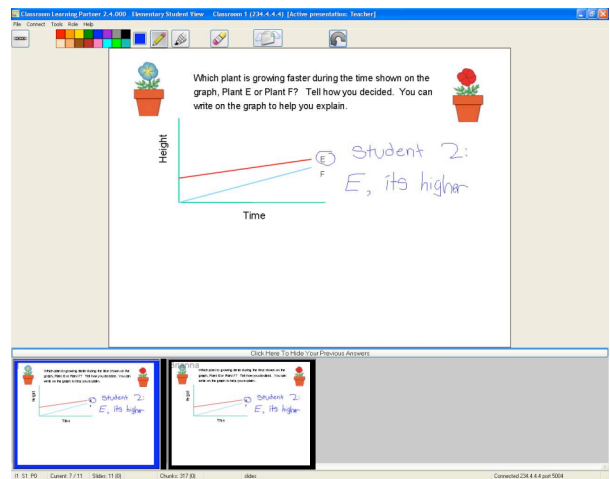
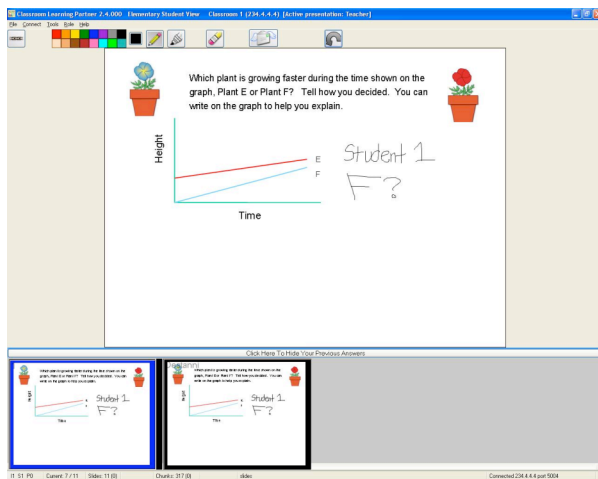


Figure 3: Example student answers for that problem

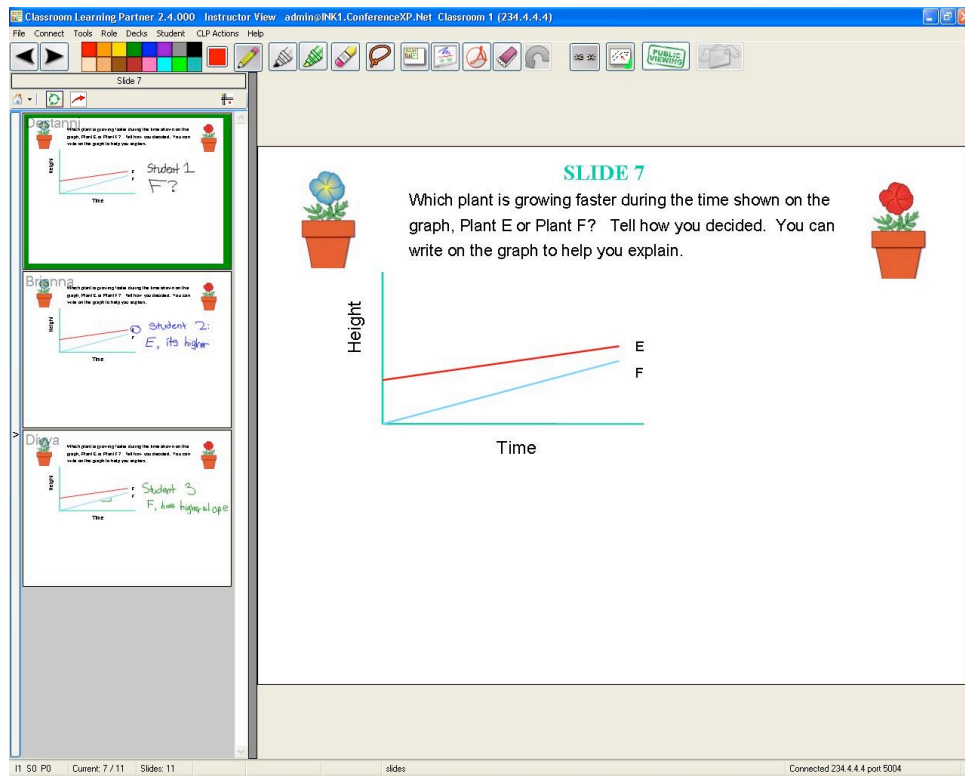


Figure 4: Student answers are visible in the filmstrip to the left of the main display window

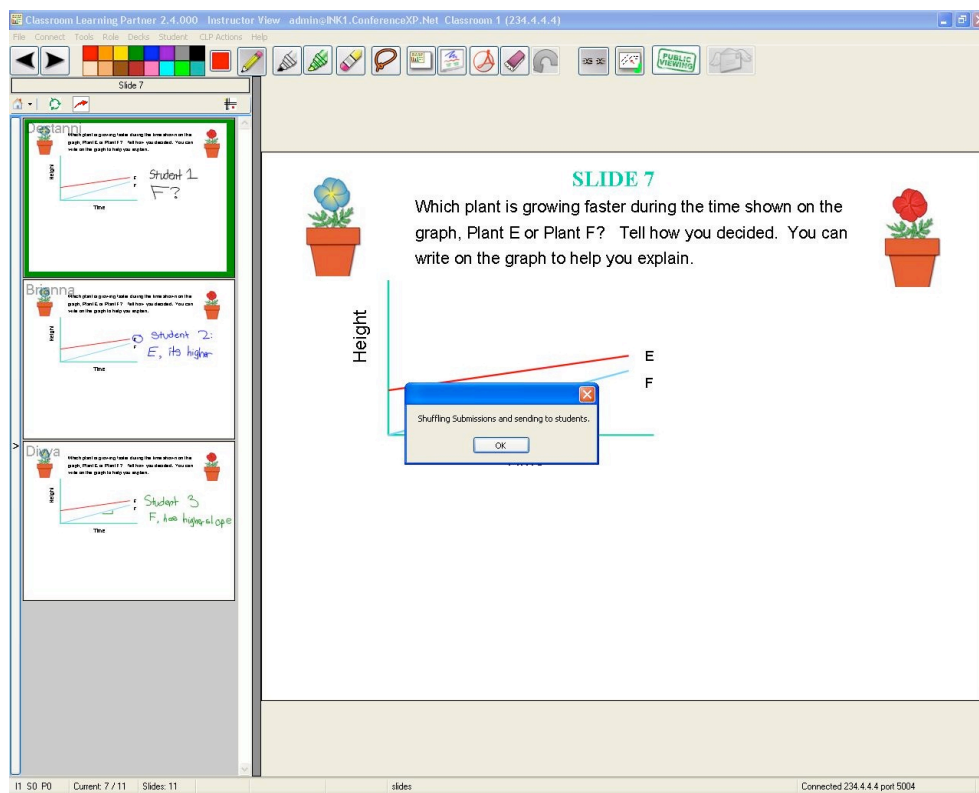


Figure 5: The teacher shuffles the answers back to the students for peer grading

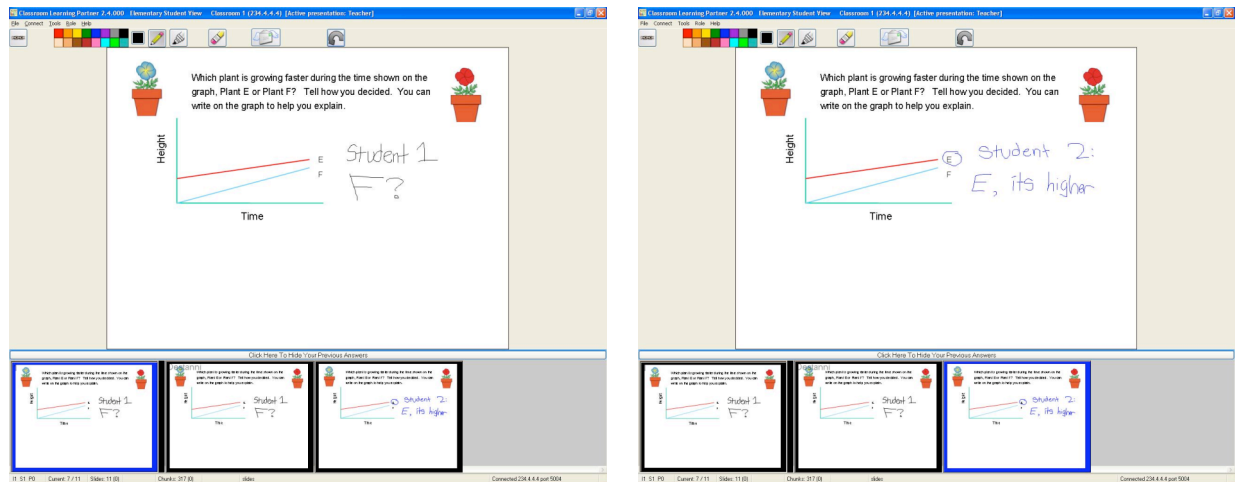


Figure 6: Examples of students receiving other students' answers to grade. Notice how the other student's answer doesn't override the student's initial view but instead show up in the history bar at the bottom. The student clicks on the thumbnail view in the history bar to display the new answer.

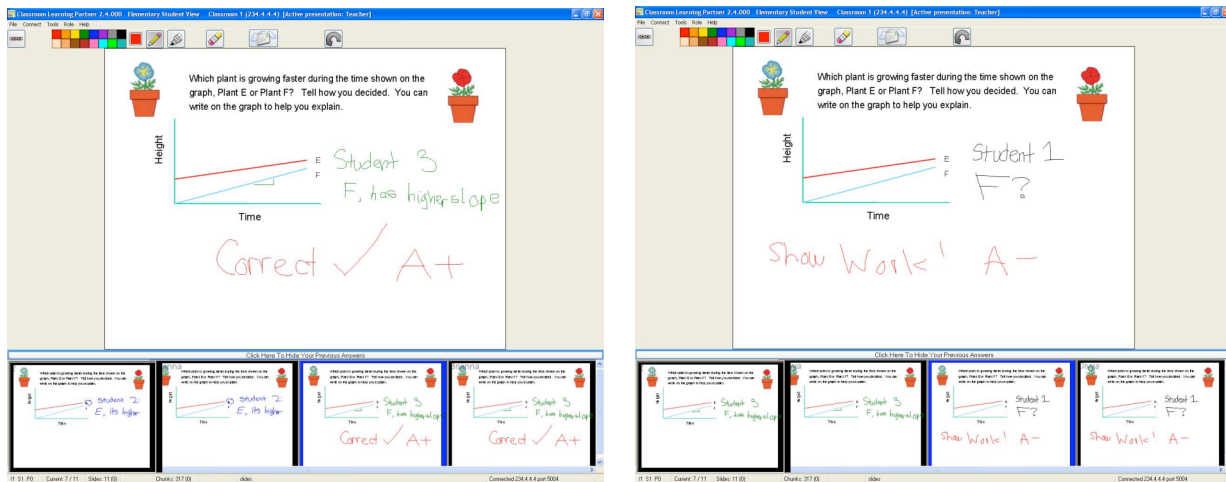


Figure 7: Examples of grading other student's work and sending them back to the teacher

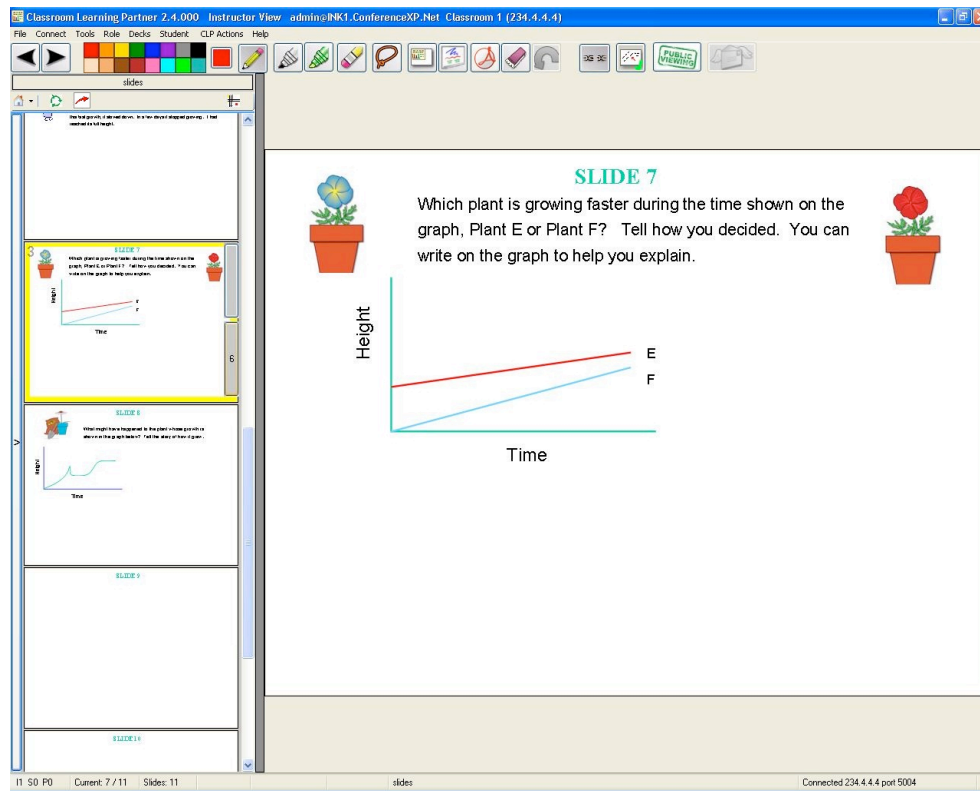


Figure 8: Teacher view when graded answers are turned back in. Note the new tab button underneath the original; it is used to access the graded answers.

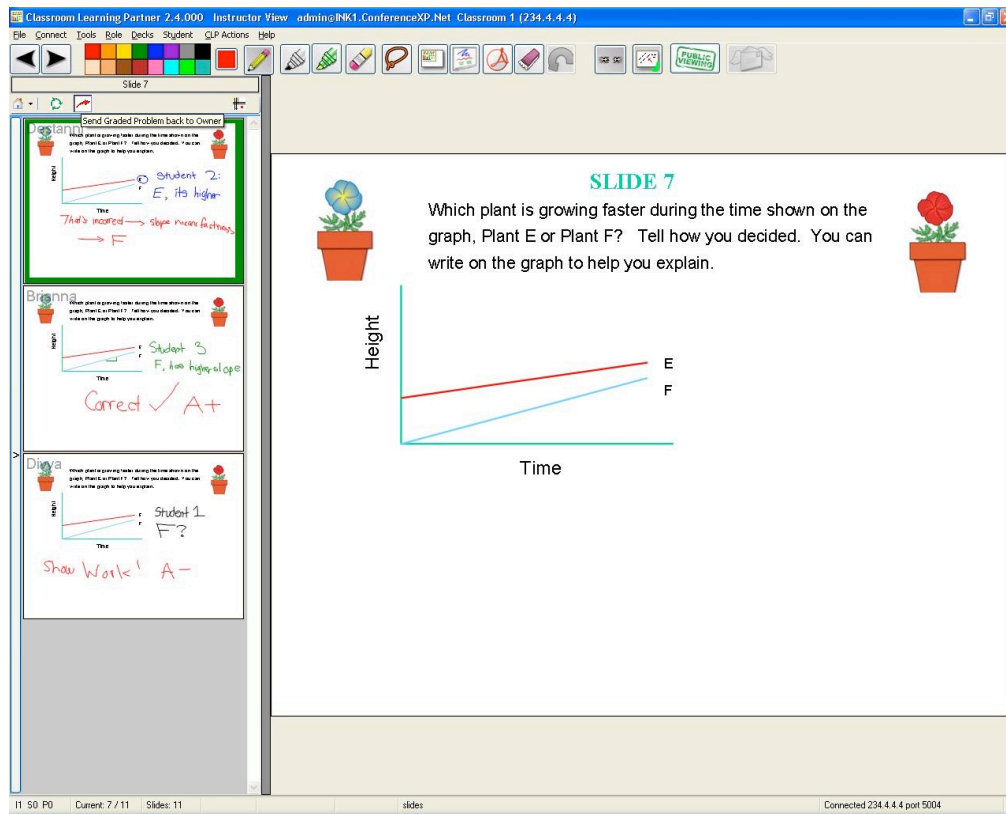


Figure 9: Clicking on the second tab allows the teacher to view all of the graded answers. From here, she can send the problems back to the original students.

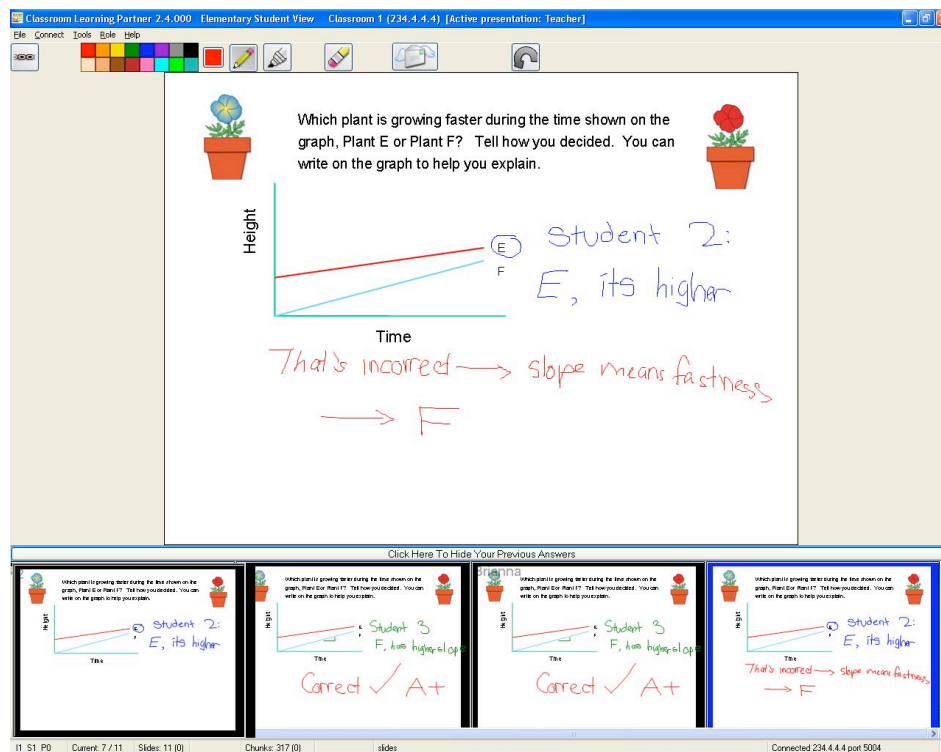


Figure 10: Student receiving his original problem back graded

7. Testing

The peer grading function, along with CLP, was tested in a 4th Grade class in an elementary school in Waltham, Massachusetts.

The teacher prepared a series of slides for the student's math lesson that day. The topic was fractions, and the students were asked to follow along with the slides as the teacher presented the topic. In preparation for the fractions lesson, students had each written fraction questions several weeks prior. The teacher wanted to use the peer grading functionality in a novel way: To not just have students work and grade a problem that she had written, but to have them each work another student's problem, which would then be graded by the student who had written the problem. This use of the system added an extra first step to our idea of peer grading: The students needed to submit their original problems to the teacher, who would then shuffle the problems, then send the problem solutions back to the problem author, and finally send the graded solutions to the original problem-solver.

In order to save time by decreasing the amount of writing required by the students, instead of having the students write their problems on their tablet screens and submitting the problem, we printed the problems out on a master list, assigning a number to each question. Students were then asked to record on the "problem" slide, the number of the problem that they had written, and submit that number to the teacher. This initial step was necessary in order for the software to know to whom to return the problem once it was solved by another student. After the students had written the number of the problem they created, and submitted that slide to the

teacher, the teacher clicked on the shuffle operation. Each student then received a slide from the teacher that contained the number of the problem they were assigned to do. The students located that problem in the master lists and started working on that problem. After they were done, they submitted their answers to the teacher.

After the teacher received the students' answers to each others' problems, she clicked on the return-to-original button. The creators of the problems (who had originally written the numbers of their problems on the slides) were now looking another student's solution to their problems. They proceeded to grade the other student's answer based on correctness and work shown. Some of the students prided themselves in handing out particularly harsh grades. (Personally I witnessed one student gleefully dole out an F- to another student's answer.) Most, however, took their grading task seriously and wrote helpful explanations on their peers' work. After the grading process was completed, the students submitted their slides for the last time to the teacher. The teacher now possessed three iterations for each slide: the number of the problem, another student's answer to that problem, and the original creator's grade for that answer. The students possessed four iterations for each slide: the number of the problem they had created; the problem they were assigned to solve; their solution to that problem; the graded version of the problem they had created, which another student has worked,

Overall there were no bugs in the program during this phase of the testing and the function came across as a success. While having the students write their problem was a somewhat roundabout way to ensure return delivery to the problem's creator, it did not prove to be a boon to the proceedings. There were several things that I noticed could be improved with peer grading in Classroom Learning Partner, which I explain in further detail in the next section.

8. Future Work

Given more time with the Classroom Learning Partner Project, there are several improvements I would make.

Differentiating whose ink is whose

The current system has no clear-cut way for the teacher to distinguish between the solution itself and the grading remarks besides for the context and handwriting. In a future iteration of the project, I could introduce a method in which the students' inks are separated from each other. One method could be reducing the opacity of the graded remarks so the teacher can easily tell which ink strokes were part of the original answer and which ink strokes were added by the grader.

Expanded view to track a single student's problem on the teacher machine

The current system groups the student problems together by iteration. This is useful for the teacher to get a sense of how many students have answered the initial problem and to get a quick understanding for the types of answers they responded with. However, it would also be very useful for a teacher to be able to track the "development" of a problem, or how it changes through time. In the future, I could introduce a view such that the teacher can easily see the

problem, the answer, and the grading of that problem in a coherent timeline. This function would help the teacher gain another perspective about students' progress in the classroom.

9. References

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