6.UAP Final Report

Implementing a Submission History in Classroom Learning Partner

Brandon Pung

Email: bpung@mit.edu

Massachusetts Institute of Technology

Supervisor: Dr. Kimberle Koile, Center for Educational Computing Initiatives

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The Classroom Learning Partner (CLP) software system is an interactive tablet computer program for delivering presentations that facilitate student-teacher interaction through a pen-based interface [Koile & Singer, 2005; Koile et al, 2007a]. This software was used in the NSF-funded project entitled *INK-12: Interactive Ink Inscriptions in K-12*. The goal of the project was to investigate how pen-based wireless technology could be used to enhance the learning environment in 4th and 8th grade science and math classrooms.

CLP is built on top of a simpler wireless presentation system called Classroom Presenter [Anderson et al., 2004], which was designed for use in undergraduate lecture-based classes. Dr. Kimberle Koile and her research group have been adding features to the CLP system in an effort to make it a more effective tool for engaging with students in non-lecture settings, especially K-12 classrooms.

Over the course of this semester I implemented a mechanism by which students can store and retrieve their own work, messages from the teacher, and messages from other students. It allows problem-solving to become a more iterative process by which students can attempt a problem, receive feedback from their teacher or peers, then attempt new solutions.

1. Background: Workflow of CLP

To use CLP a teacher first imports a deck of PowerPoint slides. The import function will convert the slides into a format understandable by the software. When the teacher is ready to start her presentation, tablet computers are given to every student in the class. The teacher also has a tablet, and there is another tablet that is publicly projecting the slides onto a screen at the front of the classroom. The teacher has the ability to "link" all of the student machines to the teacher's machine, which synchronizes the visible slide on the students' tablets with the teacher's tablet and locks them in sync. Alternatively, the teacher can "unlink" the student machines and allow the students to freely navigate between slides at their own pace.

The teacher has the ability to annotate slides using the tablet's stylus in order to create "digital ink". This ink is wirelessly transmitted through the room and is then visible on the students' screens as well as on the public projector. Students have the ability to send "digital ink" to the teacher as well. This transmission forms an interactive communication channel between the teacher and her students, which allows students to answer questions directly on the slides and submit them to the teacher for review. The teacher then has the ability to display and discuss anonymous student answers on the public screen.

2. Problem

2.1 Lack of a student submission history

While doing a trial run of CLP in a 6th grade classroom on March 5th, 2010, an interesting issue was observed. Students were presented with a problem to solve on a particular slide. After writing their solution to the problem, the students submitted their digital ink solution to the teacher. Having successfully submitted their answer to the teacher, several of the students then erased their answer from their own slide. When questioned about why they erased their answer after submitted it, they gave one of two responses. Some erased it in order to stop the people around them from copying their answer, while others erased it in order to have a clean slide to draw on for fun before moving on to the next problem.

Issues arose when the students moved on to the next slide and were prompted with a question whose solution was dependent on their solution to the previous problem. For the students who had erased their previous submission, they had no way to go back and recall the solution they had sent to the teacher because there is no persistent cache of digital ink on a student's machine other than what is currently written on the active presentation slides. At this point it became clear that students needed some form of a "history deck" that contains all of the content they had submitted to the teacher. Such a deck would facilitate recall of those submissions in the event that future questions were dependent on them.

2.2 One-way communication

CLP had an effective channel for sending answers and comments from individual students to the teacher, but it had no means by which to send unique content back to students. Because CLP

inherited its communication layer from Classroom Presenter, it allowed for private content to be sent from the students to the teacher, but only public content could be sent from the teacher to the students: Teachers could not send comments to individual students about their submissions. This functionality, while less important in the undergraduate lecture classes for which Classroom Presenter was designed, was considered by teachers and researchers to be critical in K-12 classrooms.

The value added by allowing teachers to respond to a student's submission is tremendous. It allows for an iterative process of problem solving in which the student can receive feedback from the teacher about one of their submissions and is then able to submit an improved solution. Such feedback has proven valuable in improving student learning [Black & William, 1998].

For a mechanism allowing teachers to send private responses to individual students to be effective, students need a place on their machines for storing and viewing these responses. Since there was already a need to store a student's history of submissions as described in the section above, it is logical to combine a student's submission history with the responses from the teacher.

2.3 No student-to-student interaction

To date CLP has focused primarily on interactions between a teacher and his or her students. It had no unified structure in place for communication between students, though an addition to the system supported student-to-student communication for creation and submission of a student group response [Koile et al, 2007b].

One use case for student-to-student communication of student responses is peer-grading--allowing students to grade other student's solutions to a particular problem. Grading another student's solution reinforces the concept being learned in the mind of the grader. Furthermore, students enjoy opportunities in which they can play a part in the learning experience for one of their peers.

If there were a way for students to receive responses from other students then these responses, like those from a teacher, must be stored somewhere. Building on the idea of implementing a student submission history, it makes sense to incorporate the responses that a student receives from other students into that storage scheme.

3 Proposed Solution

3.1 What content to store

There are four types of content that need to be stored on a student's tablet in order to address the three problems described in the Problem section: (1) To handle the case of students needing to recall their previous submissions, a copy of each submission that a student sends should be stored locally; (2) For dealing with teacher private responses to student submissions, we need to store a teacher's response in such a way that it can be associated with the slide to which they are responding; (3) For allowing students to grade other student's submissions, we need to store all responses coming from other students in a way that allows students to make changes to them and resubmit them to the original student; (4) Lastly, we must store the graded response that a student gets from another student.

3.2 How to store the content

As mentioned earlier, a teacher's CLP lesson is represented as a slide deck, since this representation is used by the underlying Classroom Presenter infrastructure. Student responses are represented as separate slide decks on the teacher's machine, with one deck for each of the teacher's original "base slides". In order to store the four new types of content described above, a similar set of slide decks is created and stored on the student machines: A history deck is created for each base slide in the teacher's original deck.

Consider that we have a base slide called Slide 1. For a particular student, the history deck associated with Slide 1 will contain:

- The student's answers to Slide 1, submitted to the teacher
- All of the teacher's private responses to those answers, sent to the student
- A peer's answer to Slide 1, sent to the student for grading
- Graded responses to the student's own answers to Slide 1, sent back to the student from a peer

3.3 How to display the content

CLP already has a means of displaying a deck of slides in a content panel known as a filmstrip. The filmstrip provides a way to navigate through the slides in a presentation (see Figure 1).

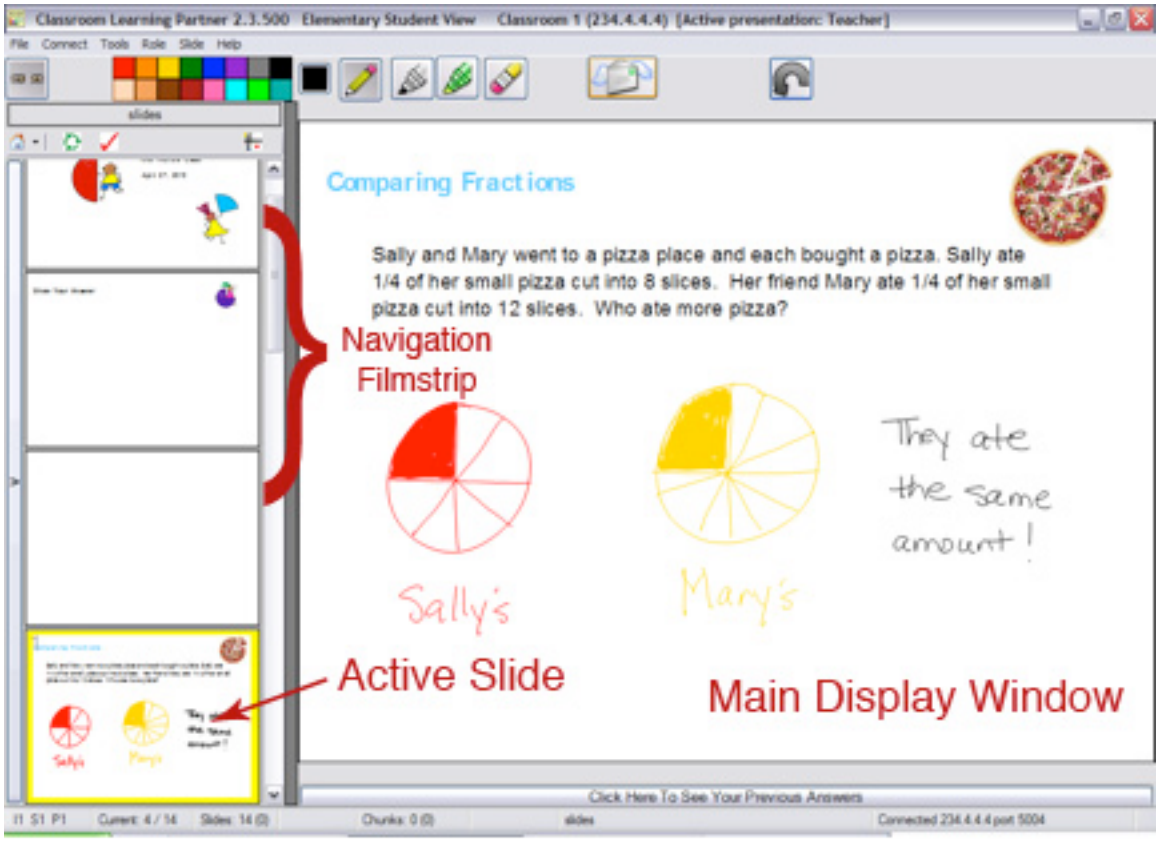

Figure 1. Screenshot showing the student interface with navigation filmstrip on the left. The active editable slide is shown in the main display window to the right of the filmstrip.

The most natural way of displaying a history deck to the students would be to closely mimic the way in which the presentation deck is displayed to them via the filmstrip. Since a history deck must be associated with a particular slide, it should update automatically every time the student navigates to a new slide. As seen below in Figure 2, by placing the history deck at the bottom of the screen in a way that mimics the presentation deck being displayed on the left we are able to maintain a look and feel that is consistent with the interaction style the students are used to. Also, by placing the history deck display horizontally, the students can easily distinguish their slides from the teacher's, shown vertically on the left. By placing the history along the bottom, the upper command menu bar remains easily distinguishable.

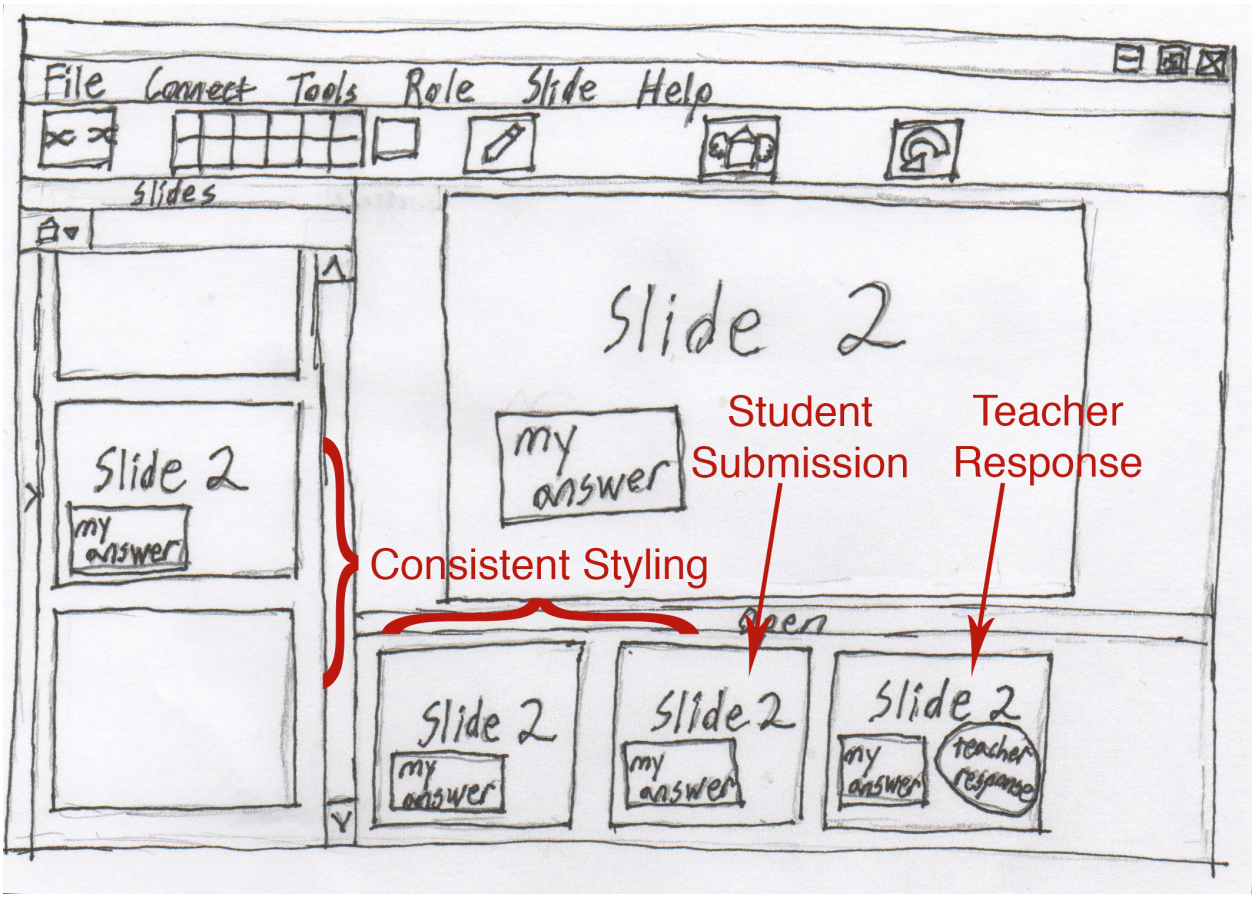

Figure 2. A mockup of the student's interface with the history visible

Displaying of the history, however, does use up valuable screen real estate. By adding in the ability to toggle the visibility of the history on and off we can allow students to only see it when it is needed (see Figure 3).

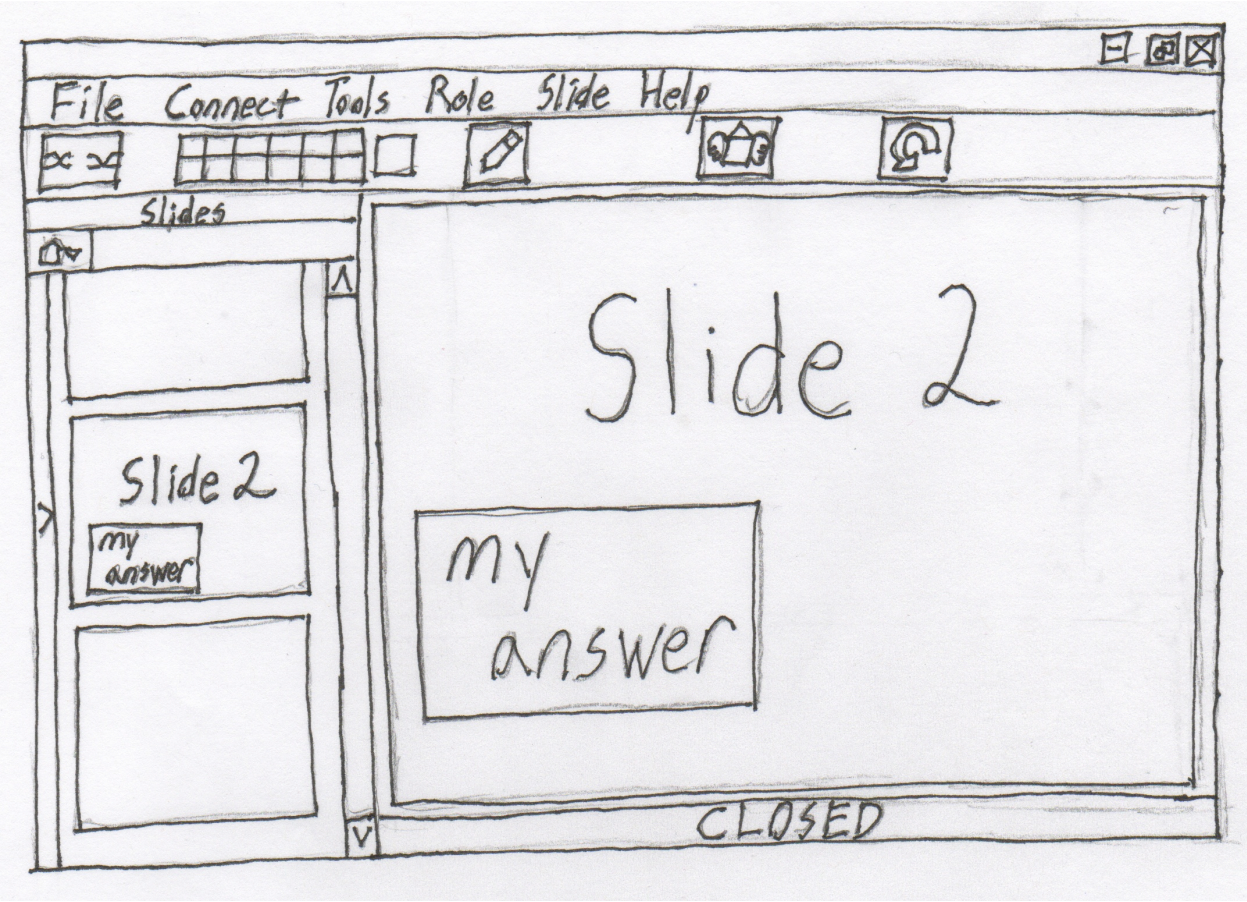

Figure 3. A mockup of the student's interface with the history hidden from view

4 Implementation

4.1 Overview

As described in the Proposed Solution section, the representation chosen for displaying a history deck is a horizontal strip of small slides placed along the bottom of the screen. The following two screenshots show the implemented history deck in its open and closed states. The history deck in these examples contains the student's submissions and replies from the teacher. The slide on the far left is the active editable slide, which is the same slide as the one seen in the actual presentation deck and, in these examples, is also shown in the main display window.

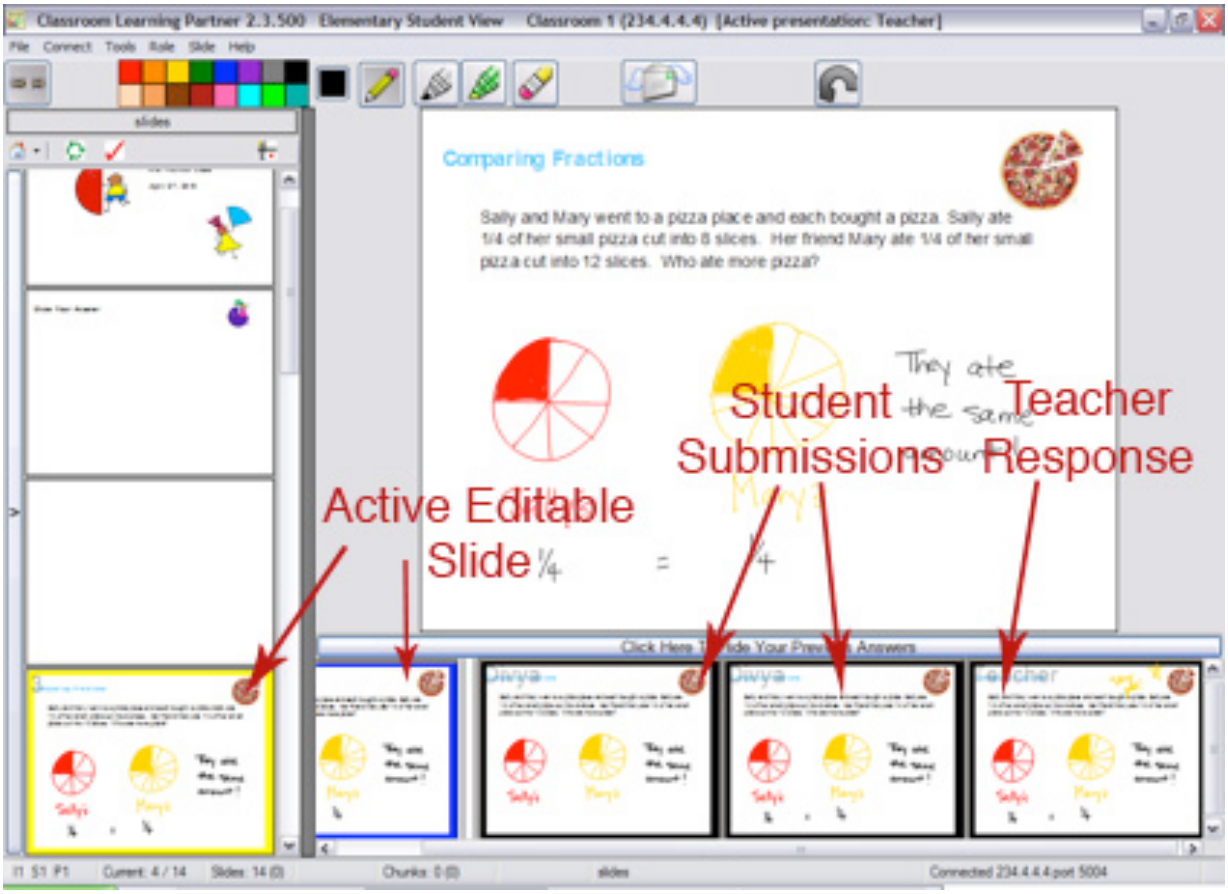

Figure 4. The student history interface when the history contains student submissions and teacher responses

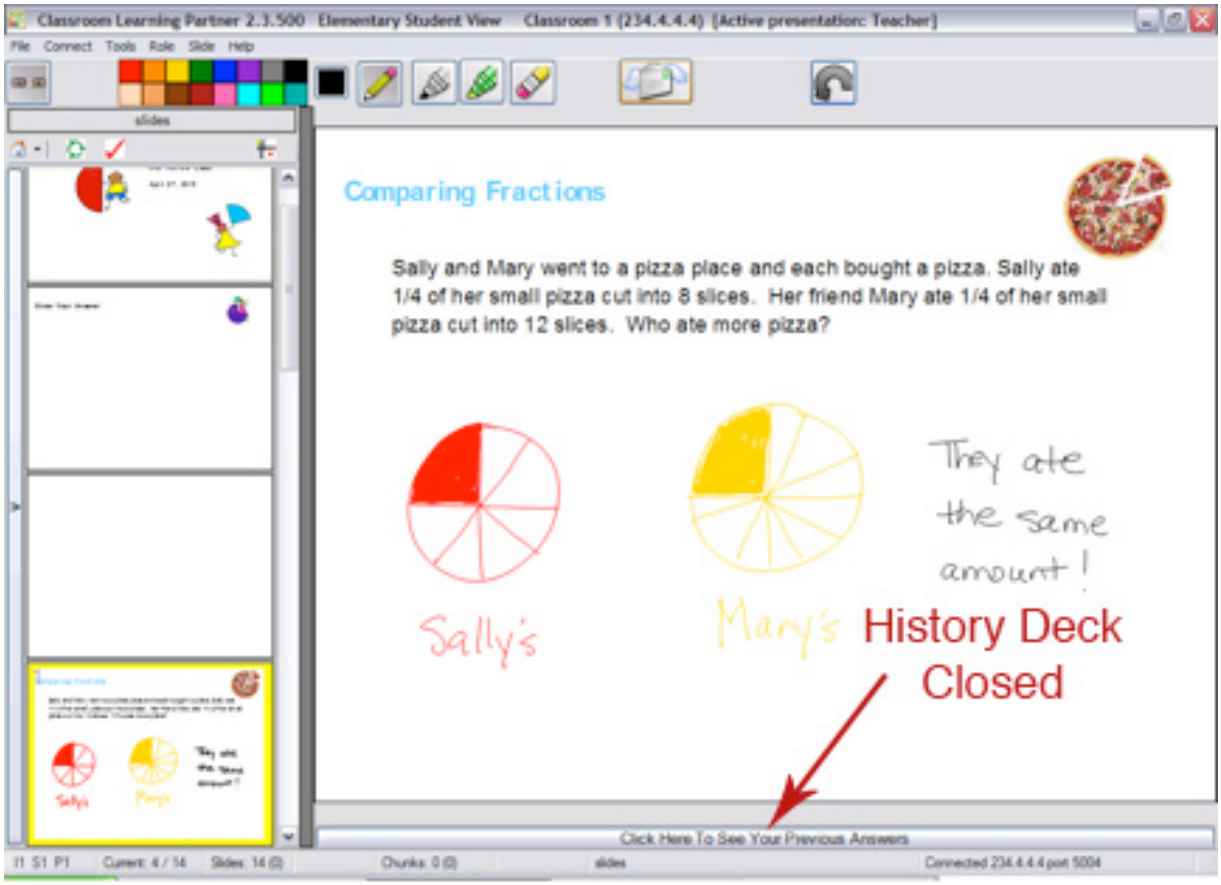

Figure 5. The student history interface when the history is closed

Students can click on any slide in the history deck to show that slide in the main display window. Student submissions and replies from the teacher are not editable, since they are meant to be permanent records. When the student selects one of these slides, all of the students writing tools are disabled and a large button is placed in the area that previously held those tools. Clicking this button will return the student to the active editable slide. Shown below is a screenshot of a student viewing one of their previous submissions for a particular slide.

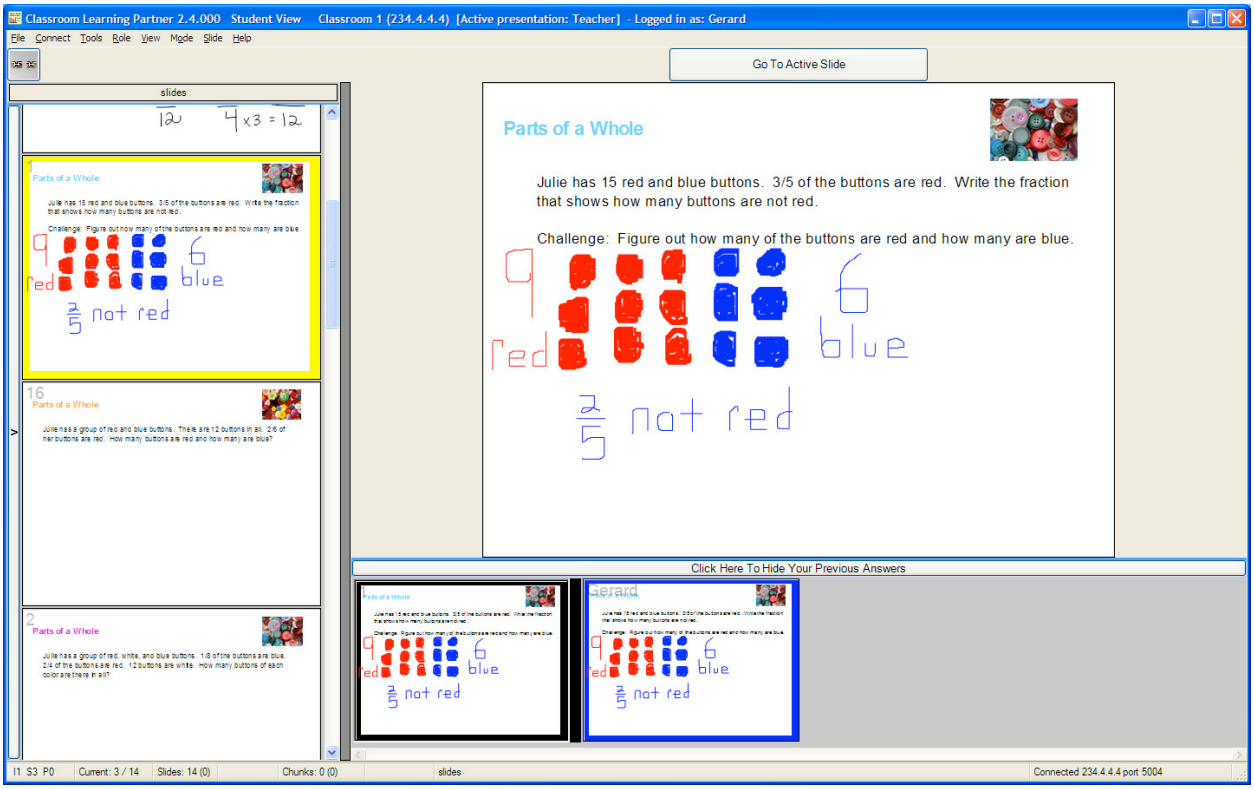

Figure 6. Shows a student viewing one of their previous submissions. The large button above the main display window allows students to return to the active slide.

4.2 Collaboration: Teacher sending replies to students

The sending of messages from the teacher to individual students was implemented by Martyna Jozwiak, a fellow 6.UAP student, in collaboration with my own work. In order for a student to receive direct messages from a teacher, the teacher clearly needs a means by which to send messages to individual students. Martyna implemented the mechanism by which teachers can send content to an individual student, creating the need for my user interface for receiving and storing content from teachers. The following screenshot shows the way in which a teacher sends a reply to an individual student addressing the student's answer to a particular question.

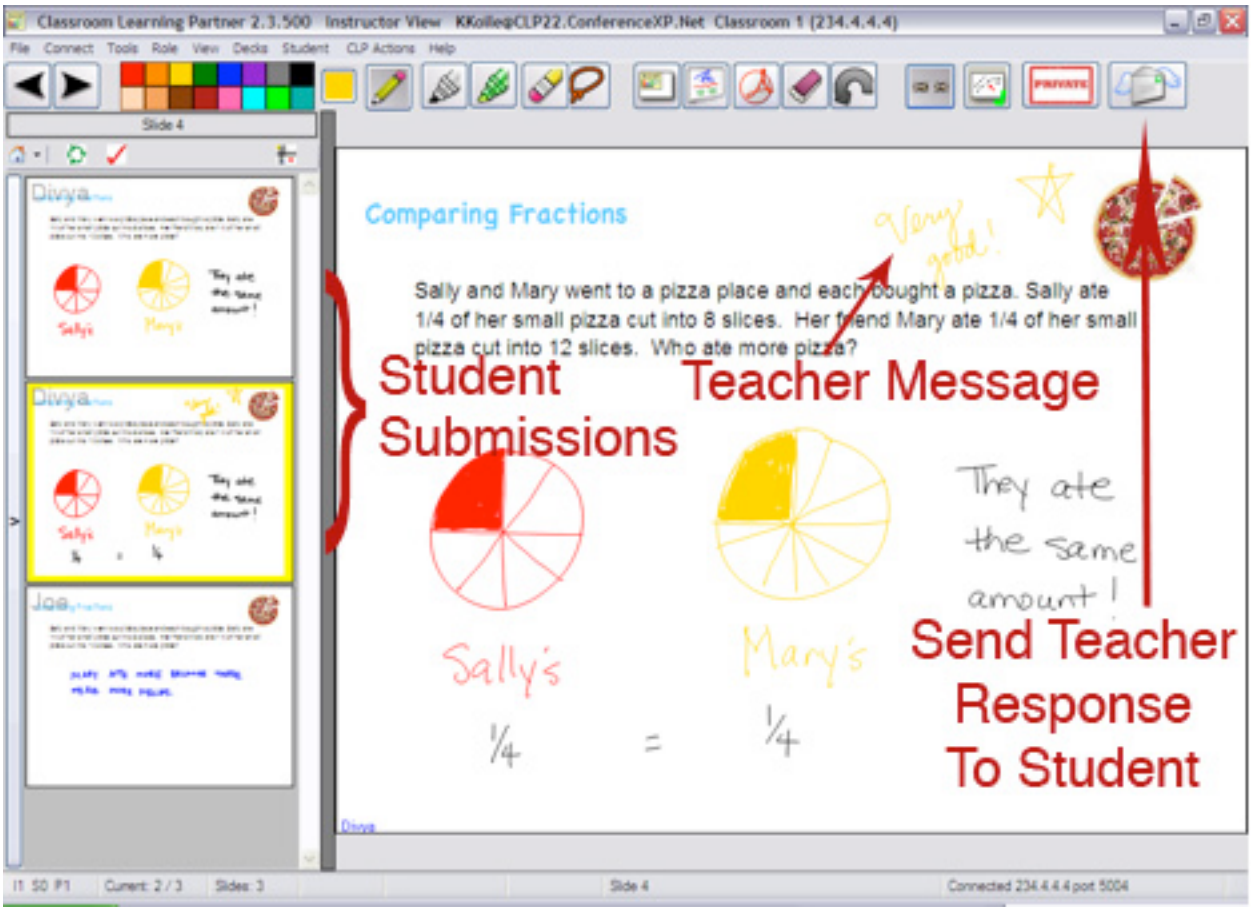

Figure 7. A teacher sending a private response to a student

I implemented the receiving end of this process: When an individual student receives ink from the teacher that ink is stored in the history deck of the slide that the teacher was commenting on. The following two screenshots show a student submitting content to a teacher and receiving a reply about that content from the teacher.

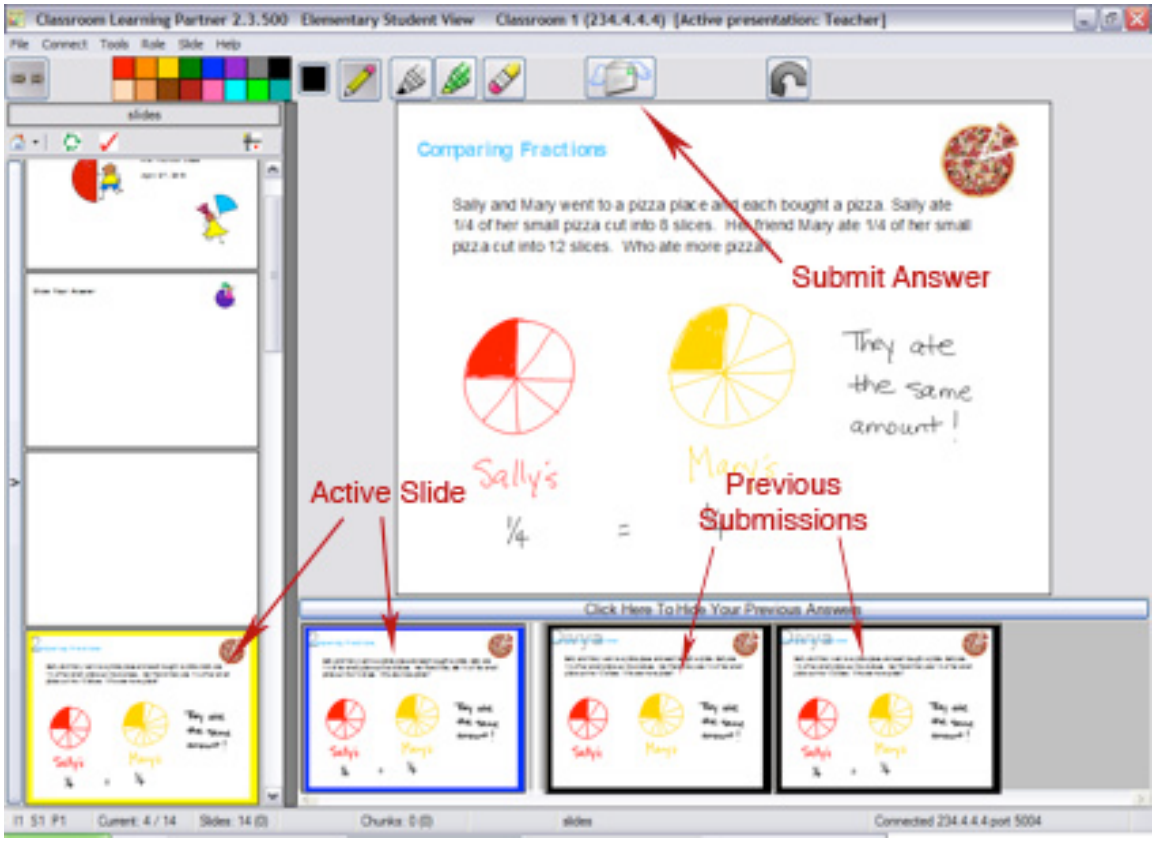

Figure 8. Student interface after they sent their solution to a problem to the teacher

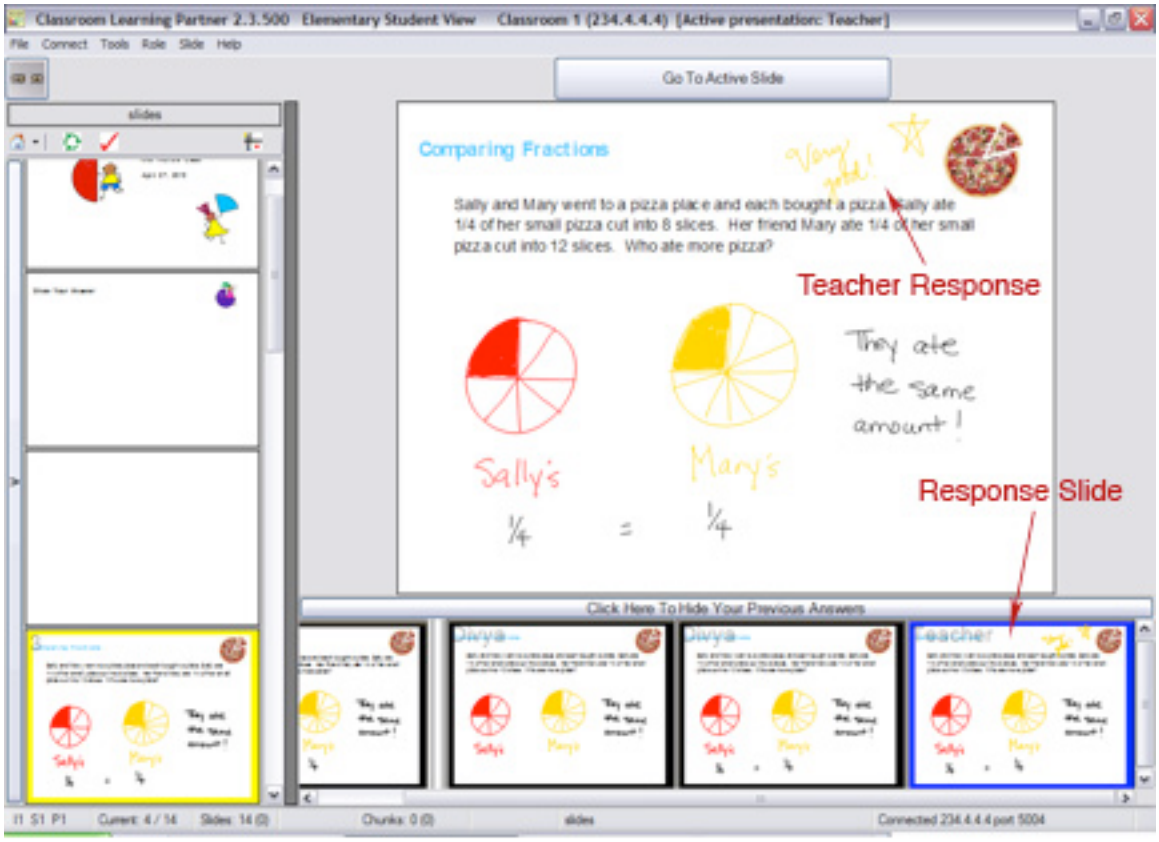

Figure 9. Student interface when they receive and view a teacher's private response to their solution

4.3 Collaboration: Shuffling

In order to allow students to grade their peers' answers to a question there needed to be a means by which answers are passed between students. Neil Chao, another 6.UAP student, implemented a shuffling feature for CLP. This feature allows the teacher to take all the student submissions associated with a particular problem and disperse them throughout the class, sending each student's answer to a randomly selected peer. The students then grade their peers' answers and submit the graded answers to the teacher. The teacher then is able to click a button that returns

the graded slides back to the original student who wrote a particular answer. The buttons for randomly dispersing answers and sending them back to their author after grading are shown in the screenshot below.

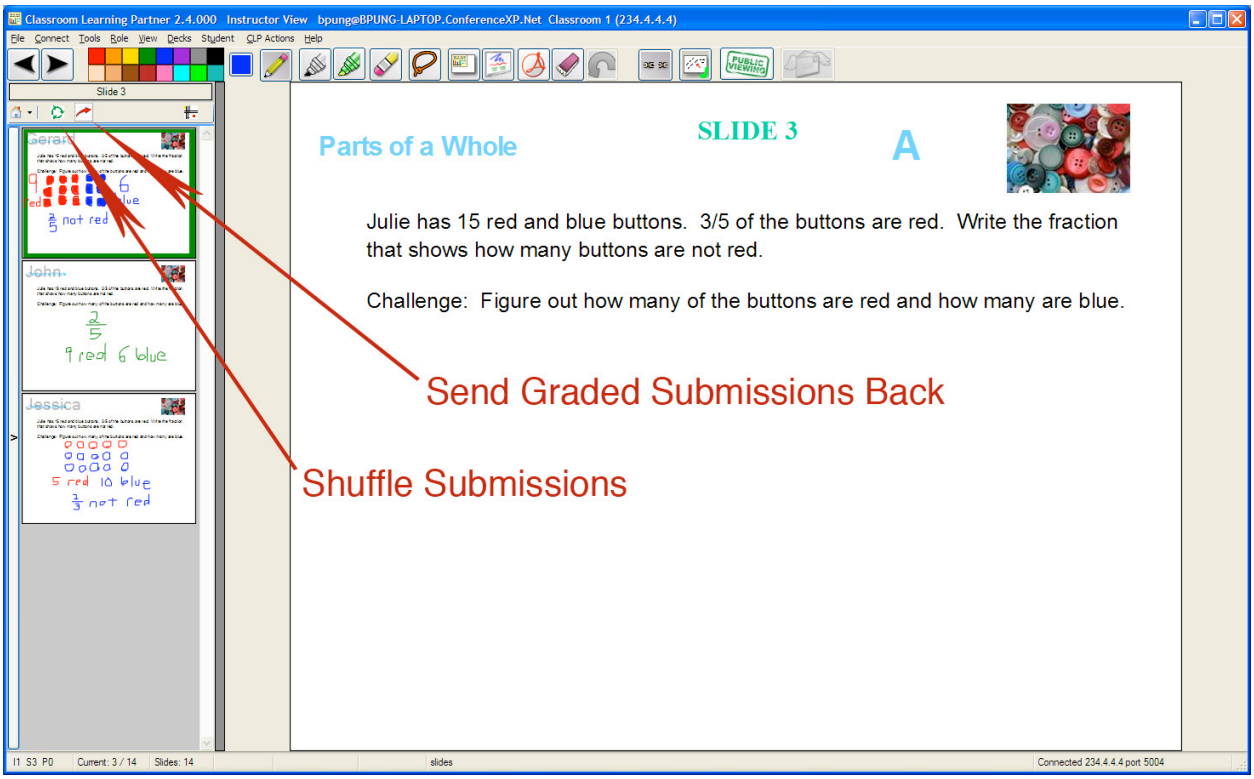

Figure 10. Teacher interface for dispersing submissions to students for grading and then sending the graded responses back to the original students

I implemented the mechanism by which answers and grades from a peer are added to a student's history deck. When a student receives an answer from one of his or her peers, the answer slide becomes editable, allowing the student to grade the answer and send it back to their peer. Slides from other students remain anonymous, so the grader is not aware of whose solution they are grading. An example of a student receiving and grading a solution from a fellow student is shown below.

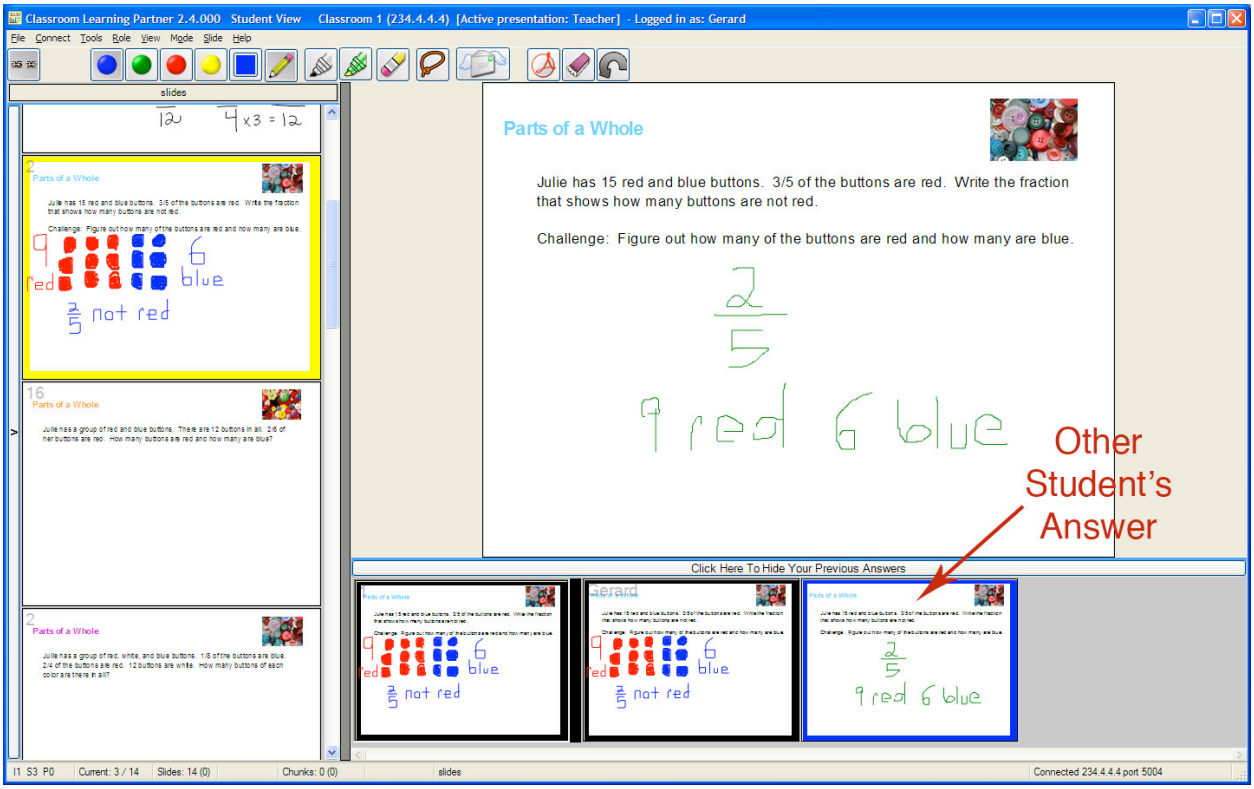

Figure 11. A student receiving a solution to the active slide from one of their peers

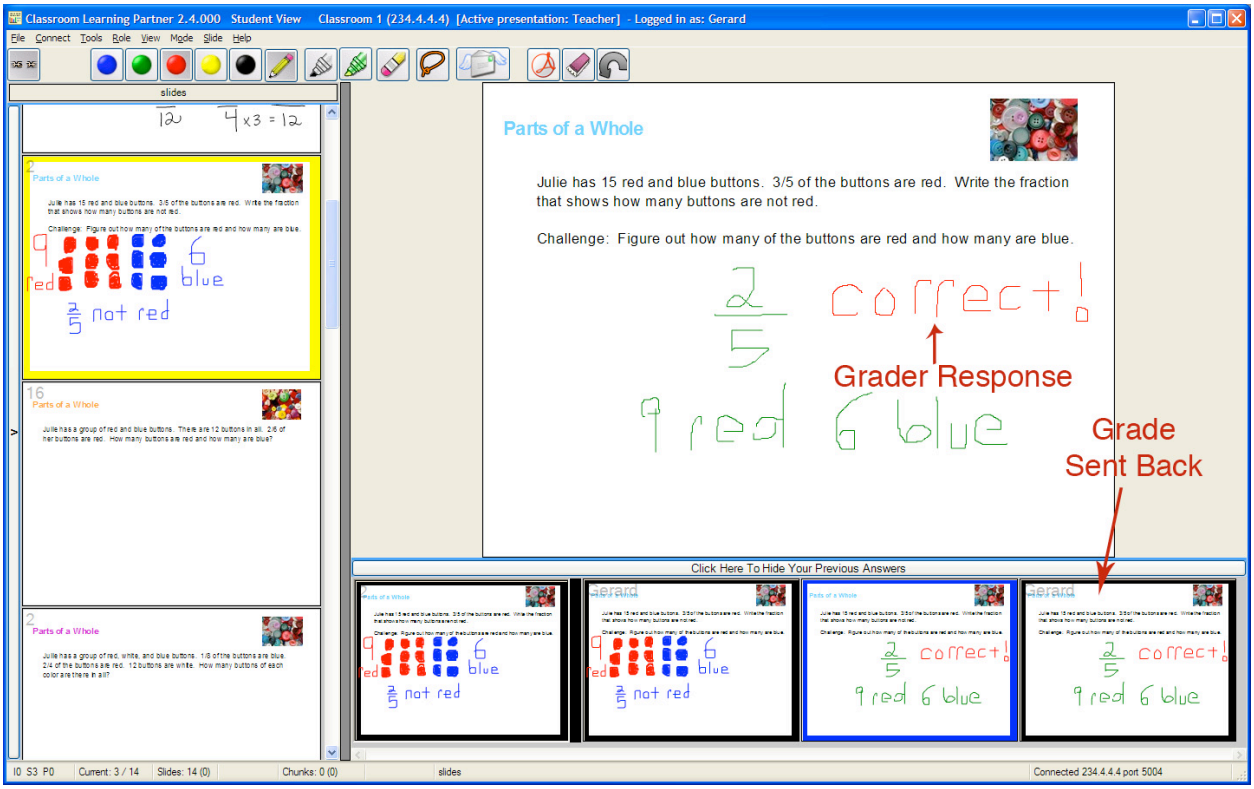

Figure 12. A student grading a peer's solution and submitting it back to them

5 Results

The history deck functionality was tested in a 4th grade classroom on April 27th and April 28th. By getting to see the students interact with the history deck I was able to draw some valuable conclusions about its effectiveness and possible future extensions.

The students very quickly picked up on how to select items within the history deck, since it paralleled the process they use for navigating around in a presentation. They quickly understood that they could not draw on previous submissions or teacher responses, and that they needed to navigate back to the active slide in order to regain drawing capabilities. Some confusion arose in the first trial run when student's history decks became very full and they had to scroll side-to-

side to view all of their submissions. The current active slide on the far left was moved out of view when the student scrolled to the right to see the latest submission or reply, and they became confused when trying to locate the active slide in order to return to it and continue drawing. I fixed this issue by having the active slide always remain fixed and visible on the far left, such that it did not scroll with the rest of the slides.

Several students receiving comments from the teacher were unaware of the comment because they had already moved on to a new slide. They had to be told to go back to that slide in order to view the teacher's reply. This issue is discussed further in the Future Work section.

I questioned the students about their experience with the new history deck features. Students really enjoyed seeing responses to their submissions from the teacher. They also liked being able to grade their peers' answers to questions. They felt that the new features made the presentations feel more interactive. Several students thought the history deck took up too much space when they were trying to draw, but they were satisfied with the ability to minimize it at any time when that feature was pointed out to them.

6 Future Work

6.1 Coupling submissions with responses

Currently the history deck displays its content in the order in which each response is received. Consider the case in which a student sent in a submission to a slide, which we'll call submission A. The student then makes some changes and submits a new solution, submission B. In the history deck, submission A would be displayed first followed by submission B, which is the

desired behavior. If the teacher then sent the student a reply to Submission A, however, that reply would be placed at the end of the history deck. So the ordering would be Submission A -> Submission B -> Reply to Submission A. The desirable ordering would be Submission A -> Reply to Submission A -> Submission B. Future work would include coupling submissions with their responses and displaying this association in a way that is obvious to the user.

6.2 Notifications for new content

Due to the way the history decks are set up, students are only able to see the history content that is associated with the active slide. If the teacher sends a student a reply to their answer for slide 2 while the student is looking at slide 3 then the student will have no way of knowing about that reply. The student would have to be told to go back to slide 2 in order for them to realize that they had received a reply to their answer for that slide. To remedy this situation, a notification system could be implemented.

One such notification scheme could use a mailbox metaphor. A mailbox with mail in it makes for a solid representation of incoming messages. A mailbox icon could be placed in the upper right corner of the student's screen. Initially the mailbox is empty. When the student receives an incoming reply to a slide, a new piece of mail will appear in that mailbox labeled with the slide number to which it is a response. So in the situation introduced above, when the teacher replied to slide 2 the student would see a new piece of mail in the mailbox with a number 2 on it. By clicking on that piece of mail the student would be brought directly to the teachers reply and that piece of mail would disappear from the mailbox. The mailbox could accumulate multiple pieces of mail as incoming messages pile up.

7 Conclusion

The feature I implemented in CLP for storing a student's submitted content as well as replies from the teacher and other students greatly increases the utility of CLP as a means of supporting interactive classrooms. Prior to this work, individual students had no means by which to receive comments from the teacher or their fellow students. Having a unique history deck associated with each slide in a presentation provides a channel for communication with individual students. This feature allows for an iterative and effective approach to problem solving in which students can submit their answers to a problem and receive direct feedback from the teacher or their peers.

8 Acknowledgments

I would like to thank my 6.UAP thesis advisor Dr. Kimberle Koile for her support and passion for the project. Her enthusiasm and genuine desire to create meaningful software that improves the learning environment for our youth was inspirational. I am also very thankful for the dinners Kimberle purchased for our group as we were working late into the night fixing software bugs.

9 References

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