USING SMARTPENS TO COMMUNICATE MATH ONLINE

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According to the Illinois Online Network, "communication, interaction, and collaboration" is a key component of an online course. [3] But, how can students communicate math online? Written mathematics communication is not difficult for instructors who know LaTex or some other software that displays mathtype well. However, most of our students have not learned this skill, thus it is hard for them to communicate math online with each other or the teacher. This paper begins with research that supports student-teacher and student-student communication for a mathematics online course. Next, there is a description of what smartpens are and how they were used in a hybrid mathematics course. Lastly, student feedback and conclusions are provided.

**Literature Review for Communicating Math & Online Courses**
Several reports in the past 12 years describe requirements for quality online courses. While the reports differ, they all agree that online courses should involve active learning and personal interactions. Quality Matters, whose mission is to promote and improve the quality of online education and student learning, has 8 general standards. One of their 8 general standards is learner interaction and engagement, more specifically, it states, "Learning activities provide opportunities for interaction that support active learning." [6] Quality on the Line is a report prepared by The Institute for Higher Education Policy whose mission is to "foster access to and quality in postsecondary education." Under the Teaching/Learning benchmark, they state "Students' interaction with faculty and other students is an essential characteristic."[2] The Higher Education Program and Policy Council of the American Federation of Teachers created Distance Education: Guidelines for Good Practice. This report emphasizes that "faculty must be prepared to meet the special requirements of teaching at a distance." More specifically, "faculty teaching distance education courses must become proficient in the communications technology employed in their distance education courses. Faculty teaching web based courses must possess strategies and skills to communicate with their students electronically in absence of visual and oral cues." This report also claims "close personal interaction must be maintained."[4] All of these reports address the characteristics of a quality online course. Research also supports communication in a regular classroom. Steinbring, Bussi, and Sierpinska state that "clear mainstream consensus that language plays an important role in teaching and learning, and, in particular, that discussion is a useful medium for developing learning. [7] Engelbrecht and Harding comment that "Mathematics courses have not been at the pioneering front of internet course development, probably because of the problems surrounding symbol presentation …another reason is that math is a conceptual subject and a common opinion is that face-to-face contact is necessary for conveying these concepts." [1] In other words, due to the language of mathematics it

seems to be more challenging to find effective online teaching methods. Oliver, Kellogg, and Patel investigated the differences between online math instruction and other subject areas. Several significant differences were noted when comparing results from math participants to results from participants in five other subject areas which suggest students learned less online and needed more communication from the teacher and more collaboration with peers. The results of a follow-up survey suggest the need to improve online content and teaching. [5]

**Introduction to SmartPens and their Educational Use**

A smartpen captures handwritten notes, audio and drawings. The recorded audio is kept indexed with the handwritten text, thus tapping on a written word starts playback of the recorded audio from that part of the recording. Samples of student work can be viewed at http://mathsci2.appstate.edu/~kmp/research/SmartPen.html. Currently, there are numerous ways smartpens are used in the classroom – at levels ranging from elementary through post-secondary. A document created by Livescribe lists 62 different uses, such as "testing accommodations," "pencast your homework to your teacher," "sharing lessons with absent students," and "talking study guide or assessment." Figure 1 shows what a smartpen pencast looks like when opened with Adobe Acrobat. Note that pencasts open in any viewer, however, the audio is only heard using the most recent version of Adobe Acrobat. At the bottom of the page (Figure 1) there are buttons for play, stop, jump back, and jump forward. As the pencast plays, the text darkens to visualize where the person is writing.

**Course Description**

As with several NC universities, Appalachian State University is trying to find ways to attract more graduate students. Traditionally, the distance education students meet once a week in the evening at an off-campus location (for example, Hickory or Yadkinville, NC). Our students are typically current high school math teachers. According to a study conducted by EduVentures for the Graduate School at ASU, students in the region want convenient and flexible scheduling. They are no longer willing to drive more than 5 miles to attend class every week for 2 years. The study also revealed that these students want hybrid courses. In other words, they still want some face-to-face interaction with most of the course online.

There are a variety of different types of online courses. Some meet regularly in a virtual classroom (teleplace), or combine the online course with a classroom course using elluminate, while some are completely automated in that students read text and practice problems online. This course is neither of these types. We met twice during the semester at a satellite campus: once the first week, and once about 2/3 of the way through the course. We had no online meeting time. They had weekly discussion questions that they were expected to respond to by Wednesday, and then respond to another students' post by Saturday. They also had weekly assignments due – most of which required the use of a smartpen. Each student was given a smartpen to use for the semester.
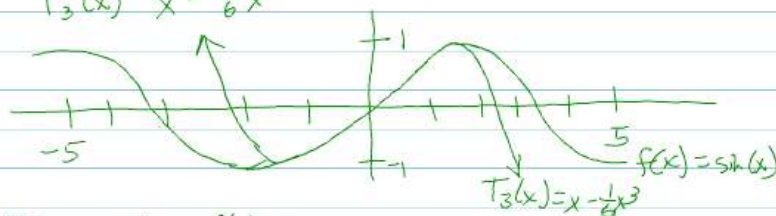
Taylor polynomials and the function $f(x) = \sin(x)$

$$T_n(x) = f(c) + f'(c)(x-c) + \frac{f''(c)}{2!}(x-c)^2 + \ldots + \frac{f^n(c)}{n!}(x-c)^n$$
where $c$ is the base point.

$f(x) = \sin(x)$ at base point $0$.

$f(x) = \sin(x)$    $f(0) = 0$
$f'(x) = \cos(x)$    $f'(0) = 1$
$f''(x) = -\sin(x)$    $f''(0) = 0$
$f'''(x) = -\cos(x)$    $f'''(0) = -1$

$T_3(x) = 0 + 1x + \frac{0}{2}x^2 - \frac{1}{6}x^3$
$T_3(x) \quad x - \frac{1}{6}x^3$



$f(x) = \sin(x)$
$T_3(x) = x - \frac{1}{6}x^3$

$f(x) = \sin(x)$    $f(0) = 0$
$f'(x) = \cos(x)$    $f'(0) = 1$
$f''(x) = -\sin(x)$    $f''(0) = 0$
$f'''(x) = -\cos(x)$    $f'''(0) = -1$    $T_9(x) = x - \frac{1}{6}x^3 + \frac{1}{120}x^5 - \frac{1}{5040}x^7 + \frac{1}{362880}x^9$
$f^4(x) = \sin(x)$    $f^4(0) = 0$
$f^5(x) = \cos(x)$    $f^5(0) = 1$
$f^6(x) = -\sin(x)$    $f^6(0) = 0$
$f^7(x) = -\cos(x)$    $f^7(0) = -1$
$f^8(x) = \sin(x)$    $f^8(0) = 0$
$f^9(x) = \cos(x)$    $f^9(0) = 1$

Figure 1:  Sample Pencast

This course, Computational Math for Teachers, is an elective course for the Secondary Education Masters program.  The content was based on how calculators actually compute and the last third of the course was about valuation systems and computational thinking. We used AsULearn, ASU's modified version of Moodle, for course management.

Here is one example of a discussion question and one example of a pencast assignment. While learning about root-finding methods, they were assigned the following discussion question: A student is using solver (on a TI-83) to solve $0=(x+1)^2$, and gets the error ERR: NO SIGN CHNG. Explain what this means or how you would help your student. There are several types of discussion boards available. For this question, the discussion board used does not allow the student to see other students' posts until that student posts an explanation. One of the assignments was to create a pencast that demonstrates a way to calculate a trig or log value (for example sin(20)). After creating their own pencast, each student watched another student's pencast and used that new method on a problem. Most students ended up using trigonometric identities, although one tried to describe pieces of the CORDIC method to the rest of the class.

**Student Feedback**

None of the eight students had taken an online math course before. Some of their education classes have been delivered online using teleplace. None of them had used (or heard of) a smartpen before this course. All of them agreed that smartpens were easy to use and would be willing to buy one. One student wrote, "I already bought one to post solutions for my own students." They all agreed that smartpens made it easier to communicate math online. And most importantly, they all agreed that using smartpens for assignments helped deepen and clarify their understanding of the math.

**Conclusions**

Smartpens created an effective way to communicate math online. Not only did creating pencasts help students with their understanding, but listening to student pencast helped me understand where they had difficulties. The main benefits were the understanding students gained from explaining their answers and from watching other student pencasts. The primary drawback was that the pencasts were time consuming to grade. Depending on the length of the pencast, it might take 1-1.5 hours to grade and provide valuable feedback. Because this class was filled with current high school teachers, I didn't just grade the math content. I also commented on the words they used to explain the math. One of the reasons for testing out the smartpens was to see if it might be possible to have our entire MA, Secondary Education Masters program to be taken in this hybrid fashion. We have just gained approval from the department to do this. Our next step is to attain Southern Association of Colleges and Schools (SACS) approval.

**Acknowledgements**

**Works Cited**

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