Using Digital Video to Strengthen Student Learning of Mathematics

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Abstract
This paper presents a description and initial analysis of the results of using student-created video products to enhance the mathematical content knowledge of prospective early childhood and intervention teachers. While it is felt that using student-designed video can support learning, there is little research confirming this. This pilot study assesses the value of having students create "video snippets" that model and explain various mathematical concepts through the use of visual representations, explanations, correct notation and vocabulary, and examples and non-examples. This paper includes a discussion of five questions related to the project: Why video? What was the design of the project? What were the desired results? What logistical and technical concerns arose? What actually resulted? The paper concludes with a description of the next iteration of the project, incorporating changes based on the issues arising from the pilot study, and a challenge to researchers to extend our understanding of the potential for the use of digital video in instruction, assessment, and research.

Introduction
The desire to enhance the learning of meaningful mathematics by prospective teachers of young children has prompted mathematics teacher educators to try a variety of methodologies, such as, the use of manipulatives (physical and virtual), cooperative group work, technology, and a variety of other approaches. While the paucity of research on the use of digital video and video streaming on the web (Schwarz & Hartman 2007) is lamentable, it is understandable, as it has only been in the last few years that the devices and means for using them have been available, let alone affordable, on a large scale. With the advent of digital technologies, the questions arise, "Can the use of multimedia act as a vehicle for learning mathematics and, if so, how?" It was with these initial questions of "Can and How" that I carried out a pilot study in the fall of 2008. I investigated one possible answer for supporting the development of meaningful mathematics by prospective early childhood and intervention teachers using the medium of digital video.
This paper includes a discussion of five questions related to the project and its design: Why video? What was the design of the project? What were the desired results? What logistical and technical concerns arose? What actually resulted? The paper concludes with a description of the next iteration of the project, incorporating changes based on the issues arising from the pilot study, and a challenge to researchers to extend our insight into the potential for the use of digital video in instruction, assessment, and research.

Why video?
Originally I wanted to come up with a way to use computers, iPods, or MP3 players that most students have. Looking around me, I saw many students "plugged into" their technology much of the time and I thought that I should capitalize on this situation. Why not have videos that could be downloaded and viewed at any time? I was using WebCT as my class management system, so I wanted to piggyback with that. Why not have students create videos using course content in which they worked with another student to develop their plan-of-action, but each had a different concept or topic to present? In

this way, everyone in the class could learn from each other, while developing critical communication skills needed for teaching. This type of video creation is called "designed video" by Schwartz and Hartman (2007) where designed video is defined as video in which the creator determines the components and features prior to videotaping. Thus, the ubiquitous nature of technology, the desire to meet the students where they are, the ability to make the videos available on-line easily, and curiosity as to the instructional value of using designed video for today's future teacher all led me to pursue the option of the use of digital video.

In addition to all of the above "good reasons" to try using digital video for instructional purposes, I am more familiar than most with the use and analysis of video in an educational setting, having spent three years working on the Mathematics and Teaching through Hypermedia (M.A.T.H.) Project with Drs. Magdalene Lampert and Deborah Ball in the early 1990s. My roles in the M.A.T.H. Project included videotaping classrooms and interviews with students, interviewing students while being videotaped, and completing detailed analyses of video clips, along with other tasks. This experience provided the foundation upon which I based the hypothesis that digital video can provide support for student learning of mathematics. Agreeing with Spiro, Collins, & Ramchandran (2007), I came to see video as a medium "to promote deep learning that results in conceptual mastery and preparation for practice (knowledge application) in complex and ill-structured domains" (p. 93). They also note, "[W]hat you do with video is not as important as why you do it" (p. 94). Based on my evaluation, I felt certain that I had ample reason to choose to use digital video as a tool in this project

What was the design of the project?

The pilot study involved the 65 students in two sections of a Mathematical Foundations course designed for early childhood, intervention services, and middle childhood non-mathematics majors in the fall of 2008. The project was assigned mid-semester, following the completion of another large project. Students self-selected partners to work with, however each student was responsible for creating a stand-alone video snippet. Initially, student pairs selected from a list of approved topics. Those students completing the project later in the semester had fewer concepts to select from, with only a few students needing to carry out the task on an instructor-assigned topic.

Students were given very little guidance, other than an example mini-lesson, a short description, and a simple rubric that included the following scoring information:

Demonstrates assigned concept	_____ out of 5
Presentation Method Effective	_____ out of 4
Provides Multiple Examples	_____ out of 4
Mathematical Accuracy in Presentation	_____ out of 5
Correct Language Usage	_____ out of 2
Total	_____ out of 20

Students were given minimal written instructions, with the first round of video snippets related to alternative computational algorithms

> "You and a partner will be preparing a video presentation that will serve to introduce and explain two alternative algorithms to your peers. The videos will be put onto WebCT. You and your classmates are to view all of the completed videos and become familiar with these alternative computational algorithms by Tuesday, Oct. 14.
>
> Read section 4.2 in the text and study the alternative algorithms handout, focusing particular attention on your algorithms. Prepare a short script and examples that you will use for your presentation. Send the script as a Word document to me by **2:00 pm**, **Tuesday, October 7**. This script will be put onto a teleprompter for your use when taping the presentation at the LTC

[Learning Teaching Center]. It is anticipated that these video will last from 5 to 10 minutes when completed.

Arrive at the LTC e-Media Lab (room 030) ready to do your presentation. You will have access to a dry-erase board on which to write. If you would like to use a SMARTBoard, this is available, but please let me know your interest so that I can arrange this with the Learning Teaching Center staff. John L____ will be the Learning Teaching Center staff member working with pairs as they create their presentation" (Assignment handout, Keen, 2008).

In spite of this minimal description, students energetically tackled the project, with later videos on additional topics, such as, greatest common factor and least common multiple using listing, Venn diagrams, Cuisenaire rods, prime factorization, and geometric figures.

What were the desired results?

The desired results included both instructional and assessment goals. The instructional goals were very different in nature. There were the standard mathematics content learning issues of learning to use visual representations, vocabulary, and notation appropriately. Unique to courses designed with prospective teachers in mind were the learning goals of how to model and explain concepts using examples and non-examples effectively. In addition, students were to gain confidence in their ability to share their thinking about concepts with their peers and, eventually, with young children.

By working in pairs, students were to acquire the social skills needed for constructive collegial relationships. By sounding ideas off each other, pairs would work to clear up any confusion they had about the concepts for which they were to create a snippet.

The assessment goals for the project were stated on the scoring form. I was anticipating that the videos would provide evidence that the students understood the concept, they knew a variety of ways to think about or represent the concept, they could identify correct and incorrect illustrations or uses of the concept, and that they would use correct mathematical and Standard English language.

What logistical and technical concerns arose?

Students selected concepts and signed up for taping times in class. I arranged for them to be videotaped at the University's Learning Teaching Center by a staff member whose job centers around helping faculty incorporate various technologies, particularly video technology, into their teaching. Students worked together to create a plan for their presentations, with one person ultimately responsible for one concept. For example, one student might present on how to use Venn diagrams to find the GCF of a set of numbers while the other would present how to use Venn diagrams to find the LCM of the same or other sets of numbers. In this way, pair-wise preparation could help students clarify what GCF and LCM really represent for a set of numbers. Ideally, students would also include application problems to help set the concepts' uses apart.

The site for videotaping was the LTC's eMedia lab's mini-studio. Students arrived with their peer, prepared with their examples, non-examples, sample problems, and scripted narrative. The plan to have students send scripts prior to their videotaping was not realized as many times students finished their preparation in the twelve hours prior to their scheduled time. This was not a problem, however, as students took this project very seriously and came prepared. The students all used the dry erase board, often using multiple colors to make their representations clearer. After the first few sessions, the videographer (John) made the suggestion to students upon arrival to put an initial example or problem on the board to facilitate their work.

After their lessons were videotaped, John minimally edited the tapes, placing titles on each, and placing a digital version on the University's streaming server with links to the video placed on the WebCT course site. There, students could view all of the videos, picking and choosing which to view based on their study needs.

Toward the end of the semester, when only a few students had not completed the assignment, these students went to the LTC individually to complete the task. Interestingly, two of the four of these individual sessions resulted in the only videos that had significant mathematical errors in the content. These individuals had not worked with another student, providing evidence that the structure of assigning concepts pair-wise was advantageous. One student decided not to complete the assignment at all, knowing that she was changing majors and she was not concerned about losing the credit for the task.

What actually resulted?

The results indicate that students valued the assignment as an instructional exercise and tool for learning mathematics, as well as an assessment task proving evidence of their competence and confidence with the mathematical concepts. With minimal boundaries imposed as far as structure, length, or protocol, students met the challenge of working outside of class to create a tool for others to view and use to enhance their understanding of the mathematical content of the course.

For several taping sessions, I sat in a remote spot of the eMedia lab, shielded from the students' view. I wanted to get a sense of how the assignment was being interpreted and to be assured that students were up to the challenge. In one of the later sessions, I heard a student use vocabulary incorrectly, using the word "factor" when she meant "multiple." This is a common problem and one that many students do not see as critical until they consider the role they will be playing in their future classrooms. I did not interrupt the session, but, while the student's peer was preparing for her session, I took the student aside and asked her what we should do about the situation, i.e., her using factor and multiple interchangeably. She was not sure what her options were, so I asked her whether she would like to offer up a challenge to her classmates to "Find the Error." I suggested that she write a brief Word® document that could be uploaded to the WebCT site in which she asked classmates to find the error, not identifying which tape it was on, and indicating that the first person from the class to e-mail the instructor with the correct answer would receive extra credit points. She agreed to this, thinking it was a great idea.

The challenge to find the one student's error turned into a wonderful way to determine if there were any other quality-control issues with which to deal. I did not do careful screening of the tapes, so this turned into a great way to get students to view the tapes, listen to appropriate use of vocabulary, and identify when vocabulary was misused. Students found one additional instance of vocabulary misuse (again, factor-multiple), making this mistake very real to them.

I was not sure how I would know whether students used the videos to study for tests, but I need not have been concerned. After returning a test for which videos had been created, several students approached me after class indicating that they did not understand why they had lost credit on one of their responses when, "We did it just like on the video!" I accepted their tests back and went to revisit the video. In fact, they were correct. The presentation student had made motions with her hands indicating how she had completed a partitive division problem, and the visual answer to the problem on the dry erase board just showed the groups' contents after "passing out" cookies in the problem. I had expected my students to show this motion of passing out the cookies in their visual representation with arrows, but students had drawn it like the video example showed. I agreed that they had made their case to receive credit and told them that they needed to indicate the passing out of cookies in some way on their papers if they were asked again.

Since my students are learning to become teachers, watching their own mathematics lessons on videotape helped them with their own teaching skills. By viewing others' tapes, students saw alternative ways of presenting the concepts, providing them with more flexibility to represent concepts in ways that make sense to children.

What next and how?

Following the semester in which the pilot study took place, I submitted and received a grant funding the purchase of a digital video camera, a tripod, memory and an external hard drive to store the videos created in the future. My plan is to spend time editing the original videos so that student's names are undecipherable or removed and the quality is assured. Then, in subsequent semesters, students will work in pairs or groups of three or four to create videos to add to the existing bank of videos. Groups will be expected to do their own videotaping and quality control, with undergraduate teaching assistants (TAs) being the second line of quality control. After the group's approval and the TAs endorsement, I will grade the videos and add them to the bank of content videos available for students to use as study tools. In this way, issues of quality control that arose in the pilot study will be addressed. The problem of an individual student's lack of participation and errors in content will be reduced through this process of group to TA to instructor production. There will be an occasional student who has difficulty completing the task, but this will be minimized.

The larger goal is to create a virtual library of videos that can be used in professional development of preschool and primary-grades teachers. Initially, this will be accessible only by students in my classes or by those individuals I approve for entrance to the web site associated with the virtual library. Putting the videos as streaming video on the University server will need to be handled initially through John at the LTC with a shift to instructor-uploading, if possible, in the future.

With the wealth of video examples now available from the pilot study, a few videos will be used as models for new students, rather than watching an instructor-created video. This will provide evidence to the new students that they are able to author and produce creative, informative, and useful video for their classmates and future students.

The instructional and assessment goals that I held for this project were met and exceeded. As the designer of this task, my intentions included the goal that my students experience all four of the common learning outcomes laid out by Schwartz and Hartman (2007): Seeing, Saying, Engaging, and Doing. I "scratched the surface" of the potential of video for instruction, assessment, and research into these common learning outcomes. With the accessibility of video technology today, I challenge researchers to investigate the promises and pitfalls of the use of digital video, particularly as it is tied to the web, knowing that many of the members of younger generations are moving beyond the web as some "old-times" are just now becoming comfortable with it. Digital video has many working environments (e.g., iPods, telephones, MP3 players), and there is much more to study and learn about the use of this medium.

References

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