Student Engagement during Pen-based Media Making Projects: Constructing in Constructivist/Constructionist Classrooms

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Abstract: This paper and poster describes evidence of high student engagement in mathematics classrooms using pen-and-tablet technology for media-making. The presentation will explain theoretical constructs embedded in pen-based digital media-making projects through the lens of sociocultural learning theories. Data presented were collected from National Science Foundation-funded digital media summer institutes held at two high schools in a two large urban school district in different states located in the United States. They were transcribed, coded, and analyzed by a large research team. The goal of this research is to establish protocols for understanding learner engagement. The team's research findings found that student engagement increased due to the combination of constructivist, constructionist, and computer-supported collaborative learning. In addition to the theoretical underpinnings, this presentation focuses on the processes by which an increase in engagement occurs.

Introduction

In an information-saturated society, finding a word to describe the knowledge of learning remain elusive (Papert, 1996). Terminology such as pedagogy, didactics, and heuristics describe the art and methods of teaching, instruction, and problem-solving, respectively. However, Papert (1996) writes that there is not a clearly definable term for the art of learning. The art of learning remains, in Papert's words, "an academic orphan" (p. 9).

Papert advocates the use of the word "Mathetic" to represent "knowledge about learning" (p. 10). Accepting Papert's vocabulary, our paper advances a process to attain "Mathetic Engagement" for students and teachers. The mediating agent in Mathetic Engagement is pen-based digital media-making.

The primary goal in this context is to understand the implementation of pen-based programs towards students' educational outcomes. The term "educational outcomes" in this paper means understanding when students and teachers are engaged in pen-based digital media making. In this scenario, pen-based digital media making in situ will allow us to see the application of socio-constructivist theory in the reflection of high school mathematics students as they interact with the innovation. Socio-constructivism yields insights in the positive and negative experiences of students as they create videos collaboratively with teachers.

Socio-cultural learning principles create and maintain student engagement through the development of digital materials using pen-based technologies. The goals of this paper are three-fold. First, this paper will illustrate the positive mathematical and multimedia outcomes on student engagement while students use pen-based and digital

media-making. Next, this paper and poster describe constructivist and constructionist learning theories and how the positively impact students who seek to learn complex concepts. Finally, this paper and poster advocates that the most effective collaborative learning environment involve the interplay of technology, students, and teachers.

Substantive Background Information

The purpose of this paper is to show how the collaborative media making process catalyzed by pen input for mathematical writing engenders a new way of characterizing and understanding the concept of peer/learner engagement, with theoretical underpinning and connections to empirical research literature. We want to show that much of the early theoretical constructs are consistent with the experiences reported by students in reflective exit interviews. We also see socio-cultural concepts of learning emerge from the qualitative data collected during summer 2015 from high schools students and teachers in two western U.S. states.

Our snapshot of data reflected in this paper is part of a larger accumulation of workshops that have been running for several years. Students are recruited by teachers who previously participated in previous workshops or who show interest in creating videos as a part of helping peers to learn. Students participate in a 5-day workshop from 9:00 a.m. - 3:00 p. m. each day. Students are given tablet devices (Bamboo tablets or tablet computers with pen input capability) and video capturing and editing software (Camtasia). With these tools, they learn how to create mathematics tutorial videos. Having learned the basics of how to use the tools in the first day, students are asked to select a mathematics question/problem and produce a short 3-5 minute video that shows how the question or problem is solved.

As the workshop progresses, students script what they want to convey in their videos, choosing which digital resources such as pictures/audio they will use. Students then edit and enhance the video in creative ways, which reflect the individual preferences and learning styles of the student videographers. Examples of creative video features include speed alterations, call-outs and zoom-ins for emphasis, audio overlay such as narration, background music for fluidity etc...

The Significance of the Pen

Digital pen input enables students to handwrite the solution process and record the screen. These steps demonstrate how the solution to the mathematical problem is reached. However, this is not just about the impact of creating videos as a way to learn subject specific content. The pen input plays a significant part of the creation process because it concerns mathematical writing. Fluid mathematical writing is achieved through handwriting, which software like Mathtype or other mathematical symbol input does not provide (Hamilton & Harding, 2010). The iterative design process, which includes handwriting mathematical concepts using pen-based technology, recording concepts, and presenting the finished product for peer review, is highly engaging and conducive to learning.

Workshop sessions are typically followed with lesson study, or peer group critique. These peer review sessions combine critical and constructive feedback on the videos. The peer review process is a scaffold for continued iterative video design improvement. Through the years, peer teaching and collaborative learning have increased. The digital media videos that explain mathematical concepts are the result of peer-to-peer, peer-to-teacher, and teacher-to-peer collaboration. The workshop continuum's life cycle reflects the application of three socio-cultural theories: experiential learning (Dewey, 1938), constructivism (Vygotsky, 1979), and constructionism (Papert, 1980).

Literature Review

Dewey (1938) argued that a teacher's job was to select "experiences" that supported future educational activities and allowed learners to transfer skills and knowledge from one learning task to the next. He recognized that much of what we learn is unintentional, and may be more important than the outcome expected by the teacher. He believed the role of teachers was to guide the learner through the use of objects and materials provided by the school He argued that the teacher's job is to create an experience that "arouses curiosity, strengthens

initiative, and sets up desires and purposes that are sufficiently intense to carry a person over dead places in the future…" (p. 14).

Technology and the incessant speed of new information demanded new methods and models to capture and retain students' attention and engagement. Robert Leamson declared, "The really difficult part of teaching is not organizing and presenting content, but rather doing something that inspires students to focus on that content to become engaged" (Saulnier (2009). Connective applications such as tools, language, and interaction between experiences and engagement fulfill the needs of 21st-century learning.

The tools a learner works with as he/she learns are the essential items for development of learners, according to Vygotsky (in Van der Veer & Valsiner, eds., 1994). From the earliest ages, learners use tools and symbols (such as language) to negotiate their social environments successfully. Unlike his contemporaries, Vygotsky did not view the learner as a vessel of completely self-directed growth, but, instead, attributed the learner's development to his mastery of the tools of his culture. The tools themselves carried cultural knowledge.

Student responses following the pen-based, digital media-making intervention reflect positive experiences of computer-supported collaborative learning. "I have learned that a student learns best from another student," said one senior. Another student reflected, "The first time I dived in (sic), I was introduced into working with teachers during my senior year. It was a bit awkward at first but things were eventually comfortable and enjoyable afterward. Instead of master and student, or boss vs employee, it was a partnership, that we needed each other in order to achieve a common goal, and that was a different sensation than just accomplishing for the sake of accomplishing. This was consistent throughout the year and I grew comfortable working with teachers."

Teachers who participated in the pen-based, digital media-making intervention concur. "In collaborating with (the student), we were able to find good ways to still incorporate guided-inquiry learning with using videos. Some of the videos will be used in a semi-flipped class. Students will do an inquiry-based lab first, then the video will put vocabulary terms to what they just learned from the lab. In science, they found that reinforcing ideas found in a lab is better than introducing concepts first and using the lab to reinforce them," said a teacher-mentor at the urban high school campus.

Papert (1980) envisioned learning experiences without curriculum or lesson plans, built, instead, upon collaborations of ideas between teachers and students. He urged teachers to be aware of the cultures students bring with them to classrooms and use the most dynamic of cultural trends to engage students. Papert held the computer, above all other tools, as a way for students to create artifacts important to them. Students in this study used computer tablets to create these artifacts.

Papert lamented the early use of computers as "presenters" of information rather than creative partners in learning. Jonassen (2005) found himself lamenting the same issue twenty-five years later when he called for educators to eliminate the computer as a tool for teachers and hand them over to students for their use. His notion of the computer as a cognitive tool was based on the idea that the learner could use a computer to construct an externalized representation of his thinking, as well as create new knowledge with it. The digital media produced in this workshop represent each student's thought processes as they solve mathematical problems, viewable by their teachers and peers.

Reflecting Papert's emphasis on technology's constructionist partnership, the computer and video creation software are an important component of the previously noted technology-mediated collaboration (Kozma, 2003). Traditionally, collaborative activities are defined as those, "where students discuss and manipulate a shared artifact face-to-face, can see each other's actions and make attributions, and can make gestures to establish coreference and work to evolve a shared interpretation" (Moraveji, Lindgren, & Pea, 2009, p. 65). The computer functions as a third participant in the collaborative, learning relationship. This relationship forms the computer mediated, collaborative bonding for deep learning to occur. It is the computer-mediated interaction in situ that produces student engagement with challenging math concepts and media-making.

To an outsider, this process may look scattered and chaotic. It is not. Students utilizing pen-based, digital, meaning-making, are iteratively engaged in "performance practice" (Zeeman & Lotriet, 2013), communicate in dynamic, yet informal ways. Moraveji, Lindgren, & Pea (2009) described their interactions as "organized mischief."

Feedback plays an essential role in the learning process (Artino, 2008). Not only are students giving and receiving feedback from each other, they are also receiving feedback from teachers and the computer software as well.

Teachers' experiences reflect positive outcomes too. One teacher concluded that intense student engagement increased student empathy, "(the video-making) allows them to see the excruciating process of planning out a lesson and trying to cover all bases." Another veteran teacher noted the engagement potential of informal, peer-to-peer learning with pen-based digital media making, "videos by students for students will capture the attention of a student faster and sustain it longer than a video of an adult trying to understand the best way to teach a student and losing attention."

Recurring themes of engagement from both students and teachers reflect the iterative video-making processes of creating, adapting, peer-review, testing, and sharing content provided the essential "mathematical integrity, pedagogical usability, and presentation quality" (Hamilton, 2011).

- "It's kind of fun for me to do it cause it's like. It's kind of like writing your own like script for like a movie I guess."
- "Making the videos was pretty like fun and it was a good way to learn."
- "It's fascinating to make videos faster."
- "Trying to make the most fun out of it when I'm doing it so it's fun for me and it's fun for them while they're watching the video."
- (from a teacher) "Kids love to make videos, love to get their parents to see what they've done."
- (from a teacher) "Videos are much more engaging than just an audio."
- "It was fun making the videos and being able to like demonstrate that I know how to do the questions I was answering. So that was pretty fun."
- "I like using Camtasia. I feel like it's easy to learn and um, It's just enjoyable."
- "I wanna keep coming here because it gets me excited and distracted from other things that kids be doing, you know."

Through the constructivist, constructionist, collaborative partnerships, students gained increasing facility with mathematical concepts, problem-summarization, questioning skills, and problem-solving skills. Rather than usurping the traditional teacher's role, (Breen, 2000), students pen-based digital media making produced engagement leading to deep learning (Hamilton, 2011, 2013; Hamilton & Harding, 2010).

Methodology

The project engaged two twelve-person student cohorts. Students who were in the tenth through the twelfth grade and enrolled in Algebra II were invited to participate in Mathematics Media Makers clubs and a ten-day media-making institute. Over the course of three years, seventy students were involved in the research activities. The students worked in student teams and also alongside teachers to create localized media that met the local state standards. While making videos, student-tutors and teachers would determine what variables while explaining mathematical problems using Wacom tablets.

Data forming the basis for analysis in this study was collected through semi-structured face-to-face interviews and semi-open-ended online surveys of both the teachers and participants in the workshops. Interviews and survey questions were developed and built from successful interview protocols and survey instruments used by the researchers in similar projects previously, with an eye to collecting data on new topics that had emerged in these workshops.

The participants were asked questions about their opinions on various aspects of the workshops as well some background information on their experience with mathematics and video-making. The interviews were

recorded, transcribed and coded by the interviewers and other members of the research team. Intercoder reliability efforts were conducted through group coding sessions and discussions.

Results

Mathetic Engagement is possible through pen-based digital media-making. Three Preliminary Results emerge from ongoing research by the Hamilton research team:

1. Socio-cultural theories explain why learning is happening in pen-based digital media making
2. Making videos contributes to a quality learning environment
3. Students' video reflections are positive for deep learning and engagement

Evaluations and Conclusions

The goal of this paper highlights the socio-cultural theories relating to student engagement in pen-based, digital media-making. Through use of pen-based technology, students and teachers were provided opportunities for digital media-making. This experience created a pathway for students and teachers to co-create content. Students became participants in the process. Qualitative interview data showed an increase in their concept engagement with mathematical principles. Creating multimedia videos offered students a visualization of complex mathematical principles while learning in a socio-constructivist arena with a more knowledgeable teacher partner. Teachers learned more about video-making in a socio-constructivist arena with a more knowledgeable student partner. Both students and teachers worked with computers as a constructionist tool to think through their learning process and satisfy learning goals. The research continues to leverage validated theories of repeated reasoning, metacognition, constructivism, and constructionism within a shared space to connect with mathematical concepts.

Future Work

Workshops continue for teachers and students on this long-range project. Data collection, transcription, analysis, and results-sharing continues. Analysis of research continues on the topics of student engagement, participatory teaching, and student identity shift as a result of pen-based digital media-making.

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