Creating a YouTube-Like Collaborative Environment in Mathematics: Integrating Animated GeoGebra Constructions and Student-Generated Screencast Videos

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Abstract. This article discusses the integration of student-generated GeoGebra applets and Jing screencast videos to create a YouTube-like medium for sharing in mathematics. The value of combining dynamic mathematics software and screencast videos for facilitating communication and representations in a digital era is demonstrated herein. We share our experience with using these tools to facilitate mathematical collaboration, focusing specifically on the power of GeoGebra for student expression and creativity.
Keywords: dynamic mathematics software; GeoGebra; screencast; Jing; mathematics collaboration; visual mathematics

1. Introduction

A wide range of information and communication tools are available to facilitate mathematics learning in this digital era. In terms of Internet tools, students can search the web to find text- and image-based information (e.g., http://mathworld.wolfram.com) or they can view instructional videos (e.g., https://www.khanacademy.org/). They can also engage more actively by interacting with virtual manipulatives (e.g., http://nlvm.usu.edu/ en/nav/ vlibrary.html) or with tutors at math help websites through the use of text, graphics, and video media (e.g., https://homeworkhelp.ilc.org/).

The shift from Web 1.0, where users were recipients of static information, to Web 2.0, which allows users to create and interact with information on the web, is reflected in a parallel change from teacher-centred to student-centred learning environments (Delich, Kelly, & McIntosh, 2008; Downes, 2005). The focus on student-centred instruction, which emphasizes that students contribute actively to learning, is featured in publications by professional mathematics associations, new mathematics curricula, and in mathematics education research. Piccolo, Harbaugh, Carter, and Capraro (2008), for example, in exploring the nature of classroom mathematics discourse found that "students need the opportunity not only to hear what the teacher is teaching but actually converse and articulate their own understanding of the content being presented" (p. 404).

The National Council of Teachers of Mathematics (NCTM) stresses that student communication is essential in mathematics. It is "a way of sharing ideas and clarifying understanding. Through communication, ideas become objects of reflection, refinement, discussion, and amendment" (2000, p. 60). Similar to the shift from Web 1.0 to Web 2.0 technologies, the NCTM message emphasizes that students should no longer be passive recipients of information, but instead be actively involved in contributing to learning and knowledge development in the classroom.

The NCTM's vision of classroom discourse is reflected in a Math-Talk Learning Community framework that was first articulated by Hufferd-Ackles, Fuson, and Sherin in 2004. This framework appears as a central theme of resources for teachers (Bruce, 2007; Ontario Ministry of Education, 2008a, 2008b) in Ontario, Canada, and has guided our focus on student mathematics communication in the project reported in this paper. A key component of the framework, emphasized in Ontario Ministry of Education publications, is that "in this environment, students as well as the teacher are seen as important sources of mathematical ideas" (2008a, p. 25). In our research we focus on facilitating online digital mathematics discourse that allows students to present their ideas in meaningful ways.

Over the past two decades professional organizations for mathematics teachers (NCTM, 2000; OAME, 1993) have also championed the application of information and communication technology (ICT) to support teaching and learning. In Ontario this focus has been picked up by the Ministry of Education and the use of calculators, computers, and communications technologies is a theme running through all school mathematics curricula (OME, 2005a, 2005b, 2007). Teachers have supported this curriculum thrust and the Ontario Association of Mathematics Educators (OAME) journal, the *Ontario Mathematics Gazette,* regularly reports on classroom applications of ICT in a "Technology Corner" section (e.g., Bourassa, 2012).

Recognizing the rising educational importance of the Internet, the Ontario Ministry of Education has articulated an *e-Learning Strategy* (e-Learning Ontario, 2012). In addition to providing fully online secondary school credit courses, the strategy also encourages classroom-based teachers to adopt a blended learning approach; combining classroom instruction with student opportunities to use online resources and tools for class interaction. Although the professional and Ministry of Education calls for ICT use predated the rise of social media (e.g. Facebook, YouTube, Twitter) by a number of years, teachers are now exploring the use of these channels to support student learning [e.g., Bourassa, 2012]. Our project follows this path; providing a social media-like environment for students' mathematical communication and sharing.

Data on the "Net-Generation" suggest that secondary school students in developed countries, a particular sample set being the Canadian students involved in our project, are experienced with the Web. Across Europe and North America two-thirds of the population accesses the Internet (Internet World Stats, 2012) and of these, over 85% use social media (comScore, 2011). Internet users of ages 15–24 years are the greatest employers of these technologies; on average visiting social networking sites for more than seven hours per month (comScore, 2011). Within this domain, online video sharing, particularly through YouTube, is a major form of interaction (comScore, 2013).

The impact of social networking tools on teaching and learning is demonstrated in research that explores strategies for engaging students in learning through the use of YouTube (Duffy, 2008), considers the potential and pitfalls for using YouTube in education (Jones & Cuthrell, 2011), and questions whether or not Web 2.0 technologies actually facilitate learning (Luckin, Clark, Graber, Logan, Mee, & Oliver, 2009).

In considering what it looks like to communicate mathematically in an online or blended learning environment it is important to recognize the specialized nature of mathematics notation and representations. Hodges and Hunger (2011), for example, acknowledge that communicating with mathematical expressions is more complicated than communicating in other disciplines, but that there are tools available for facilitating communication and collaboration on the Internet. In the example we share below we demonstrate the power of free dynamic mathematics software and screencast software for facilitating mathematics communication online, and for creating a YouTube-like environment for collaboration.

2. Methods and Discussions

This project is part of a larger exploration into the possibilities for mathematics communication in a digital era. Therefore, in this section we first briefly describe how we established an online environment for mathematical collaboration and discuss student responses to this opportunity to share. Then, we focus specifically on how GeoGebra animation and Jing were introduced to students in a Season's Greetings activity. Our intention was to help students develop technical skills in a fun way prior to the holiday season. We elaborate on this approach and discuss how these skills can be carried over to tasks that more directly address mathematics concepts.

3. An Online Environment for Mathematical Collaboration

Three free tools were integrated to create an online environment for mathematical collaboration: (i) a wiki (PBworks), (ii) GeoGebra, and (iii) Jing (see Figure 1).

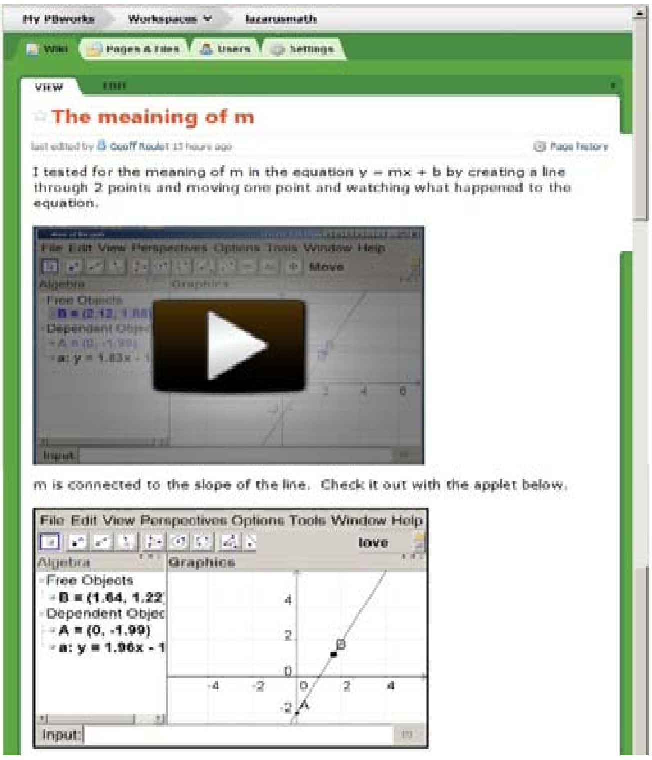

Figure 1. PBworks, GeoGebra, and Jing

Our intention was to extend the use of a class wiki, which was initially treated as a course website where students could access information (e.g., homework, deadlines), to facilitate collaboration in a math-talk learning community. In addition to contributing text to the wiki, students embedded GeoGebra applets and Jing videos which supported more specialized mathematics communication and representations.

An essential first step in this project was to establish a collaborative community in the classroom. This was particularly important since, as Lavin, Beaufait, and Tomei (2008) emphasize, "simply creating a wiki site and telling students to 'interact' (or 'collaborate,' or 'play around') on the site is unlikely to work satisfactorily" (p. 392).

We implemented this project with 23 students (11 males and 12 females) in a Grade 10 Academic (university preparation) mathematics class, taught by Lazarus in the province of Ontario, Canada. The Grade 10 Academic course "enables students to broaden their understanding of relationships and extend their problem-solving and algebraic skills through investigation, the effective use of technology, and abstract reasoning" (Ontario Ministry of Education, 2005a, p. 46). Students explore topics in quadratic relations, linear systems, analytic geometry, and trigonometry of right and acute triangles. This course provided a particularly rich context for study since our goals aligned with the course focus, and GeoGebra proved to be a particularly powerful tool for considering dynamically linked numeric (table of values), graphical, and algebraic representations of the mathematics studied.

Once students gained some experience with participating in a classroom-based math-talk community, and with using GeoGebra in class, we taught them how to embed interactive GeoGebra applets on our class wiki. Then, to support student sharing of more elaborate and creative explanations we introduced Jing screencast software. With Jing, students were able to create videos in which they recorded their screens as well as their own voices. This was particularly valuable when GeoGebra applets were animated. Before providing specific details on this latter part of the project, we present and discuss some of our experiences and the tensions that we and the students faced.

4. Net Generation or Social Media Generation?

Data concerning experience with the Internet suggests that these learners of age 15 years are experienced with communicating and sharing online (comScore, 2011), and should therefore be ready for online mathematical interaction. In the Grade 10 class, students demonstrated a wide range of technological experience, skill, and motivation. Some were quite motivated by the online aspect of the math-talk community and contributed beyond what was expected in the course. Some parents also expressed their appreciation for the wiki. They tended to like having access to course information and although the student work pages were closed to the public, a couple of parents explained that their son/daughter appreciated the wiki and was either showing them their work or expressing their interest in conversations about what they were doing. On the other hand, many students required significant technical coaching, and some were not ready to work through technical complications.

Despite arguments that teenagers have been surrounded by technology their entire lives and are therefore “digital natives” (Prensky, 2001), only a few students in this class actually appeared to be “native speakers” of the digital language of the Internet. They preferred to use the “Comment” option on the wiki for easy responses rather than engaging in the more complex task of editing pages. This is not surprising, however, since data suggest that many teenagers spend most of their time on social networking and video sites such as Facebook and YouTube (comScore, 2011) where less sophisticated short comments and the “Like” button are common responses. In a larger scale study of 2611 students in the UK, Luckin, Clark, Graber, Logan, Mee, and Oliver (2009) also found that students reported high use of social networking and file sharing sites but that their role at these sites, particularly with respect to collaborating, was relatively unsophisticated. Thus, after our experiences with student difficulties and greater reluctance than we anticipated we wondered about the question, Are we working with a Net Generation, familiar with a wide range of computer and Internet applications, or with a Social Media Generation? Introducing student-generated GeoGebra applets and Jing screencast videos allowed for student expression and creativity in an environment that seemed to more closely match their online experiences with social media sites such as YouTube.

5. GeoGebra as an Animation Tool

The animation feature in GeoGebra was introduced in a Season's Greetings activity in the days leading up to our school Christmas break. At this point, students were familiar with using GeoGebra in class and with embedding applets to the wiki. They were also a few months into the course and had various experiences with collaborating, so for this activity they worked in groups of three or four during class time, all working on one computer.

To help generate ideas we showed students a few examples, such as the animated star GeoGebra construction shown in Figure 2.

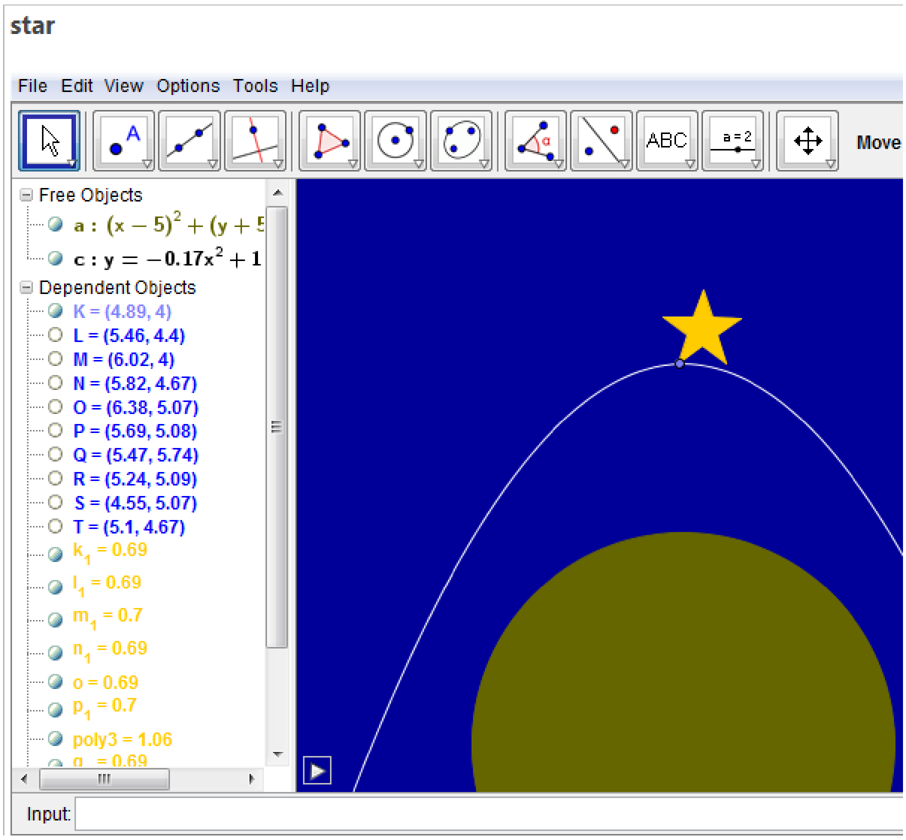

Figure 2. Season's Greetings example: An animated star

In this example the construction of the star originates at a free point on the parabola. The star can then be easily animated to follow the path of the curve by selecting the point with a right-mouse click and then selecting "Animation On" from the drop-down menu. The parabola and the point on the curve can be hidden, but showing these objects was helpful for demonstrating the animation feature in class.

GeoGebra allows users to show or hide views (algebraic, graphic, spreadsheet), objects, and toolbars, and we encouraged the groups to hide anything that did not contribute to their pictures. As the groups were finishing up their GeoGebra constructions we introduced the use of Jing. With this software the students could capture the GeoGebra window on the computer screen, recording the animation in video, and simultaneously, with a microphone connected to the computer, record a Season's Greeting message. Posting of these videos to the wiki allowed the students to share their greetings, as in our model Star video.

6. Student Expression and Learning from Animation

The Season's Greetings animation activity was a key step in introducing technical skills and in developing students' commitment to online expression and creativity. Although during initial tasks with the class wiki we found that students experienced difficulties and showed some reluctance to communicate online, they were actively engaged in expressing themselves through animated GeoGebra applets and screencast videos. They contributed a range of unique and creative constructions, of which two examples are shown in Figure 3.

Figure 3. Animated Student Examples: "Snowman" and "Cookie!"

Various curves were employed in the students' constructions and animations. As in the images shown here, multiple circles were used, but more importantly the groups used different curves for the animated objects. In *Snowman* the falling snowflakes are points travelling along hidden vertical straight lines, while in *Cookie!* the students decided to have the cookie, the brown circle, follow an ellipse as it flew by the Santa Claus figure. This use of a variety of geometric forms provided opportunities for mathematical explorations related to a major theme of the Grade 10 course, that of linear and quadratic relations.

The opportunity for creative expression in this Season's Greetings assignment carried over into subsequent course tasks. In a final assignment for one unit, for example, students were asked to submit their solution to a problem in a form that they felt was most appropriate. Although not all students contributed Jing videos, a variety of creative responses were submitted. Some students still preferred to submit the more traditional paper-and-pencil write-up while others shared GeoGebra constructions along with text and/or Jing recordings to explain their work. One student even explored special effects in his creation of a video using a different type of video software to communicate his solution (Figure 4).

Figure 4. Promoting student expression and creativity

Beyond their school experience many students are experimenting with digital technologies. For some, opportunities to employ their ICT skills and express themselves through creative displays of work can be a motivator for mathematics study.

The potential for learning from GeoGebra animation became clearer to us after implementing the holiday greetings activity. Looking back we realize that time constraints during the period of the activity, and perhaps our focus on supporting the development of technical skills required for future course tasks, contributed to our not taking advantage of some of the rich student-generated learning opportunities.

At the time of the activity, the class was exploring non-linear second degree relations. The students knew about parabolas and quadratic equations but they had not explored other conics such as the circles in the examples shown in Figure 3 and the elliptical path of the cookie. The shapes of the curves that the groups were using and the related equations shown by GeoGebra provided avenues into exploring a wider range of second degree equations. In particular, an examination of the equations related to the shapes constructed using the geometry tools would have shown that all except for the straight lines had at least one squared term, either for x or y.

The groups' desires to produce rather elaborate animations also provided opportunities for GeoGebra skill development. In the Cookie! example in Figure 3, when the group first attempted to animate the cookie they experienced complications. Instead of the cookie moving along the ellipse, it grew very large and actually covered the entire screen—it became an "Infinite Cookie!" Class members, in creating their pictures, had discovered the "Circle with Centre through Point" tool and used this to construct multiple fixed circular shapes such as those shown in Figure 3. In the case of the circular cookie, the group continued employing this GeoGebra tool, attaching the centre to a movable point on the ellipse and having the circumference pass through a fixed point on the plane. In this case, animation of the centre point caused the radius to stretch and the cookie to grow. This unintended and, surprising to the group, outcome motivated an exploration of the other GeoGebra circle construction tools. With experimentation the groups discovered that the "Circle with Centre and Radius" tool generated the effect that they desired—a circle of fixed radius travelling along an elliptical path. Unintended animation outcomes can be strong motivators for exploration—much more motivating than direct instructions from the teacher since the "Why?" question originates with the students themselves.

7. Conclusion

While we experienced some tensions in our exploration of mathematics communication in a digital era and while we viewed the student-generated Season's Greetings activity as essentially a fun way to introduce technical skills, we did find that this task was a key step in the project. In addition to building a YouTube-like environment for collaboration in mathematics, which appears to be more closely aligned with students' online experience, introducing these skills through this activity promoted student commitment as well as a desire to show their self-expression and creativity within a mathematical environment. This discovery may have implications for future research, and for teachers who are using ICT as part of their mathematics instruction.

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