Techniques for Communication, Collaboration and Community in Online Mathematics Classes

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Abstract

The purpose of this article is to provide the reader with a collection of possible tools to increase collaboration and class community among students in online classes, and how instructors can communicate with their classes in such a setting.

Introduction

Online classes are quickly becoming the preferred mode of education for students whose work, family, or lifestyle obligations make attending a face-to-face class at a brick and mortar university difficult or impossible. With online classes students have almost instantaneous access to course materials, video lectures and textbooks. However, what makes an online class live and breathe – and what distinguishes an online class from a correspondence class – is collaboration between students, community of a class, and effective communication between instructor and the students. This article summarizes several techniques for accomplishing these varied goals in the context of online mathematics classes. Interaction among students in online classes has been shown to increase student satisfaction (Rovai, 2002), and can create a rich learning environment (Rovai, 2004; Pomper, 2007).

The discussion is not limited to student success: There are monetary considerations as well. The Department of Education delineates between correspondence courses and telecommunication (online) courses. There are limits on the number of correspondence courses that colleges may offer to students and award financial aid. One of the principal distinctions between correspondence and online courses is "regular and substantive interaction between students and instructors". The results of non-compliance can be dramatic. An audit of St. Mary's of the Woods College (Indiana) in 2012 found that the college improperly awarded $42.4 million in financial aid over a 5-year period, which the Department of Education promptly asked to be returned (Department of Education, 2012). In its report, the Department of Education emphasized that communication between instructor and students cannot be limited to minor email contact, or to posting classnotes or a syllabus, or even to communication between a grader and the students.

Tempting as it may be, it is not sufficient for an instructor to rely solely on publisher created material and algorithmically generated problem sets to be responsible for teaching a mathematics class. In the following, we will consider some techniques for creating community, and ensuring meaningful interaction between faculty and students. Online courses typically rely on the linear entry of text, by way of a keyboard. While this method of text-entry may work very well for most disciplines, we need not elaborate on the difficulty it poses for displaying mathematical formulas. However, the correct use of formulas is often essential in order to guide students to an understanding of mathematics.

Communication

Most educators would agree that the combination of visual messages and the spoken word is a very effective way of communicating mathematics. But it is not the fact that the symbols are spoke that helps the learner understand – it is the explanation of the professor that supplements the written statements. We may recall with trepidations the aloof mathematics professor who copied the mathematical formulae from his Springer Lecture Notes book to the blackboard, while pronouncing all the symbols, but not providing any additional insight. Good teaching is characterized through the professor's ability to rephrase the symbols, to contextualize, and to explain their meaning in different words. The same is true for online classes, where teaching also requires that the professor provide some additional explanations besides the print of the textbook. A well-constructed online class has an additional advantage over the traditional classroom: While the spoken word in the traditional classroom is ephemeral, technology allows the online teacher to archive both the written and the spoken word.

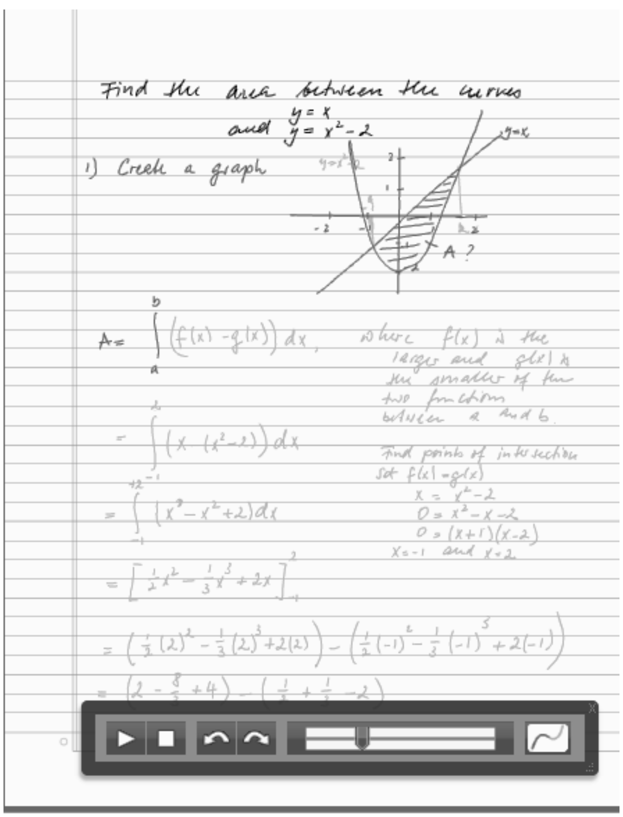

Figure 1: Example of an Echo Pen Sheet

EchoPen

An EchoPen essentially acts as a pen and microphone in one. The pen has a built-in camera and microphone. When writing on specially designed EchoPen paper, the pen records what is being written, and what is being said at the moment of writing. The user may then download a document in pdf format which contains an image of the written page and a recording of what was said when the document was written. As the recoding plays, a change in the color of the written text indicates what the author was writing at any given moment in the recording. The viewer may pause, rewind or fast-forward the video, as needed. The adjacent picture (Figure 1) shows a screen shot of an echo pen lecture. The text turns green as the narration goes on. The reader can easily move the cursor to a specific place in the document to cue to a specific part where additional clarification may be needed.

Short Videos

In some instances, it may be advantageous to create short video clips in order to supplement the course material. This may be particularly useful if the essential aspects include media that is not just writing and speech. For example, we might decide to include an animation, or a jpg image into the video, while the narration is going on. For this kind of media, a self-made video may be useful. However, the producer should keep in mind that the average attention span of an adult is 12 minutes. The length of the videos should be kept under 10 minutes (Pan, et al., 2012).

Animations

Very few mathematicians – and presumably even fewer students – rely entirely on the use of mathematical symbolism in coming to an understanding of mathematical structures. Mental images often allow us to visualize what a mathematical object might look like, even though mathematical objects do not have a physical appearance. An easy example of a mental model for a set is a Venn Diagram. As effective instructors, we can help our students create the mental imagery by providing them with a graphic representation of our own mental model. The strength of a mental model is determined by how well the model is adaptable to recognizing exceptional situation, and whether it is able to anticipate counterexamples. The use of computer animations allows us to provide a visual representation of dynamic mental models.

For example, one baffling problem in a course in naïve set theory is the following:

> Suppose that $\mathcal{Q}$ is the empty family of subset of the real numbers.
> Then $\bigcup_{A\in\mathcal{Q}} A = \emptyset$ and $\bigcap_{A\in\mathcal{Q}} A = \boldsymbol{R}$.

A static Venn diagram may not be able to motivate this sufficiently. However, an animated diagram may begin by showing the intersection of a large family of sets. Then the family is reduced by removing successively one of its members at a time. This results in a larger and larger area being identified as the intersection of the family, until finally the intersection of the empty family is represented by the entire universe.

An online class provides a suitable medium where an instructor can provide animations with dynamic mental models in order to illustrate difficult subjects.

Collaboration and Community

Learning is a social process. Albert Bandura (1977) notes that

> "*Learning would be exceedingly laborious, not to mention hazardous, if people had to rely solely on the effects of their own actions to inform them what to do.*

> *Fortunately, most human behavior is learned observationally through modeling: from observing others one forms an idea of how new behaviors are performed, and on later occasions this coded information serves as a guide for action*."

Students in online classes are often geographically far removed from one another, which makes it direct observations difficult. In order to allow students to observe one another, an effective online class will encourage the formation of communities of learners where this exchange of experience can take place. The following paragraphs provide some suggestions on particularly useful ways of forming community in online mathematics classes.

Discussion Forum

The discussion forum is an asynchronous message board, in which contributions are threaded by time of contribution. The forum therefore lends itself well for the linear development of a solution to a problem. An example of such problems could be a difficult modeling problem in Calculus. It may be too much to ask any particular student to develop the entire solution –from creation of a mathematical model, to mathematical solution of the problem, to providing the correct solution. However, a class of 20 students can collaborate, under the guidance of the instructor, and take small steps at setting up the problem and solving it. It has been observed that a discussion forum in an online class acts as an equalizer, which allows shy students to contribute (Vonderwall, Liang, & Alderman, 2007). The crowd-sourcing approach to solving applied problems in calculus involves the entire class in the solution process, whereas in traditional classes, a professor will usually rely on only a few trusted individuals in solving a problem. Even in cases where students appear to be just nodding in agreement, this virtual interaction still provides a basis for community building (Hrastinski, 2008). In order to illustrate how this crowd-sourcing approach may work in an advanced class, we consider this snapshot from the discussion forum in an upper-division math class (Figure 2).

The different colors in the document indicate different students who contributed to the problem in various stages. The additions were made over the course of 24 hours. Red additions are hints that the instructor had provided. We should note that some students contributed several times. Some contributed only once. Also, students adjust the degree of difficulty in their posting. Some choose to focus on routine algebraic manipulations, while others provide the layout for the entire induction proof.

Prove: $3+11+19+\ldots+(8n-5)=4n^2-n$ for all natural numbers n.

Let $S=\{n\in\mathbb{N}\,|\,3+11+19+\ldots+(8n-5)=4n^2-n\}$ (we have defined S to be the set of natural numbers for which the statement is true. We show the statement is true for all natural numbers by showing that $S=\mathbb{N}$)

Start: By substitution, 3=4(1)^2-1, so $1\in S$

Inductive Hypothesis: Let n be a natural number such that $n\in S$.

We therefore obtain that $3+11+19+\ldots+(8n-5)=4n^2-n$

(we show that $n+1\in S$, that is, we need to show $3+11+19+\ldots+(8n-5)+(8(n+1)-5)=4(n+1)^2-(n+1)$)

LHS: $3+11+19+\ldots+(8n-5)+(8(n+1)-5)=$ <--- By Inductive hypothesis

$= 4n^2-n+(8(n+1)-5) =$

$= 4n^2-n+8n+8-5$

$= 4n^2+7n+3$

$= 4n^2+8n+4-n-1$

$= 4(n^2+2n+1)-(n+1)$

$= 4(n+1)^2-(n+1)$

This shows that if $n\in S$, then $n+1\in S$

By the PMI, $S=\mathbb{N}$. That is $3+11+19+\ldots+(8n-5)=4n^2-n$ for every natural number n

Figure 2: Example of a Proof in a Discussion Forum

WIKI

A WIKI is a document that all member of the course can edit. In contrast to a discussion forum, there is no threaded record of the conversation. The advantage of this medium in creating class community is that students can directly insert a comment at any place in the document, and may later retract this comment if needed. The WIKI may be used for collaborative assignments, such as a lengthy problem. However, the WIKI's advantage is for problems where students are asked to comment on an existing document. For example, a major objective of many upper-division math courses is to determine whether a given sequence of statements is a valid proof. Here, the instructor may provide the WIKI with the questionable statements in it, and students can add their comments at any place in the document, annotating it as if they were grading a paper.

Small Group Assignments

In large classes with more than 30 students, the discussion forum or WIKI can often become cumbersome. In this case, it is often best to create assignments in which students work with a small group of peers. This selection process may be random, may be based on the student's performance (deliberately creating a mix of abilities in each group), or it may be based on student self-selection based on the time of the week when the students prefer to contribute to their group work.

An instructor may decide to split the discussion forum into several parts, but then would need to monitor and lead the discussion each of the forums. This work may then be delegated to a graduate assistant whose task is to prevent the discussion in their forum from stalling. An instructor may also choose to assign projects to each group. One caveat about this technique: Unless there are clear expectations for collaboration, students may simply decide to divide the problems of the project (Student A does problem 1, student B does problem 2, etc.) and then forgo the group-discussion of the problems. If a group assignment is to be effective, it must be designed in such a way that students cannot easily divide the work up into individual assignments that can be solved independently of one another.

Peer Review

The concept of peer review is a powerful teaching tool: Students could be asked to exchange homework assignments, and should provide comments on this assignment. A selective pairing of students may allow the instructor to counteract a student's perception that "nobody is getting it", when in fact this student is presented with a variety of work by peers who are in fact "getting it".

An example of a peer-review assignment from a course in Real Analysis asked students to review the peer's proofs, and indicate any flaws in the argument. If there were no flaws, the students were asked to suggest how the proof could be improved. The instructor also provided feedback, and both peer review and instructor's review were given to the author of each paper for a chance to improve the assignment. While this method can produce good results, there are significant logistical obstacles in keeping track of peer reviewers, and making sure that the reviewer returns the paper on time, so that the original author can make the revisions.

The Synchronous Element

Distance education classes allow students to participate in class from anywhere in the world (provided that there is a sufficiently reliable internet connection). Many distance education classes are set up for asynchronous participation: Students may have weekly or bi-weekly deadlines, but are otherwise free to decide at which time of the week they contribute to the class. This is contrasted with the strictly synchronous Monday-Wednesday-Friday 10:00-10:50 am schedule of a face-to-face class. While many online students cherish the relative freedom of asynchronous discussions, there are some cases when a synchronous conversation is more effective. Al-Shalchi (2009) observes that adding a synchronous discussion to an online class may increase some students' inclination to participate in discussion.

Depending on the nature of the class, a synchronous element may be a chatroom, or may be a video link, which allows the instructor to transmit both audio and video to the students. The image in Figure 3 shows a screen shot of one such system: The instructor has a high definition webcam focused on a writing pad and provides written and verbal explanation, while students participate by typing in the chat field. If needed, the instructor can allow individual students to speak.

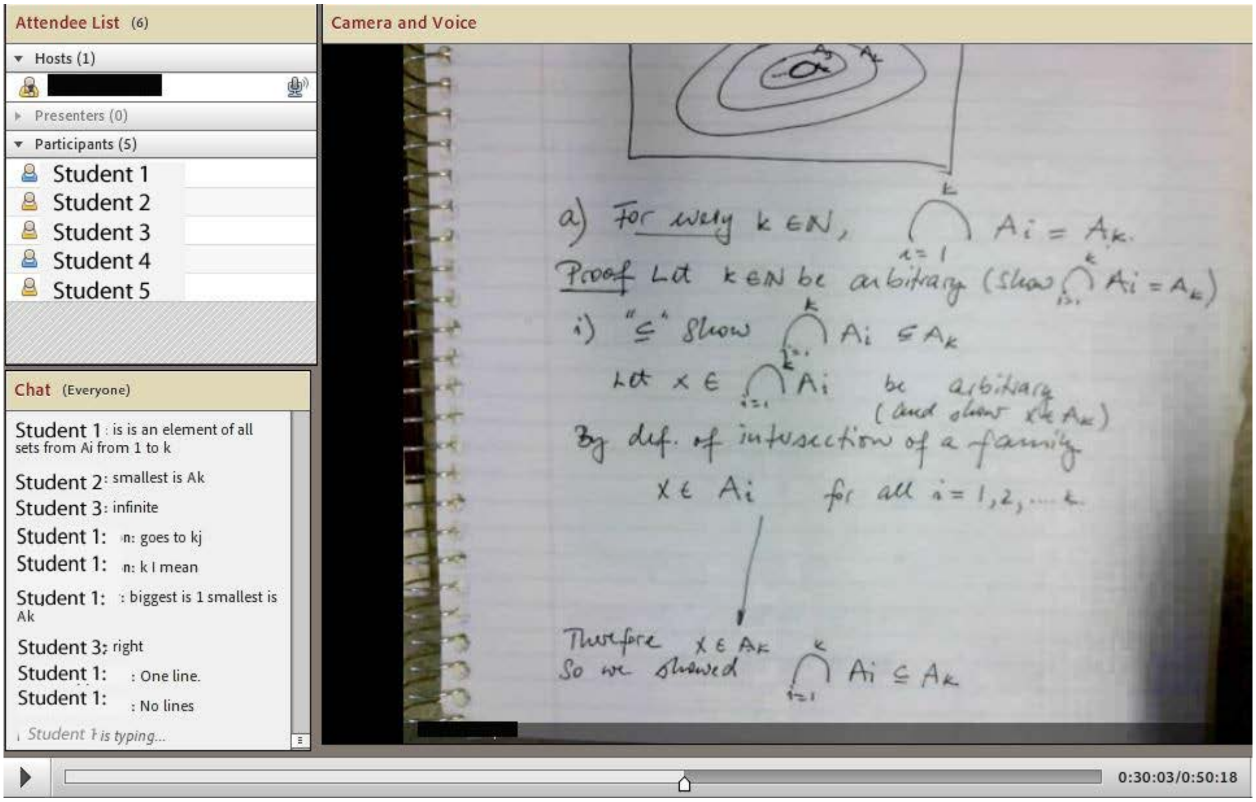

Figure 3 Screen Shot of a Live Discussion

Conclusion

Online courses come to live (and meet the legal requirements of the Department of Education) when students interact with one another and with the instructor. This interaction may come in different forms – just as each instructor their own teaching techniques in the classroom, online instructors must choose methods for engaging students that meets their personal style and the objectives of the class.

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