

## USING ONLINE DISCUSSION BOARDS TO FOSTER MATHEMATICAL DIALOGUE

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In recent years the use of communicating and writing mathematics has become a hot pedagogical topic. This fire has been fueled in part by positions taken in national documents such as the National Council for Teachers of Mathematics *Principles and Standards for School Mathematics* (2000) and the *Undergraduate Programs and Courses in the Mathematical Sciences: CUPM Curriculum Guide 2004*. The NCTM recommends that school instructional programs provide opportunities for students to develop their mathematical thinking through communication and using mathematical language to carefully explain mathematical concepts. They suggest that writing in mathematics can help students organize their thinking because reflecting on their ideas helps them to clarify their thoughts. The Mathematical Association of America's Committee on the Undergraduate Program in Mathematics (CUPM) echoed this call when they issued the *CUPM Curriculum Guide 2004* as a collection of recommendations for mathematics departments in designing curricula for their undergraduate programs. The *CUPM Curriculum Guide* provides six general recommendations for mathematics departments; the second of which is "develop mathematical thinking and communication skills" (2004, p. 13). They suggest that courses and programs should foster students' ability to "read and communicate mathematics with understanding and clarity" (2004, p. 16).

The online discussion board is a natural vehicle to facilitate mathematical dialogue and create a community of learners with online collaborations that supplement and complement in-class discussions with a flexibility that transcends class time. Online discussion boards are an excellent partner in a marriage to a wide array of mathematical writing assignments. In communicating mathematical ideas or justifying their reasoning to their peers, students gain insights into their own thinking. Peer to peer learning is enhanced as students are learning from one another as well as from the teacher. Each student has the same opportunity to contribute to the discussion. Students too reticent to speak up in class may find their voice in this time-delayed environment. Additionally, student misconceptions can be identified and addressed. Students are not restricted to the boundaries of class and may access and submit messages anytime from anywhere.

Using online discussion boards to discuss mathematics gives students the opportunity to test their ideas and to see whether they can be understood and sufficiently convincing. Thus helping students to come to an understanding as to what constitutes evidence, as recommended by the NCTM (2000). The asynchronous nature of the discussion boards means that students have time to organize their thoughts and ideas before publishing their

comments. This allows for more reflection that can serve to improve their writing and the quality of their mathematical reasoning and critical thinking. This is supported by Newman, et al (1995) who found a relationship between critical thinking, social interaction, and deep learning. Students in the computer-based interactions exhibited significantly deeper overall critical thinking measures than did students in the face-to face interactions.

The electronic platform provides a conduit for mathematical discourse in a wide gamut of classrooms settings from college to high school, spanning traditional classrooms to distance learning courses. Some schools have adopted electronic educational platforms such as those offered by Blackboard™ or WebCT™. These course management tools allow instructors to post course information (assignments, grades, etc.) and facilitate course related discourse using discussion boards. Particular software packages are not necessary as numerous other options, ranging in price and focus, are available on the internet. Online discussion boards are even supported by the group feature in Facebook™. Interested parties could also construct their own discussion boards. Directions can be found online or one can enlist the assistance of a local web expert. Mathematical type-setting is becoming easier with increasingly sophisticated mathematical software. Evolving technologies include online discussion boards in which the participant can easily publish video files as well as traditional word processing and spreadsheet files transforming the electric platform from a purely text-driven medium.

In this paper several versatile writing assignments are presented. The assignments include structured and unstructured models that are easily adaptable and transportable to a variety of mathematics classroom setting and have been used to facilitate student engagement and interaction outside of the classroom. Suggestions for variation and assessment are included as are future projects.

#### Class Notes and Directed Questioning:

There are a variety of models for using online discussion boards to publish class notes. In this example, students in a course for prospective secondary teachers present the material from assigned section(s) of the course textbook, *Mathematics for High School Teachers, An Advanced Perspective*, by Usiskin, et al (2003). These presentations consist of a class presentation and a set of class notes for their section published on Blackboard™. Students are further responsible for fielding questions from the class and the instructor on their material. The class notes should contain all of the important concepts and relationships, definitions and theorems, with illustrative examples and/or proofs as appropriate. The presentations are to be brief but clear and careful overviews of the material in the assigned section(s). The details and justifications arise naturally from the questions posed or with some prompting from the instructor in class discussions. Student presentations also include a 3-2-1 Reflection: 3 things you learned from the section, 2 questions you have about the concepts and activities, and 1 connection between that class and either the real world/daily life or what you will be doing as a teacher.

This assignment is easily modifiable and can be used in different forms in numerous mathematics courses. The class notes assignment described here is largely unstructured but is easy to adapt or provide more structure with additional direction or directed questioning. Using directed tasks or problem/question posing can take virtually any form and may be integrated throughout a course or used in specific circumstances. An open-ended form of directed questioning was incorporated into the previously described class notes assignment. The intent was to stimulate in-class and online dialogue and to ensure that students were prepared for their peers' presentations. In this case, "audience members" were expected to have read class notes for each section for understanding and have at least three questions prepared for each section other than their own. At least two of these questions were posted online, so that each audience member would have at least one question for the presenter at the time of the presentation. This gave the students multiple media through which they addressed questions, thereby honing both their written and verbal mathematical explanations. Furthermore the online discussion boards gave students the chance to follow-up on the in-class discussion with clarification (as needed) and afterthoughts (as appropriate). In this case the questions were originated by the students, but the instructor can pose her own questions to which the students can respond.

Online discussion boards are also used as an "overflow" for class dialogue when in-class discussions get too lengthy. Students respond to questions stemming from class discussions, offering follow-up comments and questions. Typically questions have been posted by the instructor, but in future iterations more onus will be placed on the students (with guidance by the instructor) to be responsible for starting threads to continue classroom conversations. Alternatively, students could respond to prepared discussion questions, perhaps coupled with a reading assignment or problems from the text or general problems of interest. Additionally, the 3-2-1 reflection is easy to adapt and appropriate for many levels as a guided self-assessment of reading comprehension. For more information on the 3-2-1 reflection, please see Zygouris-Coe, et al. (2004). Another strategy for getting feedback after class is by requiring students to address questions often posed in the "minute paper" as described by Angelo and Cross (1993).

Several additional variations for the use of online discussion boards to publish "class notes" or facilitate student response to directed questioning exist and others are easy to generate. Some examples include student summaries of lecture notes, specific notes on current or review material with detailed examples, or solutions to problems (computational or theoretical). For additional information on the use of these types of writing assignments see Johnson and Green (2007). Additionally, see Spitznagel (2007) for a nice discussion of student use of online discussion boards to publish solutions to theoretical problems. Spitznagel's results suggest that using this writing assignment helped even struggling students to improve the quality of their mathematical writing. The online record resulted in problem solutions with revisions as well as careful critiques by classmates and the instructor for the benefit of the whole class.

### Looking for Mathematics (in the Real World):

Students use online discussion boards to publish observations about the course content that they find in their everyday lives. This is a very open assignment. Observations can come from other courses or non-academic contexts. Students hone their communication skills by writing about the mathematics in the world around them, which promotes active learning and writing across the curriculum. Students publish a wide variety of real-life situations in which they have found mathematical concepts studied in class. They respond to peers' observations, modify the scenarios of others to make a different comment, and extend or generalize the original comment. Students also pose their own questions to which their classmates can respond. Upon trying different variations, my preference is for discussion board forum topics that parallel course content. So in a course focusing on differential calculus, forum topics might include function families (for example: power, exponential, trigonometric, logarithmic, and general functions) the derivative, and the definite integral. Student comments are assessed on the quantity of submissions and the quality of a variety of factors including: mathematical content, mathematical language, clear and thorough explanations, spelling and grammar, and appropriate citations (when applicable).

This activity has become a perennial favorite for the students and the professor – from the calculus sequence to courses required for prospective teachers. Although classroom activities were no more grounded in real-life applications than in other semesters, students who have been required to write about mathematics demonstrated a widespread appreciation for the applicability of mathematics. This assignment is a student-centered authentic writing assessment in which students experience mathematics in context, as suggested by the NCTM *Principles and Standards for School Mathematics* (2000). It can meet any or all of the process and content Standards. The only content requirement is that the mathematical content is easily related to or identified in real-world phenomena. The students' background and teacher's learning objectives guide the use of online discussion boards to promote mathematical dialogue. Directed questioning can be employed to focus students' mathematical observations or facilitate electronic discourse between the students.

### Student and Instructor Feedback:

End of the semester feedback is collected in which students speak to which course components they found least/most valuable to their learning and suggestions for improvement. Space prohibits more than just a sample of student feedback. Student comments are presented verbatim and are generally representative of student feedback, with the following caveat in the "looking for mathematics" assignment. Because of the open-ended nature of this assignment, students can be hesitant to make their first post, largely because they think that they don't know what is required. Once students' fear of publishing a "wrong answer" is assuaged, the conversation can really get going.



"I really think that looking for math in real life situations is helpful. There really is math everywhere and having us post them on blackboard as a good idea. I think that there is especially a lot of statistics and probability to look at. This is an effective method for teaching, as well as for us teaching younger students."

"Blackboard postings allowed me to publish thoughts while I was thinking about them and gave me an additional way to practice communicating mathematical concepts. There is a surprising amount of math I encounter through other studies and then, don't have a chance to share it, so this was a good outlet."

I encourage you to experiment with using online discussion boards to support mathematics writing in your classroom. There are many ways to create writing assignments using online discussion boards and almost as many ways to assess student work, but discussions are enhanced when grades depend on regular participation. Evaluation and assessment can be light or it can be complex and both have their relative advantages and disadvantages. Beginners may prefer a shallow dip in the online discussion board pool, but points allotted should be commensurate with your expectations of student effort and work. It is useful to discuss assignment details and assessment criteria in class and online so that students have the chance for clarification as well as an electronic record. Additionally, general information about what quality postings should and could include, as well as specific examples of exemplar work are given so that students have "model examples". Anonymous postings are discouraged for two reasons. One is the grading logistic and secondly there is also a greater accountability in student responses. Furthermore, when students are working in groups it may be necessary to remind students that each student should publish using only their own account. Lastly, students can be reluctant to submit messages initially, so it helps to break the ice with an "introduction" message. No mathematical content is required as the intent is to increase students' comfort in this online environment.

The next experiment will be to revise an article reflection assignment for an online discussion board medium. The article reflection assignment was originally used in a math content course for prospective elementary teachers. The objective of the article reflection reading/writing assignment was to use content focused educational resource readings coupled with directed questions to develop students' mathematical discourse. The rationale is to use the online discussion boards to "continue the conversation". Mathematical misconceptions can be addressed as well as struggles that students may have in seeing the instructor's role in facilitating student understanding. As an example, prospective elementary teachers supported the use of manipulatives as a means to better understand concepts, but did not speak to the teacher's role in facilitating student learning. In particular, they did not recognize the teacher asked questions to spur discussion and draw out students' reasoning. By ignoring the role of question posing, students overlooked one of the most powerful tools at their disposal.

Using online discussion boards for mathematical writing assignments gives students the opportunity to evaluate others' mathematical thinking and to communicate mathematics. This helps students to organize their own mathematical thinking as is recommended by the NCTM in *Principles and Standards for School Mathematics* (2000). Students use online discussion boards to communicate mathematical ideas in contexts that interest them. This in turn promotes a community of learners reflecting the different interests, abilities, and learning styles of the individuals that comprise the community.

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