

Beautiful Homework: The Artists' Critique Group in the Mathematics Classroom

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Abstract:

One never knows where one will find inspiration. In the following article, I will discuss my attempts to use an artist's critique group model to combat specific problematic behaviors in the teaching and learning of mathematics, particularly at the upper division level. In an effort to show the students producing disorganized work that it was truly possible for a student to create clean, readable, and beautiful work, I began searching for a way to share the best student products with all students in the class. This led me to create an electronic repository for the work produced by each student in the course that allowed all students to see each other's work and my comments on that work. Ultimately, this structure fosters asynchronous cooperative learning.

1. Frustration as the Mother of Invention

After slogging through years of homework produced by students in upper division mathematics courses such as algebraic structures, advanced linear algebra, and real analysis, I noticed a trend that intrigued me. Most, though not all, of the successful students prepared proofs that were easy to read and understand, with clean layout, making full and correct use of standard mathematical notation. Tellingly, none of the poorer performing students produced this kind of beautiful homework. It seemed obvious that the students with the greatest understanding of the material would have the time and/or inclination to produce beautiful homework, but I began to wonder if this was too simple an explanation. Could clean layout encourage clear thinking? Could something as simple as homework format be used to increase learning?

It seemed ridiculous to try to reverse engineer successful proof-writing with format, but I had a powerful secondary motivation. My own poor vision can make grading excruciating, so I was particularly interested in finding a way to impose format expectations that I could cloak under the mantle of enhanced student learning. I began by requiring that homework be written on only one side of each page and that problems not be broken over multiple pages. In exchange, I offered neatness and completeness points and bonus points on routine homework and exams. Some of my students began typing their homework. This made it much easier for me to read, but while they seemed to be benefiting too, the student effects were small. Nonetheless, I believed that I was on to something. I wondered if the students who produced sloppy work simply didn't realize that it was possible for students to create the kind of beautiful work that their peers produced. After all, no student necessarily sees the work of any other student. Over the next several years, I continued to encourage clean layout, but made little progress with how to achieve student interest in producing beautiful homework.

As I was contemplating this issue in my teaching life, I began painting in oils in my personal life. In my professional life, I participated in the Viewpoints workshop held at Franklin & Marshall College in

Lancaster, PA run by Marc Frantz (Indiana University) and Annalisa Crannell (Franklin & Marshall College). I also started attending the Bridges Conferences. The confluence of these experiences made me aware of artists' critique groups.

In the art world, a critique group (crit group) is a group of artists usually, but not necessarily, working in the same medium that gather regularly to (re)-view and comment on each other's works, both in progress and finished. The goal of the group is to improve the work, celebrate the successes, and offer support during the struggles of each participant. When a crit group is functioning at its best, its members grow in ways that would be impossible for those individuals in isolation; it becomes a gestalt promoting the success of each member in unpredictable ways.

The crit group model is heavily used in visual arts education. When an assignment is due, students are asked to place their work around the periphery of the room, and then, the professor and the students roam the room viewing and commenting on each work, mentally, verbally, or in writing. This was what I wanted my students to experience. I had considered having them write-out some of their homework on large artist's sketchpads and displaying them around the room in the process outlined above or distributing photocopies of the best work. I worried that this might upset some students, but what I eventually did was significantly riskier.

2. Creating a Mathematical Critique Group

Since mathematics is an essentially creative endeavor that is driven by pattern, symmetry, and the breaking of pattern and/or symmetry, it is reasonable to look to the artistic community for a critique model that will promote the growth of each student to the fullest extent of her abilities. What I had been struggling with was the medium in which the critique process could unfold. Time and psychology seemed to be the biggest barriers. I needed a structure that would allow the critique to happen without losing considerable amounts of class-time and an emotionally safe environment for the students. Relocating the critique process to the electronic world seemed to solve both these problems.

What I decided to try was a process that required the students to post their homework online for all their peers and me to see. Then, the students and I would post our comments creating a discussion for each homework exercise. Next, students post revisions of their work based on those comments. Revisions were followed by a final round of comments. This is how I present the process to the students.

For each section of the text that we cover, each student will be responsible for the following:

- Posting their assigned homework problems in our online class portfolio.
- Reading all other students' postings and the instructor's comments.
- Posting at least one **substantive** comment on another student's work.
- Responding in a **substantive** way to at least one comment by a fellow student, not necessarily about your work.
- Posting revised homework for each problem that was not correct and well communicated in the first submission.

Allowing homework revisions meant that I had to revisit the traditional approach of setting one assignment that all students submit individually. It seemed that posting all homework online would make the revisions invalid. So, I decided to give disjoint homework assignments to each student or group of students. This had four additional advantages. First, it drastically reduced concerns about copying

homework. Secondly, it allowed me to reduce the number of exercises assigned to each student to compensate for the logistics of posting the homework online. Paradoxically, this actually allowed me to assign a greater total number of homework exercises, creating a broader and deeper experience from the homework. The fourth benefit of disjoint homework is that the students become invested in the critique process since they are all held responsible for knowing everyone's homework; they must read everything posted with a critical eye.

3. Logistics and Limitations

Once I had set my mind to create this online mathematics critique group, I needed an electronic environment. This is where I was un-creative, and I have never, over many years of revising this methodology, done better than my initial copout. I used BlackBoard, which is an inelegant, math-unfriendly course-management system that allows faculty to create relatively simplistic, overly structured course websites. The unfriendliness of BlackBoard to mathematics is so extreme that work needs to be prepared in another program, such as Word, PowerPoint, or TeX, and pasted into or uploaded as an image to BlackBoard. There is one pedagogical reason to stick with this clunky process. It forces my student to be creative at the same time as they are trying to prepare professional-quality presentations of mathematics. Neither they nor I know what software will or will not be available to them when they enter the workplace, but they should not allow themselves to use less-than-proper notation and layout regardless of their circumstances.

In addition to the clunkiness of BlackBoard, the student must be given *course-builder* status so that they can add content to our course site. This means that I must trust the students to behave responsibly. Anyone of them could permanently delete the work of another student, my work, or even the whole course from our server. My willingness to demonstrate this high level of trust in their technical and emotional maturity paves for why for their willingness to try this unfamiliar learning experience.

This trust also sets the stage for professional standards of emotional and social behavior. I have the advantage of being at a small, liberal arts, catholic-affiliated university. I believe that this makes it easier for my students to function in the online crit group setting. Students are expected to comment civilly on each other's work and respond to those comments in kind. When concerns about tone or content of posting did become an issue, I have been able to post a mild warning/reminder, and this has almost always defused the bruised feelings and corrected the problematic behavior. Since piloting this pedagogy in the spring of 2005, I have only once had to speak to a student privately about tone and content of posting on our course site. I suspect that small class size also reinforces civility. Class size limits this methodology in another way.

The aspect of this crit-group-pedagogy that creates the most obvious limitation is the disjoint homework sets. While I enjoy not having to grade the same proof 15 times, I freely admit that my total grading time has probably gone up, but not by much. The real problem is appropriate class size. I teach at a university where upper division mathematics courses rarely have more than 15 students, so class size is not a problem for me. When I have less than eight students in a course, they work individually; when there are more than eight students, they work in pairs (with the occasional triple). I suspect that the pedagogy outlined in this paper could not work well, even with students working in groups, with class sizes of greater than 30 students. I wouldn't do it with more than 20 students.

It can be difficult to keep track of which exercises have been posted the first time, which commented on, which resubmitted, and which need new comments. My students and I have worked out a color coding system to keep track of the status of each exercise. I also maintain the front page of our

class site as a comprehensive to-do list that shows what each student has been assigned and, via the color coding, the status of each exercise.

4. Student Responses

Many students resist this pedagogy at first. They resent having to type their mathematics, and many of them have technical issues with BlackBoard. Within a matter of days or weeks, though, most students are thrilled to see their personal work look just like a page from our text. They really do adopt a new, higher, and internal standard of clarity and presentation.

The resistance to commenting on each other's work can actually be harder to overcome. It can take three to four weeks before students feel comfortable commenting online and responding to the comments and questions of their peers. I have had two students over the last five years who have refused to participate in the critique aspect of the course. This hurt their grades, in one case significantly. Every student who has wanted to participate in the critique has been able, with some coaching, to find his or her own voice.

The majority of students mention the critique group experience prominently and positively in their personal narratives reflecting on the math department's goals of proof writing and communications in our capstone course. Over the last five years, I have also asked separate end-of-course evaluation questions about the critique pedagogy. I asked students to compare certain aspects of their experience in the critique-based course to other upper division courses they have taken. Since my university is small, so is the sample and there is no way to have a control group. That said, here is what how my students had to say.

- 80% of students reported that the critique pedagogy created a better than average sense of camaraderie and collaboration
- 90% of students reported that the critique pedagogy created a better than average increase in their ability to communicate mathematics
- 80% of students reported that the critique pedagogy created a better than average increase in their ability to present mathematics professionally
- 30% of students reported that the critique pedagogy created a better than average appreciation of the mathematical content of the course (70% of students reported no increase or decrease in appreciation)
- 60% of students reported that the critique pedagogy created a better than average understanding of the mathematical content of the course

Only five students have reported the belief that the critique pedagogy created an overall negative impact on their ability to perform in the course and learn the course material.

5. Conclusion

This online critique group pedagogy is still a work in progress. The logistics can be daunting, and I fall behind in posting my comments a couple of times each semester. I remain committed to refining the process because I believe that it is an immensely valuable experience, especially for students heading to graduate school or into high school classrooms.