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Portfolio Assessment in Liberal Arts Mathematics

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SUMMARY
This paper describes my efforts to incorporate problem-solving portfolios into my liberal arts mathematics course. I begin with a description of the components of the portfolios and the factors I consider in evaluating them. I then address some of the more significant obstacles I have encountered as well as what I consider to be among the major benefits. A selection from one student's portfolio is appended.

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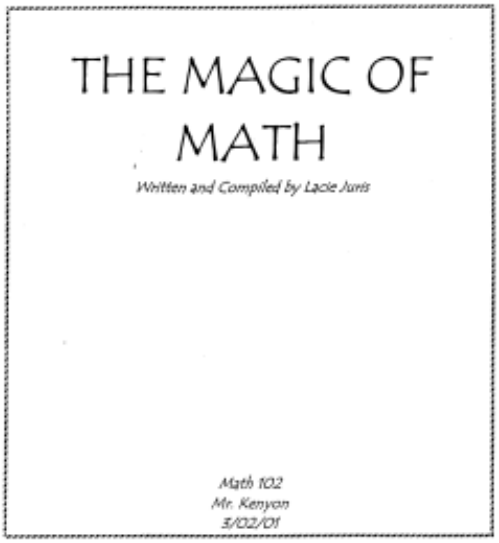
My use of portfolios in my liberal arts mathematics course (Math 102, "The Nature of Mathematics") grew out of my desire to expand on my traditional and often too-narrow use of homework, tests, and not much else to formally assess my students' work. My office adjoins those of some of my colleagues in the English Department, and I have had the opportunity to observe their successes with the use of the portfolio as an assessment tool. The liberal arts mathematics course has an emphasis on a variety of problems suitable for thoughtful investigation and comes with the added benefit of typically being populated by students with particular talents in writing and the arts. As such, it seemed to be a course that was conducive to piloting portfolios.


THE MAGIC OF MATH

Written and Compiled by Lacie Juris

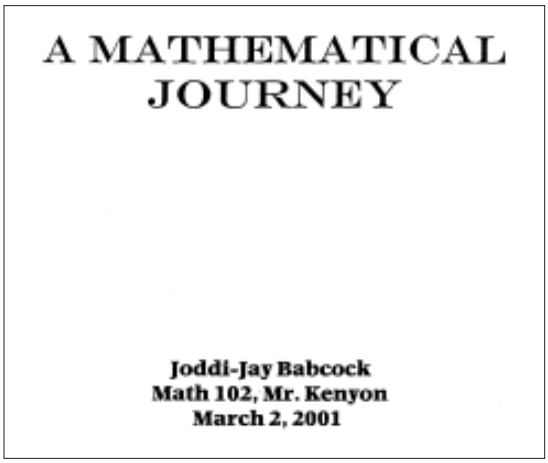
Math 102
Mr. Kenyon
3/02/01

An excerpt from *The Magic of Math* follows the conclusion of this article.

The portfolio, as I use it, is made up of three major parts. One is the problems themselves. Prior to the start of the quarter, I select between twenty and thirty problems from my list of homework problems and designate them as being eligible for inclusion in the students' portfolios. I select problems that will require some investigation and analysis on the part of the student; the straightforward computational problems are not included—unless there is something special about them that an insightful approach might reveal. As the quarter progresses and I make further assignments, I will also mark some of them as eligible for inclusion. Selected test problems can be included as well. Each student selects five of the eligible problems to include in her portfolio. I suggest that students will want to rewrite their solutions to make them look more presentable; many students do this even in cases where it might not have been necessary. For each of the five problems, the student then writes a page or two about the process she used to solve the problem, the techniques she attempted to use, what worked, what didn't work, and what she learned from both the successful and the unsuccessful attempts. (I usually refer to word counts rather than page lengths as guidelines, in order to eliminate problems with fonts, margins, and the like. I give a guideline of 250 – 500 words for these papers, but I also generally tell students that the paper needs to be as long as it needs to be—no more, and no less. A well-written paper that is a little shorter is better than a poor paper of greater length.)

The second part—which almost always appears at the beginning of the completed portfolio—is a reflective introduction, a 500 – 1,000 word piece that ties the problems together. I point out that, in most cases, there will be some common thread running through the

problems each student chooses, and I ask the students to identify those commonalities and reflect on what this body of work shows about their progress over the course of the quarter. One student, for example, opted to showcase the problems she felt most directly applied to "the real world." Many students, though, have been successful with this even (or especially) when their problems do not, at least superficially, appear to have much of anything in common. In fact, some will go out of their way to choose problems that seem to have nothing whatsoever to do with each other. Those students are then able to point out something deeper about the problems and their solutions to them that shows how they have developed their ability to investigate complex problems. In some cases, students have simply chosen their favorite problems. One student explained her selections with these words: "With the wide range of subjects covered in this class, some of them of realistic use in daily life and some of them fairly abstract, I found the variety of problems coupled with their difficulty was forcing me to use critical thinking skills. More importantly than that I found myself enjoying this activity … Maybe just like everything else in life problem solving was more about the journey than the destination, so I chose the problems in this portfolio based on how interesting the journey was." [Lyczewski]


A MATHEMATICAL JOURNEY

Joddi-Jay Babcock
Math 102, Mr. Kenyon
March 2, 2001

It is in the reflective introduction that the students are most likely to look back on the course as a whole and fully appreciate all that they have done. As one thirty-something student wrote, "After an absence of 17 years from mathematics … even though I did well in Math 95 [Intermediate Algebra] and developed some understanding of algebraic concepts, I continued to have serious reservations about taking another math class. I still failed to see the relevance mathematics had for me personally … Although this particular course has come to an end, I do not believe I have arrived at the end of my mathematical journey." [Babcock] Another student explained, "In the past, I have always considered math an intriguing subject, though not terribly exciting. However, that opinion has changed dramatically. I have discovered, through the topics addressed in this course, that the subject of math possesses many amazing, if not 'magical' qualities…Overall, each piece in this portfolio demonstrates not only my skills as a student, but also my abilities to learn new information and apply it to different circumstances." [Juris] Having read those comments and others like them, as well as the portfolios that contain them, I am led to believe that compiling the portfolios has afforded the students the opportunity to look back on their work and see the individual problems in the larger context of the entire quarter. That, I think, makes the students more likely to realize what they have done and to reflect on what it may mean.

The final part of the portfolio is a 500 – 750 word review of the book *Fermat's Enigma* by Simon Singh. We read the book over the course of the quarter and discuss it chapter-by-chapter in class, and also watch the NOVA video *The Proof*. I point out that this is, after all, a book about a problem (albeit a very difficult and famous one) and its eventual solution and as such seems entirely appropriate in a problem-solving portfolio. Where possible, I encourage students to include references to their book reviews in their reflective introductions, but I note that this isn't always possible, and if it doesn't seem to fit with the rest of the material in the introduction, they shouldn't try to force it. This component could, of course, easily be removed in a course that did not have outside reading.

Each of the five problem write-ups counts for 10% of the portfolio grade, as does the book review. The reflective introduction counts for the remaining 40%. I assess each paper in seven areas:

1 The essay should have a clear focus on a specific main idea.
2 The essay should be relevant to the reader.
3 The essay should show that the student has made an effort to be aware of herself as a problem solver.
4 The essay should include specific examples (from the attempts (successful or otherwise) to solve the

problem, from the reading, from class discussions, and the like) in support of the points being made.

5 These examples should be analyzed, not merely stated.

6 The essay should be well-organized.

7 Mechanics, usage, grammar, and the like should be correct.

The student earns a score of 4, 3, 2, or 1 (excellent, good, fair, or poor, corresponding roughly to grades of A, B, C, or D, respectively) in each area on each paper. (The exception is that I find it is usually not appropriate to look at the student's awareness of herself as a problem solver in her book review.) The scores on each paper are averaged to give an overall score for that paper, and I add the scores for each paper (counting the reflective introduction four times) to get a score for the portfolio out of 40 possible points. Merging this with the rest of the student's work for the quarter (homework, tests, etc.) turns out to be a little challenging, because a grade of 3 out of 4 is a B on the portfolio, but 75% is not a B on other assignments. To compensate for this, I end up with a percent score for the portfolio (but 30 out of 40 is not 75% in this scale), and I have the rather absurd situation of recording a portfolio grade to the nearest hundredth of a percent. It works well enough, though. (The gory details are available upon request.)

I gave students very little direction on this project the first time I assigned it. I gave them a two-page handout describing the guidelines and criteria during the first week of class and occasional reminders as the quarter went on. We spent little if any class time on it, though I did make it clear that I was entirely willing to read over rough drafts and offer my feedback. (Several students each quarter take advantage of this.) I remain uncertain as to whether I had a stroke of genius in this minimalist approach or just got uncommonly lucky, but I was simply delighted with the quality of the work I received. It was clear that the students had taken the project seriously and were determined to showcase their best work.

Since then, I have asked students who have written exceptionally good portfolios for permission to copy them and share them with my colleagues and future students, so I now have samples to share with my classes. I have also expanded (and, I think, improved on) my explanatory handouts and discussed what I'm looking for in more detail. This includes devising a handout that explains in a sentence or two what characteristics will earn a paper a score of 1, 2, 3, or 4 in each of the seven areas, all of which seems to make for a much better-conceived project.

(I have never, incidentally, been turned down when I asked a student for permission to copy his or her portfolio for future use. One student, in fact, was delighted by the request, saying that no teacher—and certainly not a *math* teacher—had ever wanted to keep a copy of her work before!)

There are, of course, challenges involved in undertaking such an endeavor. Not least of these is the time involved in evaluating them. Portfolios frequently run in excess of twenty pages; a length of thirty pages is not all that rare. I find that I require at least 45 to 60 minutes (often more) to read and comment on each portfolio. (I never write comments directly on the student's paper. All of my comments are on separate pages.) I simply cannot read more than four or five in a single sitting; at that point, my brain turns to jelly, and it's futile for me to try to go on. Couple this with the rest of the time pressures that come at the end of the quarter, and it's a non-trivial exercise. (Don't expect any sympathy from the students, either!) To accommodate this, I generally make the portfolios due either at the start of the last week of classes or the end of the week before. I don't give extensions, or, more precisely, the truly extraordinary conditions that would warrant me giving an extension have not yet arisen.

The nature of this writing is such that plagiarism is rather unlikely to be an issue, but it is still good to keep an eye on any overwhelming similarities that might appear between students' work. And one student submitted a problem that hadn't even been assigned (much less listed as eligible for inclusion) that quarter. My first clue came when she wrote that it was the fourth problem on our third test, which only had three problems. In fact, she had lifted "her" work almost word-for-word from one of the sample portfolios I had provided from previous classes. Fortunately, such cases of academic dishonesty are both rare and relatively simple to identify.

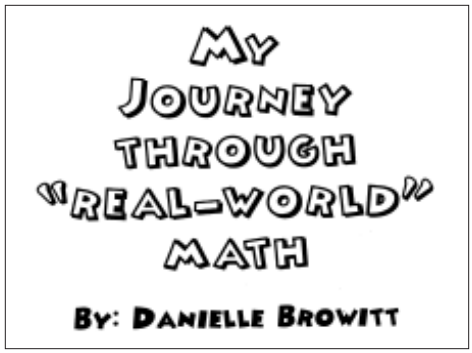
There is no grade of F represented in the 1-through-4 grading scheme, and at first that bothered me at some

fundamental level. What, I wondered, would I do if and when I received a truly atrocious paper? As it turns out, though, I have never, in the three classes with whom I've done this, received a complete portfolio that merited a grade of F. There have been cases where students have decided that three or four problems instead of five would be sufficient (it's not), or that the book review isn't a necessary component (it is), or that it's all right to turn in a portfolio three days late ("Late portfolios will not be accepted" is not, in my view, subject to multiple interpretations).

There is no provision in the grading for mathematical accuracy. I concluded that since the student can choose any five problems she wants from a list that ends up including close to forty options, she is obviously going to choose ones that she knows she has right. This has almost always been an accurate assumption. In the few cases where it has not been, the accompanying paper has (perhaps predictably) been so poor as to more than penalize the student for the mathematical errors.

By and large, I have been thoroughly impressed by the quality of the work I have seen in these portfolios. Students have taken the project quite seriously, done a great deal of careful introspection and analysis, and composed excellent bodies of work reflecting their progress.

There is, of course, some initial (and sometimes lasting) resistance to the idea of writing in a mathematics course. But that resistance often gives way to a certain sense of welcoming the opportunity to use other talents to showcase their mathematical progress, especially in a course targeted to the liberal arts student. In several cases, I have seen students whose abilities do not appear to be reflected in their test scores doing significantly better when they are given an opportunity to use another assessment instrument. Better yet,



the converse does not hold: I have not yet had a student who was doing well otherwise but submitted a poor portfolio.

An unexpected benefit to this project has been the number of students who have gone on to take additional mathematics courses. We generally assume that the liberal arts mathematics course will be the last mathematics course a student takes, and it does not serve as a prerequisite for any further courses. But since I have begun using portfolios, I have had a surprisingly large number of students elect to take college algebra in subsequent quarters. (Both liberal arts math and college algebra have intermediate algebra as their prerequisite.) Whether this is a result in any way of the students' experiences with the portfolio project is not at all clear, of course, and I haven't analyzed those students' performances in college algebra. But the very fact that they opt to take it is encouraging.

There does not appear to be any obvious reason this concept would not work just as well in other mathematics courses, but while I have thought about doing so, I have not extended my use of portfolios into my other courses. I expect that minor (or even major, in some cases) modifications would be in order, depending on the specific course in question.

I am entirely willing to share samples of my students' work (the best ones, of course!) as well as the current incarnations of my handouts, rubrics, and feedback sheets. Feel free to contact me and let me know what you want to see.

I am grateful to my colleagues in the English Department for their advice and the resources they have provided. John Delbridge and Tracy Case Arostegui encouraged me to go forth with the idea when I mentioned it. Sandy Schroeder provided me with reading material as I began, and Dodie Forrest's rubric was an excellent model for my own. Carolyn Calhoon-Dillahunt has always made herself available to respond to my numerous questions, and has also been vital to the crafting of this essay.

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