

Incorporating Writing into the Undergraduate Mathematics Curriculum

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Introduction

Writing is essential in almost all careers, subjects, and disciplines. Many mathematics instructors have been using writing extensively in their courses and researchers testify to its benefits. These benefits include:

- Facilitating deeper understanding,
- Strengthening numeracy skills,
- Developing communication skills,
- Providing instructors with deeper insights into students’ learning and reasoning.

Writing in the math classroom can take a variety of forms including:

- **Reflective:** students reflect on their personal thoughts, feelings, and experiences that relate to the content being learned,
- **Expository:** students explain complex mathematical ideas to non-experts,
- **Excogitative:** students explain their mathematical thinking carefully and thoroughly (often coupled with a mathematical proof or computation).

In this poster I document the writing projects I have tried in my university math classrooms and students’ reactions to them. Although these projects were used at the tertiary level, they can be easily modified to be used at the secondary level as well.

Writing Assignments: Differential Equations

In Summer 2015 I taught a second-year differential equations class at McMaster University. Students were asked to use short narratives in a variety of ways on five written assignments. In particular, these assignments consisted of *reflective*, *expository*, and *excogitative* based questions, which emphasized writing quality over mathematical correctness.

Student Perceptions

By analyzing students’ written assignments and the results of an administered survey, Miroslav Lovric and I found the following*:

- Students held a positive attitude towards the written assignments and appeared to view writing as an effective learning strategy (unified course concepts, pushed students to work harder, question their understanding, seek help).
- Students viewed writing and mathematics as distinct entities. In particular when the activity of writing was seen as competing with the process of working on calculations, they tended to hold negative views about the written assignments.
- Students held pre-existing beliefs about the nature of mathematics; they viewed it as a purely symbolic and algorithmic discipline. They felt uncomfortable with analysis that involved other means, such as theory and geometry.
- While students moderately believed written assignments improved their ability to communicate mathematically, they did not view the skills as transferable and did not tend to believe that writing improved their general communication skills.

It is unlikely that one course alone could be enough to cause a paradigm-shift in students’ attitudes towards the relationship between communication and mathematics. Instilling the idea that writing does belong in the math classroom must be emphasized in multiple courses throughout their development.

*L. DeDieu, M. Lovric, Student Perceptions of the Use of Writing in a Differential Equations Course, to appear in *PRIMUS: Problems, Resources, and Issues in Mathematics Undergraduate Studies*.

Journal-Writing

In Spring 2017 I taught an upper-division *Cryptology & Number Theory* class at the University of Minnesota. There were 40 students in the class from a variety of different majors (computer science, actuarial science, math). Students kept a course journal and submitted a weekly response to a writing prompt.

Prompts

Here are a few of the prompts that students could choose from:

- Is there a particular topic that you do not understand? Please share and try to describe in as much detail as possible what you are having trouble with.
- How does the material we are covering this semester relate to the material you have covered in other math courses? Do you see any connections?
- Did you have any “aha!” moments this semester? E.g. perhaps something really wasn’t making any sense to you, and then there was a moment when it clicked.
- How should we use class time to best advantage?
- Cryptology has lots of interesting historical connections. Choose a topic that we have covered in class and find out more about its history. Share this story.
- In this course, we have been gaining experience in formal proof-writing and professional problem writing. With your future career goals in mind, reflect upon if/how these writing exercises may help/ influence you in your post-university life/ career.
- What were three of the most important discoveries or realizations you made in this class? In other words, what are you taking away from this class that you think might stick with you and/or influence you in the future? Explain why these three discoveries or realizations are important to you.

Potential Benefits

Metacognitive: Most university students are rather weak in the metacognitive processes of reflecting on their own approaches to learning, accurately assessing what they do and do not know, and modifying their behaviour as a result.* By reflecting on study techniques, articulating what they find confusing, and analyzing the moments when the material clicks together, students can become better learners.

Motivation: Journaling allows students to explore topics that they find interesting in greater depth, which can boost interest in course content. Reflecting on past mathematical experiences can help students see the progress that they have made. Moreover, thinking about how their future selves may benefit from the skills being learned can help students see value in the course.

Channel of Communication: Journaling gives students a venue to ask questions and provide feedback. This allows the instructor to get to know her students better, gain greater insights into their thinking processes, and modify her teaching accordingly.

“I think journal writing was a positive addition to my cryptology experience. Thinking about all the connections between my present and future helped motivate me to succeed. It also facilitated looking at course content in various contexts, whether explaining things to Alice, reflecting on what makes a good exam, or troublesome homework questions. My favorite prompts were the ones that asked about my favorite math class and what makes a good teacher. So often writing is focussed on the present, but it’s very meaningful to revisit how you got here and the people that catalyzed the journey.” – Quote from Cryptology Student

* Benassi, V. A., Overson, C. E., & Hakala, C. M. (2014). Applying science of learning in education: Infusing psychological science into the curriculum. Retrieved from the Society for the Teaching of Psychology website: <http://teachpsych.org/ebooks/asle2014/index.php> .

Professional Problems

In my *Cryptology & Number Theory* class, in addition to responding to journal-writing prompts, students were required to submit solutions to four Professional Problems. These problems were graded based on mathematical correctness as well as quality of writing. Usually students were asked to respond to a specified audience (e.g. client, community member).

Prompts

Here is an example of one of one of the Professional Problem prompts:

You have been transported hundreds of years into the past (an age before computers). A secret message has been intercepted. It is your job to decipher it. Your intelligence has some leads about how it was encrypted; they suspect it was encrypted using the affine cipher. Moreover, they have reason to believe that it was encrypted using the 29 letter alphabet, ordered {a b c d e f g h i j k l m n o p q r s t u v w x y z _ , . } . The intercepted message is “XFPUPTNJHTV,RPUJXV_PTOPP.TXBTZPTMBOHXJOXLQTJLPUXGT CBUTXFPHPT.BSHTJO.T,POTNPUPTOBXTXBNOT.BSHTJO.T,POWTFXPQTNPUPTHJ_JSPHGT JLLTBCTXFP,GTNFBTYO PNTOBTLJNTZKXTXFPTLJNTBCTMLKZTJO.TCJOSW”. You must break this code. Also, you are going to be teleported back to the future Monday evening, and so in addition to simply breaking the code, you must write a detailed report on how you broke the code, so that these people will know how to decipher codes after you have gone.

*The other prompts are available upon request.

Student Reactions

The final journal writing prompt asked students the following:

- Discuss whether or not you think journal writing has enhanced your experiences in this class. Which journal writing did you like the most? Least? Why?

The majority of students (24/39) claimed that the journal-writing was helpful.

“My eng skill is not good. So, whenever I have question, I feel uncomfortable to ask you. However, this journal makes me feel better. Whenever I have questions I can use the journal to ask you and then always I get answer from you. This makes me to participate more.”

Perceived Student Benefits	Number of Students
Communication with Instructor (feedback, questions, personal stories)	15
Reflection	14
Communication Skills	9
Course Content	8
Motivation	7
*Some students reported benefits in several categories (39 students total).	

Almost all students (10/11) who did not see value in journal-writing expressed that they did, however, find the Professional Problem writing valuable.

“While I strongly disliked writing up the professional problems, I feel they did the most to enhance my learning. Being able to do a homework problem is completely different from being able to communicate your findings in a concise, professional, and understandable manner. I feel like the PP write ups forced me to sit and communicate my findings in a simpler, less mathematical way which is similar to what math majors do in their careers.”