
Assessment Summary, BC1

The use of novel assessments went, in my opinion, very well this semester. Unquestionably, students thought the course was very challenging, especially the conceptual problems on exams. But on the whole, it seems that the class enjoyed the course. Some comments, extracted from student essays (with grammar edited):

- I enjoy this class despite its difficulty.
- He has many new methods that help spark interest in the course.
- I really like Dr. Matsko's way of grading, with CCs and ECs. However, sometimes this can make it very easy to get a lower grade (B/C range), yet extremely hard to get a high (A) grade. However, I still think that this different method of grading encourages to see the big picture and learn concepts instead of just trying to get an A.
- Conceptual questions are a bit too hard, but fairly graded based on their difficulty.

The spreadsheet of comments is available on the department server in an aptly named folder.

Many students (14 of 42 respondents) recommended the course move at a slower pace. At the beginning of the semester, we moved through the introductory material fairly quickly. This was partly because I felt it was possible to accomplish the same goals in different ways (for example, we revisited sign charts again when we learned to differentiate), and partly because students who completed calculus anecdotally volunteered the information that BC1 starts off very slowly. Their performance on the exam on this material (Day 8) indicated that they did understand the material despite the quicker pace. On the first exam, the numbers of students who scored CC (completely correct), EC (essentially correct), or NC (no credit) on problems #6–9 are shown below:

Problem	Completely Correct	Essentially Correct	No Credit
6	33	14	0
7	31	15	1
8	28	18	1
9	40	5	2

Of course it is difficult to interpret the meaning of the "essentially correct" column, but the totals in the "completely correct" column are high enough that it seems that the important ideas related to these topics can be communicated fairly efficiently.

Moving more quickly at the beginning had its advantages; despite what students thought, the only content we covered beyond the usual curriculum was hyperbolic trigonometry, which took three days over the course of the semester.

In addition, the extra time allowed for:

- Three directed learning days (PlayDays), where students were able to choose how they spent the day. Informal surveys revealed that some students did not find these very helpful as they were too open-ended, so some thought needs to go into how to make them a more positive experience for all students.
- Three "oral quizzes." As content permitted, before three exams, we had a true/false oral quiz (see Day 25). I made up one question for each student, and randomly picked students names from the class roster. When it was that student's turn, he/she was given a true/false question. If they got it right, they got a 10/10 as an exam grade, and if they got it wrong, they were excused from that assessment, so it had no impact on their grade. Students clearly enjoyed these, and all were actively engaged in all the questions. Moreover, it got them studying ahead of time.
- Two in-class work days writing original problems. The first was for the first assignment, as it was a new way of thinking for most of the class. The second was for the third assignment, where class time was used to introduce students to LaTeX (more on this below).
- A final "pre-review." I put last semester's BC1 Final Exam Review online, and told students they could spend the day continuing the current work (which some did), or planning their study for the Final Exam. (This was two weeks before the Friday BC1 Final.) They were to make a detailed outline of their study plan to get some idea of what it was going to take to get ready for the Final.

Students responded positively to using class time in this way, although many thought they could have done without hyperbolic trigonometry. Perhaps a brief comment might be in order. I have found that while hyperbolic trigonometry arises less frequently than circular trigonometry, it does arise often enough to warrant some familiarity. In addition, it is easy to see from the definitions that cosh and sinh parameterize a hyperbola. Derivatives are easy, and give students extra practice. Moreover, the inverse functions have exact formulas, and give students additional practice in solving equations of "quadratic type." Worksheets used for this topic are available on my web site (see Days 33, 34, and 56).

One very successful innovation was the introduction of the writing of original problems into the curriculum. When I first came to IMSA, I noticed that there was significant copying on take-homes. Informally, students admit that this is true, although to a lesser extent than with MI. (Any student who was willing to be honest with me indicated the large extent to which students copy these assignments in the residence halls.)

Of course with the writing of original problems, copying is less likely, and I have had no problems with this issue this semester. Students had a 10-point assignment grade to upload their work to turnitin.com. But beyond this, students really got to put some of themselves into these assignments, and they truly appreciated that. Some took to learning ahead; before we did the derivatives of trigonometric functions, one student found the derivative of $\sin(x)$ in a different way than usual – she used a different trigonometric identity. Another student learned to differentiate $\text{arcsinh}(x)$ – before we learned hyperbolic trigonometry or the chain rule. A third researched the derivative of $\ln(x)$, and wrote up a method I had not seen before.

The third assignment – writing multiple choice questions in LaTeX – was particularly successful; informal survey results are given below. (Thanks to Noah Prince for piloting this assignment in BC3 – its success there inspired me to try it in BC1. Additional thanks to Noah for suggesting Question 5.) I was pleased with the responses to Question 1 – they show that it is possible for students to be exposed to new technology in a manageable way. This encourages me to try such an assignment in the MI sequence next year.

1. The use of LaTeX in the recent assignment was at an appropriate level of difficulty.

Disagree	2	3	4	Agree
0	2	3	17	21

2. I was pleased with the quality of the appearance of my work.

Disagree	2	3	4	Agree
0	1	2	11	29

3. I am glad that I learned LaTeX for this assignment.

Disagree	2	3	4	Agree
1	2	15	12	13

4. I will likely use LaTeX for future assignments.

Disagree	2	3	4	Agree
7	9	11	11	5

5. I feel more comfortable with computer science after having learned LaTeX.

Disagree	2	3	4	Agree
6	7	12	13	5

   Note: the numbers in the lower range are larger than might be expected; this may be explained by some students remarking that since they were already comfortable with computer science, their overall attitude did not change.

6. Did you use any resources other than those listed on the course web site? Please specify.

   Approximately one-third of the students responded, usually using the Internet (most often), or peers.

Opportunities for such creativity are missing with more traditional assignments – and often, traditional writing assignments are very heavily scripted. Moreover, students enjoyed the shorter assignments, and I was able to give more detailed feedback since I can comment on briefer assignments rather than one large writing project. Since there were three such assignments this semester, students were able to learn from their past mistakes.

One student wrote in her reflection, "After taking this calculus class, it looks like my math grade, in general, has improved. I believe this is due to several reasons. First, I treated the math course seriously, but partly because the teacher actually taught in the class and gave us opportunities to investigate mathematics rather than instruct us to fill out worksheets during all of the class period." It would seem that having students write original problems really *does* foster exploration and investigation. (More comments from students are included at the end of this document.)

Finally, I remark that working with new approaches to assessment engaged *me* as an instructor. This enthusiasm clearly was communicated to the students, many of whom remarked on the enthusiasm of the instructor in the online student surveys.

For me personally, this is a very significant point. I intend to take similar ideas to MI 3 and MI 4 next year – and in fact, some students suggested this in their reflections. I think that students at all levels are able to benefit from the ideas I had success with this semester in BC 1.

Reflections on Writing Original Problems

I have included many excerpts from student reflections; it is not intended for anyone to read through them all. The problem-writing experience seemed to be a positive one overall; the many comments indicate that such positive experiences were not isolated phenomena.

The full text of the reflections, in additional to examples of graded work, are available on the server. For their final reflection, students needed to create a document with their reflection and scanned copies of their graded assignments.

Note: Minor errors in grammar have been edited. Students were prompted to reflect on their problem-writing experience, and specifically address (1) their growth as a problem writer, and (2) the value of writing original problems. Comments are numbered sequentially for easy reference.

On Independent Learning and Confidence

1. Over the course of the semester, I have gradually become more and more comfortable with learning independently, and have lost my fear of trying new things even when I was unsure what the outcome would be. [YA]

2. Reading through math books is no longer comparable to reading in a foreign language, and even intimidating problems do not seem as difficult as before. Essentially, I feel that I have become a bit more comfortable with math as a whole because of this assignment. [JR]

3. As a problem writer, I took a whole new approach to problems. The questions in my math book no longer held the same daunting, threatening air that they did before my experience with writing original problems. I had dissected a problem myself, I had designed a question and crafted a solution. I could see through the problems in the math text and find the most effective ways to approach them. [MA]

4. Writing Original Problems was a new experience for me this semester, and I feel that it has been extremely beneficial and has given me more confidence in my skills in calculus and math in general. I have gone through a significant amount of growth in my problem-writing abilities. [HM]

On Creativity

5. I think that I have a new appreciation for the creativity and drive that math teachers must have in order to effectively challenge their students with new problems. [YA]

6. Probably the most exciting realization from writing original problems in my opinion is that the experience introduced me to the more creative aspects of mathematics. [CG]

7. Writing original problems helped me to grasp things that I didn't already have an understanding of. For me it served as a creative outlet even though it was math. Now I'm not saying that mathematics cannot be creative, it can – but I had never pursued it in the way that this assignment showed me to do. I went through several packs of loose leaf and a pad of graphing paper. If I bound them all together I could call it my math sketchbook. [EZ]

8. I've really liked doing original problems. Original problems give me the chance to be creative with math, and I rarely get the chance to do that. Usually, my math classes are very strict. Original problems have made math less strict and more fun. [RU]

9. However, as I began to write more problems, I began to develop my own style; almost as if I was writing a paper. I also began to create more complex problems that even drew from topics in the MI series. I was very surprised to see all of the different ways I could encapsulate one topic in another and all of the different ways to think about and approach a certain type of problem. It certainly showed that math was a lot more creative then I thought, as opposed to purely procedural and methodical. [KW]

On Growth as a Problem Writer

10. As the semester progressed, and as I wrote more and more problems for the assignments, I became more fluent in the language of problem writing. I believe that this fluency has allowed me to understand problems given to me in all places, both on FunDays [exams] and also on tests in other classes. Not only do I understand problems more effectively, but I also am able to dissect a problem statement more efficiently and use this information to aid me in my attempts to solve the problem. [BA]

11. Although my grades on the three assignments didn't go up each time, I still felt like my problem writing got better with each problems I wrote. [BR]

12. When I looked back at my work of the semester, it became quite apparent to me that I had improved my skills tenfold. At first I was writing basic problems that did not require much thinking and calculations and seemed to bore everyone....Writing the second original problems was much easier. The experience I had gained, along with the notes I received from Dr. Matsko on how to improve my questions, enabled me to excel. [NP]

13. But ultimately I think being more confident and comfortable with creating my own conceptual questions is the biggest sign of my growth as a problem writer. [CC]

14. Over the course of the semester, I have definitely improved as an original problem writer. I started out being very confused and working a lot but not getting much

accomplished. Also, I really struggled with making problems conceptual. However, by the second original problems assignment, I was much more comfortable with writing conceptual problems. By the time we got to the third set of original problems, I was feeling fairly comfortable with concepts, since I had frequently encountered them in class, homework, and Fundays [exams]. [AT]

15. I was really surprised by how much more confident I became in my problem-writing abilities over the course of the semester....My main growth, however, came in the understanding of what I was doing. As the semester progressed, I moved from somewhat guessing on the explanation part to truly understanding what I was doing and writing in the problems. [WB]

16. As a problem writer, I have grown in many ways by participating in these original problem assignments. As I have mentioned above, I now have a greater understanding of the amount of work that needs to go into thinking up and writing a problem of ones own. I also believe that I now have a greater appreciation for the nuances that math problems contain. By learning to write problems more efficiently than before, I have also learned to see the way problems work, so that I am more easily able to solve problems, mathematical and general....These problems have been a great way to learn both math as well as problem solving in general, and I hope that they are continued for future classes. [AS]

17. First and foremost about these original problems: I can honestly say that I have never done anything like this before, making this a good learning experience for me. Throughout my many math classes, no teacher had ever had me create problems (apart from the basics, such as a multiplication quiz). So, writing challenging problems was difficult for me in that it required me to think further then the basics, and I wasn't positive about what I should be doing. Throughout the semester, the purpose of this assignment became clearer to me. As I began to understand what I should be doing, I think that my original problems improved in difficulty and in depth of content. [HK]

On Writing Problems

18. Overall, I learned that as a question writer, I need to be patient. [ST]

19. The experience of writing the original problems was like a great adventure to me, almost like a treasure hunt. Every time I wrote my original problems, I was like exploring everywhere to excavate good parts that can be assembled to make the problems. [HJS]

20. I ran into another problem as well. Namely, I was never sure what a good original problem was. I held myself to a very high standard. I expected that the problems I would come up with would be as good as a professional's, which obviously would not be the case. Just the same as writer's block, I had calculus block. I should have learned that I needed to talk to others about the problem. I think that if I write original problems in the future, I will make sure to talk to others about them well in advance. [JC]

21. Furthermore, the [third] assignment wasn't something that needed a lot of time to write, only a lot of time to think. [AK]

22. Also, these assignments were refreshing. They are definitely not the typical assignment you have in math class. [RU]

23. On the FunDays [exams], I was able to see which types of problems were conceptual, and which types of problems were skill related. This allowed me to assess my own problems easily, and write them consistently. [DX]

The Power of Reflection

24. The reflection portion of each problem was also helpful because it made the assignment worth it. After I wrote my first original problem, I didn't really see any point to the assignment. It wasn't until I wrote the reflection that I realized how much the assignment was really helping me. [TY]

25. Throughout the course of this semester, I have come to understand the type of learner I am in math. For example, my usual strategy for studying or understanding math involves taking notes in class and doing the practice problems assigned for homework. If I still have trouble, I usually do some extra problems from the book, watch some tutorials online or ask a friend. This semester, with the heavy emphasis on conceptual questions, I realized how very skills based my learning strategy was. [SS]

On the Usefulness of Problem Writing

26. I do, in fact, believe that these assignments were *extremely* valuable. Each one has allowed me to reflect upon my understanding of each concept that we covered in the unit prior to the assignment. Then it also forced me to review and focus upon each topic until I was able to make an original problem based on them. Then, by my own actions, I would make an original problem that involved the topics I was the *least* effective in. This was in invaluable studying technique that I may incorporate into my other classes. [BA]

27. Completing these assignments has given me more of an understanding of which areas in BC Calculus I need to go back and fully learn. Creating original problems has helped me gain a better insight into the material we've covered in BC 1 and into my own personal habits regarding math. If we were given this assignment again, I would be able to continue developing my understanding of BC Calculus, and be able to improve upon my conceptual skills. [VA]

28. This is a valuable assignment because it gives me an excuse to review anything I had trouble with. It encourages me to be honest with myself. And, to be quite honest, I enjoy the challenge. [JC]

29. The most rewarding original problem assignment in my opinion was the multiple choice one. This is because the assignment forced me to think about the steps involved in solving my problem, and consider the mistakes people could make along the way. It also made me aware of the consequences of such mistakes. [MB]

30. I found this Original Problems experience to be extremely invaluable. I find myself wanting to practice this lesson in nearly every class I have because it prepares me well for what the teachers will ask me, while still reviewing my material. When my problems did not work out, or if Dr. Matsko said that something was wrong, I was motivated to see what happened. So, Original Problems have driven me to better my work ethic as well. [BG]

31. Instead of forgetting the chapter material until the finals, like I had previously done with my other math classes, the original problem assignment forced me to review the chapter once again and understand the important concepts. [DP]

32. In my opinion, this assignment was extremely valuable because it forced me to look back at the ideas we learned in class and expand and go deeper into them to create the problems. Also, it was a fun assignment. [AK]

33. As I worked on my first pair of original problems, I realized that problem writing only comes with a complete understanding of the topic in question and it can be used as a tool to measure your progress in the specific area. This is literally what I did towards the end of the semester; I first tried my best at understanding the topic, and checked whether or not I completely understood the topic or not by trying to write original problems. [RC]

34. I thoroughly enjoyed these Original Problem assignments because they allowed me to show my capability to think in new ways. In fact, the process of making a problem has actually helped me by clearing up some misconceptions that I had on certain rules or concepts. [TM]

35. I recommend keeping original problems for students in the future. Although writing these problems is time consuming, the future BC students can handle it. And really, just in general, writing original problems has increased my interest in mathematics. It was a worthwhile experience. [CG]

36. I feel like the most beneficial part of this process was the fact that, by writing problems on material I was unsure on or not completely confident in, I managed to learn more about that material. [MH]

37. If I were to create my own problems in future courses of mathematics, I believe I would more deeply understand the concepts and applications of each new unit. [CC]

38. I definitely felt that these problems were valuable. Apart from learning how to write effective problems, I felt that through these assignments, I learned how to think more conceptually. [BR]

39. These original problems are one assignment that I will miss if they don't continue on into BC II and III. [EZ]

40. After writing six of my own problems, I feel more prepared for the challenges that I will find in future math classes. Furthermore, I reviewed skills that I will need in the future, such as the logarithm rules and my algebra skills. Writing conceptual problems truly gave me a wholesome grasp of calculus. [AT]

41. Thanks to the Original Problems, I was encouraged to move beyond course structure and curriculum and research new areas of mathematics. As a result, my problem writing skills improved and I gained new insight into many interesting and exciting fields of mathematics. [GH]

42. Also, for me personally I have somewhat felt a loss of the joy I used to have while doing math since I have come to I.M.S.A. But I actually had a nice sense of satisfaction and fun while creating these problems (when I did not procrastinate them to the last day). So I think for me, at least, these assignments were valuable and good practice. [RG]

43. I believe problem writing is a valuable assignment because it allowed me to thoroughly think through and understand concepts without having to do a vast number of book problems. Although it takes roughly the same amount of time, I was able to completely understand a topic because I had to write a detailed solution to each problem. When I do book problems, I find the answer and move on to the next problem. However, when I write original problems, I double-check my solution is correct and thoughtfully explained. [DX]

44. Furthermore, even though sometimes I felt that I had a good understanding of a mathematical concept, writing an original problem gave me much more insight and showed me that there was much more to be learned about the concept than I had originally thought....I believe that if all math students were able to experience writing problems like we have, they would also show a significant growth in understanding of what they have learned. Oftentimes, simple memorization of rules and formulas is not very effective in promoting deeper levels of thinking that are necessary to truly understand the mechanics behind a mathematical concept. Writing new and original problems not only reinforces the knowledge that students have already learned, but also allows them to go beyond and be think in new and innovative ways. [EG]

45. The most useful aspect of these problems was the opportunity to explore a troublesome area. [WB]

46. By shifting the focus toward the bigger picture, the assignments have helped me re-train myself to pay attention to the underlying concepts, and taught me to discern which parts of a unit were more important. I feel more confident approaching the concepts portion of FunDays [exams] because I understand where the questions are coming from, and I have experience thinking in that way. Overall, I thought the original problems were extremely valuable. They have definitely made a difference in my understanding of calculus. [WB]

47. However, as I took on the task of creating my first two original problems, I noticed something interesting: I was reviewing and understanding the concepts which I focused on in each problem much better than I would have by simply doing a worksheet. Also, I actually had more fun working to find difficult and creative ways to cover the concepts we had continuously talked about in class, especially when I gave it to other students to struggle with, such as BC3 students. [EM]

48. I am not sure that this is a valuable assignment. It seemed that I spent more time doing these problems for a small amount of learning, instead of possibly studying for upcoming math exams. I think that other learning methods would be more appropriate and efficient. [MK]

49. One of my problems for the second set of original problems was faulty, as I forgot to account for when an equation is undefined. This threw off my answer, and therefore also my reflection on the problem. The returned problem, graded and with comments, was just as helpful to identifying my oversight as solving a similar question on a quiz would have been. Therefore, I had the opportunity to fix one of my mistakes as a result of this assignment, so that I will not make that same mistake later on. [HK]

50. Original Problems have definitely been valuable assignments, and I think they should be continued for BC classes in the future. [HM]

On Problem Writing in MI

51. I feel as though the experience has not only increased my own knowledge of mathematics, but also made me more confident as a mathematician, as I was able to prove to myself that I am capable of writing eloquently and accurately using mathematical terms, and learning new skills and concepts on my own. I think it would have been interesting to try to write original problems while in the MIs, so that I could have developed this confidence earlier in my career as an IMSA mathematics student. [YA]

52. I would definitely suggest incorporating these into future BC classes, and even MI classes as well. [BR]

On Improving the Problem Writing Experience

53. Also, I had trouble distinguishing between a skills and a conceptual problem. [JH]

54. I do think that two problems became too much, especially as the expectations grew. Writing a single conceptual problem or two skills-based questions would have been a more manageable assignment. [MA]

55. Overall, I did learn important things from this assignment. However, I do not think they were as significant and valuable as I wished them to be. I don't see myself as a significantly better problem writer, and the results of my problems were always disappointing compared to how much effort I put into them. [MS]

56. I think original problems were a good idea and it might be the fact that I struggled with BC1 that made original problems not have as great an impression on me. Therefore I think that the original problems were a good idea and should simply have been discussed in class for a little longer. [HF]

57. In fact, after writing the original problem, I actually felt as if it might have been beneficial to make the original problem due before the unit exam. Writing this particular problem greatly aided my understanding of the chapter. If I had written the problem prior to the exam, it may have been good preparation for the Fun Day [exam]. [CG]

58. As a little suggestion, I think the partner assignment might be more beneficial if it was the first one we did, rather than the last. Because the process got easier through the semester, the first assignment was really challenging and the last was pretty easy, made even simpler by the fact that we had partners. [MH]

59. One suggestion I do have is to either provide examples of what you are looking for or clarify the instructions on the prompts, so that future students do not get as confused as I initially was. [HK]

60. Original problems are a great study tool for solidifying knowledge, yet when one goes into writing a problem without great understanding of a topic, it usually really doesn't help....I think that using more in-class time to focus on these original problems as a study tool and having peers or instructors there at your aid can fix this problem and will really help in the future. [KW]