Teaching and Encouraging Meaningful Reading of Mathematics Texts

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Introduction

Students in lower division mathematics classes rarely read their textbooks. If they do attempt to read them, they generally lack the skills necessary to read the material effectively. We have become convinced that teaching students to read math with understanding will have large positive benefits in their learning in our courses. In this paper we report on strategies for teaching mathematical reading we have tried in several lower division math courses offered last Spring and Fall at the University of San Diego, some involving active use of technology and some not.

The University of San Diego is an unaffiliated Catholic institution with an undergraduate enrollment of around 5000. USD offers no graduate programs in mathematics. Generally fewer than eight students graduate each year with a major in mathematics. Many of these students plan on becoming high school teachers. USD also has 60-70 students a year who major in Diversified Liberal Arts, with the goal of becoming elementary school teachers. One could safely characterize the majority of our lower division classes as being service oriented courses, and the initial enthusiasm of our students for learning mathematics as mediocre at best. The first priority for faculty at USD is teaching, and students both expect and receive much faculty help and interaction both inside and outside of class.

Our explicit goals are two-fold: we wish our students to read the text book before attempting homework problems, and further to read the book actively, 'with pencil in hand'. We expect several benefits to derive from such an emphasis. In the short term we hope to make more effective use of class time. We can spend less time in class on basic definitions, freeing up time for a more profound discussion of topics. We are also able to cover more material at a deeper level. In the long term we want to develop proficiency in our students at reading hard, technical material, and in fact lead them to become independent learners. We take this latter goal especially seriously for our pre-service elementary and secondary school teachers.

In this paper, we describe specific varied attempts we have individually made to encourage active reading, and finally discuss our impressions of the results of each.

Dr. Perla Myers

Math 50 Calculus I

I based my approach on the work of Boelkins and Ratliff who described their email-based reading assignments at the August 2000 Mathfest (see [1], [4]). Before we covered a section in the textbook, I asked students to carefully read the section and answer few questions. I also expected them to ask a

few questions of their own. I tried somewhat different approaches in my Fall 2000 and Spring 2001 calculus classes. I used essentially the same questions both semesters; the major difference was the extent to which I used technology. In the fall the responses were to be sent to me via email, while in the spring students turned in typed or hand-written answers, with the option of using email. My revised method in the spring worked better to achieve all my goals.

Calculus classes at University of San Diego meet four days a week for 55 minutes. My Fall 2000 and Spring 2001 classes had 25-35 students. Most of the students were freshmen. Some of the students came from a College Algebra class, and several took a calculus course in high school. We used [2] as our textbook.

The reading assignments contained questions that would encourage the students to read actively. My short-term goals are for students to predict what is coming next, understand the basic definitions, and start making connections to previous and future sections. Both semesters the questions were posted on my webpage, making them very accessible to the students.

I graded the reading assignments using a binary system. The students earned a 1 if they made an honest attempt to answer the questions and posed some questions. Otherwise they made a zero.

The responses to these reading questions gave me much insight into how well the students understood what they read. I became aware of common misconceptions and areas that needed clarification. The students came to class with some understanding, no matter how incomplete, of the material and with specific questions. They had a basis on which to build greater understanding.

My reading assignments in the fall and spring semesters differed mainly in the way in which the work was to be turned in. In the fall semester I asked the students to email me their responses. I set up a special account to avoid overloading my email. I received about sixty emails daily! Somehow, this number of emails felt more overwhelming to me than a pile of sixty papers. I had asked the students for questions, and I could not control myself. I spent too long each night responding to many of the emails. I felt that I had an opportunity I could not pass up: I could give each student a hint or a push to expand her/his understanding. All this even before we discussed the section in class! Each email response took me a long time to compose, and the email made it somewhat less personable.

The email-based reading assignments definitely did open the lines of communication with my students outside of class. Students felt very comfortable asking questions and sharing their progress with me via email.

I reflected on the results from the fall semester: I felt that the reading assignments were successful in many ways. They encouraged the students to read the book and ask questions. The students' preparation resulted in more meaningful discussions during class: the students came to class already familiar with some of the terminology and with good questions, and I had an idea of what areas needed more focus. An unexpected advantage was the open line of communication that developed between the students and me. I conducted many email conversations with students who were not able to attend office hours, or were initially too shy to ask their questions in person. I also believe that the process of reading technical material became easier and rewarding for those who faithfully completed the assignments (87% of the students).

For the spring semester, I decided to adjust my approach. I changed the format for turning in the reading assignments. I gave the students an option of emailing the assignment or turning in a hand-

written (or typed) copy. Only two or three people chose to send the answers via email every week. The rest of the students turned in hand-written or typed responses to the reading questions in class. The "paper" assignments seemed easier to handle. I could spend half an hour each night writing some helpful comments, or "critical thinking" questions on most of the papers. The students accepted these comments very positively.

I thought that most of the benefits of the reading assignment process that I used in the fall would be retained under the “paper” scheme with two major exceptions: 1) Because the students turned in the answers as they walked into class, my ability to read all the responses prior to the lecture would be eliminated; and 2) student-instructor communication, enhanced by the email assignments, could be lost. In fact, not much was lost. The two or three assignments I received via email were somewhat representative of the rest of the responses. Also, since I used a slightly modified version of the fall reading assignments, I could predict some of the misconceptions and areas where the students could use some direction. the enhanced student-instructor communication also continued. In order to keep the open line of email communication, I sent out email reminders, questions and announcements often. I also encouraged students to use email freely.

Overall, I believe the reading assignments accomplished their short-term goals. In the future I would like to set up an online "chat room" where students can discuss problems and interesting questions.

Dr. Jeff Wright

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WebCT

WebCT (www.webct.com) is an online course management system that has been adopted for use across USD. WebCT offers a variety of tools, including web-based grade book maintenance, centralized communications capabilities (email, conferencing, bulletin boards), course calendaring, and quizzes and assessments with automated grading for questions of true/false, multiple choice, match-up, and fill in the blank type. I am currently using the grade book and online quizzes. The grade book capability has two main features that I like: without my direct involvement it allows my course grader to enter homework grades, and it allows students to check their grades as the course progresses.

The text I used was [6]. This traditional calculus text comes with a companion website (http://www.prenticehallmath.com/varberg/) that includes a set of true/false questions relating to the reading for each section. The questions are superficial, testing simply whether the brain of the student has processed the words on the page. I have adapted these quizzes to be delivered through the WebCT system currently in use at USD, so that they are required to be completed before a given lecture. The WebCT system automatically grades the quizzes and posts the grades to my course grade book.

WebCT also includes functionality to report on the correct/incorrect rates for each specific question on the quiz. This data should be useful in constructing lectures, although I found that in reality I seldom used it, due to lack of time. This is another area that I intend to take advantage of in the future.

I have generally received very positive remarks from students about their WebCT experience. They report to me that the online quizzes are very low stress (they can repeat as many times as necessary to

receive a passing grade), and that students feel better prepared when coming to class having read the section in advance and with some familiarity with terminology. My own subjective view is that I was able to push students harder this semester without being subject to the complaint that I was covering material they had not seen before or moving too fast.

Email

I also used email for this class, but in a slightly different way than Perla did. I sent daily e-mails to my students reminding them of important dates, etc., and also encouraged my students to send me questions about homework by email. I then responded to the entire class with hints. I learned from talking with students that my hints were gibberish to those who had not tried the homework yet, but that they did serve to keep the pressure on to continue working and not fall behind. When students saw evidence of their colleagues' efforts, they tended to redouble their own.

Dr. Jane Friedman

Math 11 College Algebra
Math 21 Liberal Arts Math

Several years ago I became aware of George Exner's wonderful book, *An Accompaniment to Higher Mathematics* [3]. This book, written for mathematics majors moving into upper division courses, teaches students how to read mathematics actively. Students learn to read with a paper and pencil. When they read a definition, for example, they stop and make up examples and non-examples (examples of objects which do not satisfy the definition). They ask and answer, if they can, questions about the material. I was quickly convinced of the soundness of the Exner approach and have tried in various ways to incorporate it into my classes.

In this paper I will briefly discuss my experiences trying to teach students in Math 11 (college algebra) and Math 21 (a general education liberal arts mathematics class taught out of [5]) to read the textbook. I was very influenced by Exner's book and wanted to try to develop ways to modify his approach for use with these less mathematically adept students.

Students were required to read assigned sections of the textbook before I lectured on this material in class. I wrote lists of questions in worksheet format, which they were required to hand in at the beginning of class. Many of these questions were not deep, and were designed merely to make sure they had read the material. For example, I might have them state a definition that was given in the text. I would want these to be completely correct, since one of the points I was trying to get across is that small differences in wording create substantial differences in meaning. Other questions might require students to create an example or solve a problem or explain something. These were deeper questions requiring more thought, and not co-incidentally requiring more time to grade. The final question on each sheet was ``Do you have any questions or comments?'

I graded these assignments very leniently, on a plus, check, minus scale (with zero for assignments not turned in at all). Most students got pluses on almost all assignments. Less than a plus meant an incomplete assignment, an assignment that appeared to represent almost no effort on the part of the student or an assignment that appeared to reflect almost no understanding of the material.

Each class meeting began with either a quiz or with students working a few warm-up or review problems independently. This gave me a few minutes which I could spend glancing through the reading assignments the students had handed in, and I could then make some modifications in my

lecture to take into account questions or problems they may have had.

I think that this approach did help somewhat. The students did spend some time with the textbook before class and this did help in their learning of the material. There were some problems. The assignments were too long, and I think some students merely skimmed the text looking for answers to the questions. Since I wrote them fairly quickly sometimes there were poor questions. Grading the assignments was way too time-consuming. But I did gain valuable insight into how my students were doing and the last question on the sheet opened up a space for students to comment in general on the course. In the future, I hope to write different questions, which are, if possible, easier to grade and at the same time push the students to go deeper in their reading. I also plan to spend more time in class teaching the students how to read for understanding, using a modified Exner approach.

Conclusion

We all remain convinced that teaching students to read mathematics is a worthwhile endeavor, which can contribute both to the short-term goal of providing deeper learning in a particular class and to the broader goal of developing students who are independent learners. The choice of how to accomplish this depends somewhat on the inclinations of the particular instructor, for example Perla found that written questions worked better for her than email -- the opposite of the experience of Boelkins and Ratliff. Jeff believes that the convenience of webCT makes up for the constraints it imposes on the types of questions, which can be asked. All of us need to find ways to balance our desires to help the students learn with the reality of our finite time. Perhaps more flexible software tools will be the answer. Can we Exnerize software?

References

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[4] Ratliff, Tommy, "How I (Finally) Got My Calculus I Students to Read the Text, Innovative Teaching Exchange," MAA Online.

[5] Tannenbaum, Peter and Robert Arnold, *Excursions in Modern Mathematics*, 4th edition, Prentice Hall, 2001.

[6] Varberg, Purcell & Rigdon *Calculus*, 8th Edition, Prentice Hall.