

The Effect of Journal Writing Upon Mathematical Learning

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Overview:

- The purpose of our study was to observe the effects of journal assignments (given for class preparation) upon student performance as well as upon student attitudes in the Calculus 150 A course.

Questions:

- Do journals influence performance on either conceptual or overall quiz scores?
- How will student attitude be affected toward math?
- Will journal assignments encourage students to read the textbook before attending class?
- Will journal assignments promote more effective reading of the text?
- Will weaker students benefit to a different degree from writing journals than stronger students?

Hypotheses:

- Students who complete journals will perform better on corresponding conceptual questions on quizzes.
- Students who complete journals will perform better on quizzes.
- Journals will promote a positive attitude toward class by helping students prepare better for classes.
- Students will learn how to better read mathematical texts.

Context:

- We became interested in this project because journal entries aided one of the project designers in learning to read mathematical texts, including learning to identify and extract key concepts from reading a lesson, as well as in learning to absorb mathematical concepts effectively as an undergraduate student.
 - Tara was the instructor of two sections of the first semester calculus course, Math 150A, during Fall semester 2009. Anneliese was a teaching assistant for two other sections of Math 150A during Fall semester 2009.
 - Math 150A students are generally not mathematics majors, and many took this course to satisfy core requirements.
 - There were 34 students who completed the entire semester of 150A in Tara's class, and 14 students who completed the entire semester of 150A in Anneliese's class.
- The majority of the students in both classes were Freshmen in their first semester of university attendance.
- All sections of students were taught by an instructor, and were to attend optional recitation sections led by a teaching assistant.

Methods:

- The students were instructed using the lecture method for the majority of the classes.
- During the semester, one of Tara's sections and one of Anneliese's sections were both designated as "odd", and Tara and Anneliese's other sections were designated as "even."
- To promote fairness in grading, the odd sections were given journal assignments, 1, 3, 5 and 7. The even sections were given journal assignments 2, 4, 6, 8.
- Students in either the even or the odd section were given a journal assignment, which included instructions to read and take notes on the section which the lecturer would cover in the subsequent class. Students were also given a conceptual question to answer, and were asked whether they had any questions regarding the material they had worked on. Students in the section with a hiatus week were given access to the conceptual questions as well.
- Journals were not graded for correctness, but rather for completion. The journals were returned to students before they took the quiz. They would receive comments about their response as well as an answer to any questions they had.
- A quiz comprised of both computational and conceptual questions was given following each journal assignment. Conceptual questions were directly related to the specific conceptual question which was asked on the corresponding journal assignment.
- In addition, we collected a survey both at the beginning and the end of the semester to assess student attitudes. From the final survey, we were able to assess student attitudes regarding the journal assignments.

Example of a Journal Question and Corresponding Quiz:

Journal Assignment:

- Read section 4.7 in the textbook
- Take notes on the reading, including writing down all important definitions and formulas
- Answer the following question: WHY is it that when we solve optimization problems we look for absolute extrema as opposed to local extrema? You must explain your answer. Points are given based on thoughtfulness, not correctness.
- Is there anything in the section that you read which confuses you?

Corresponding Quiz Questions:

(Conceptual) Suppose that $f(x)$ represents the cost required to build a fence on your property, where x represents the amount of material used. Let $f(x)$ have a **local** minimum at $x=2$. What does this mean in physical terms? Would you want to buy a fence that cost $f(2)$?

(Computational) Find the area of the largest rectangle which can be inscribed in the ellipse $x^2+a^2y^2=1$, where a is a positive constant.

Quantitative Data Analysis:

Using the statistical analysis program, SAS, as well as Excel, we computed the following. We used the 'genmod' procedure, which performs linear regression for clustered data.

- For combined data of all four sections:
 - We calculated the effect of journals upon conceptual quiz scores, but obtained all p-values greater than 0.05, and thus had statistically insignificant data.
 - We calculated the effect of journals upon the entire quiz grade, including computational scores this time, and again obtained all p-values greater than 0.05, and thus had statistically insignificant data.
- For data of only Tara's sections, and separately for Anneliese's sections:
 - We again calculated the effect of journals upon conceptual quiz scores, but obtained a value of p greater than 0.05, and thus had inconclusive data.
 - We again calculated the effect of journals upon the entire quiz grade, including computational scores, and again obtained a value of p greater than 0.05, and thus had inconclusive data.

Note: All data was tested twice. Once, we ignored student ability, and the other time we normalized, using the first test scores.

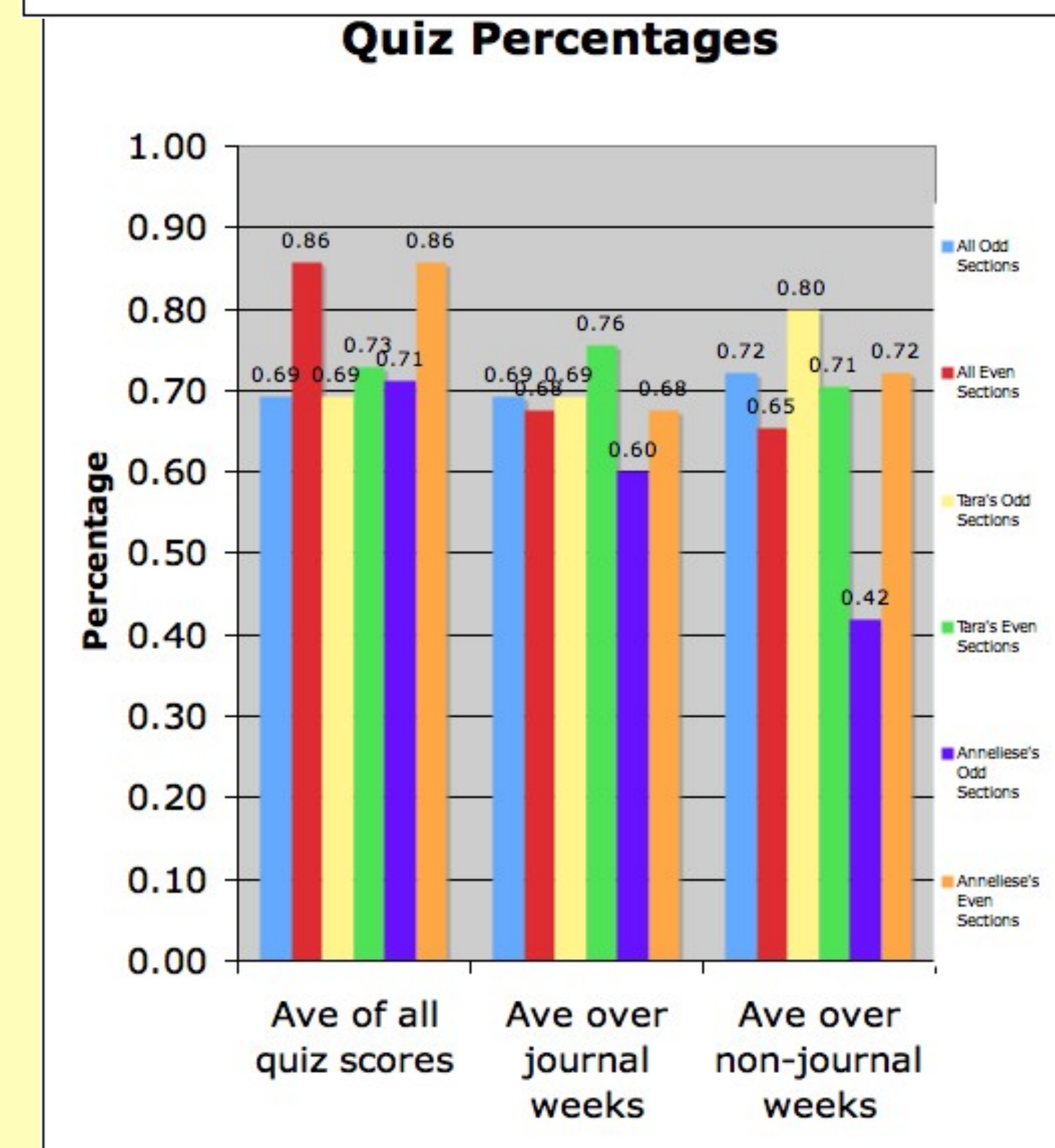
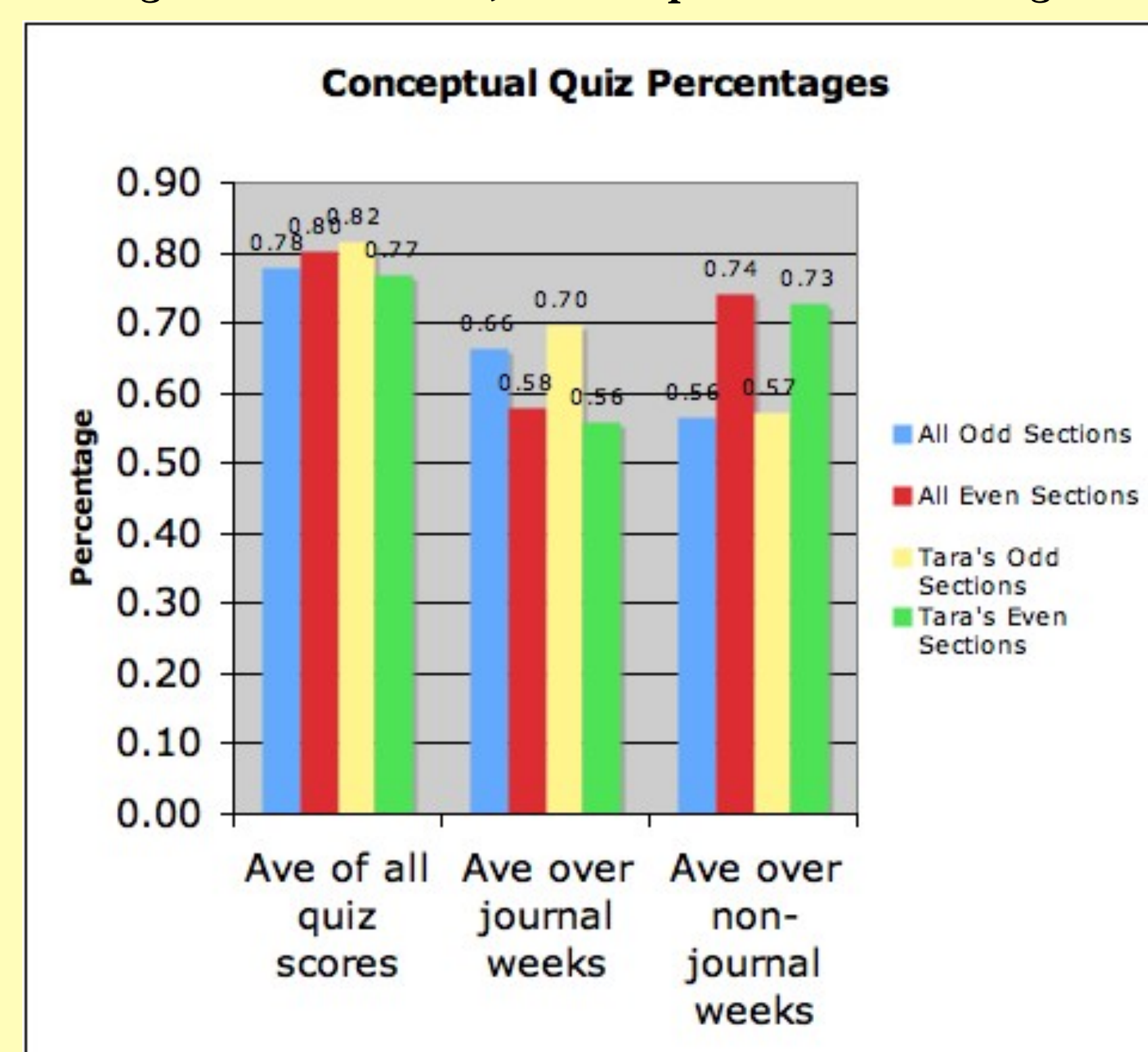
- We calculated whether there was any significant difference in the overall quiz scores of the four sections, and concluded after normalization that Anneliese's odd section had lower overall quiz scores by 14.2 out of 100 points than her even section. ($p=0.0212$). We found that while the abilities of Tara's two sections were statistically indistinguishable, both Tara's sections scored lower than Anneliese's even section. Tara's even section scored on average 8.9 points lower on quizzes ($p=.0244$) while her odd section scored on average 6.5 points power on quizzes ($p=.0191$).

We calculated whether there was any significant difference in the conceptual quiz scores of the four sections, and concluded after normalization that Anneliese's odd section had lower overall conceptual quiz scores by 20.2 out of 100 point. ($p=0.0352$). We found that while the abilities of Tara's two sections were statistically indistinguishable, both Tara's sections scored lower than Anneliese's even section. Tara's even section scored on average 13.8 points lower on quizzes ($p=.016$) while her odd section scored on average 12.6 points power on quizzes ($p=.0119$).

Conclusions from Qualitative Data:

- Our intervention of journal use neither hurt nor helped the performance of any students on either conceptual or overall quiz performance.
- The four sections were of varying abilities, or "smartness" (judged by performance on quizzes and conceptual questions). Anneliese's even section was smarter than any of the other 3 sections, although Tara's two sections were indistinguishable in this sense.

Using Microsoft Excel, we computed the following:



Qualitative Data Analysis

From the exit surveys we gathered responses to the following statements. The students answered on a scale of 1 (completely disagree) to 10.

1) Doing the journal assignments helped me learn to read the textbook effectively.

The average answer to this question was 6.67, with a standard deviation of 2.4.

2) Doing the journal assignments made me more motivated to read the textbook on my own.

The average answer to this question was 5.76, with a standard deviation of 2.4.

3) Doing the journals made me prepared for the quizzes.

The average answer to this question was 6.13, with a standard deviation of 2.4.

4) Doing the journals was useful.

The average answer to this question was 6.85, with a standard deviation of 2.6.

Using Excel we were also able to find a weak negative correlation between the answers to Questions 3 and 4 and final grade in the class ($r=-.21$ and -0.20 respectively). That is, students who received higher grades tended to think the journals were less useful and prepared them less for quizzes, while students who received lower grades found the journals more helpful overall and in preparing for quizzes. We also found a weak positive correlation ($r=0.23$) between conceptual quiz score and final grade in the class. (Such a correlation has also been found on a previous TAR project by Tara during 2008-2009).

Conclusions: The students overall believed that the journals were helpful, helped with quizzes and reading the text, though not overwhelmingly so. Based on this indication, students who do better on conceptual questions receive higher final grades in the course. One reason that the students who obtained higher grades found the journals less helpful is because they already possessed a higher level conceptual understanding; on some level they did not need the journals as much. However, in mathematics, especially introductory level course where math anxiety is prevalent, any intervention which decreases anxiety could be thought of as beneficial, in particular for the weaker students.

Representative Quotations from Students:

"Sometimes the concepts we were required to analyze would be contained on true false portions of the exam. This was very helpful and I would recommend using the journals in all calculus courses." "The journals were most useful in helping further understand class lectures because I had already heard of the concepts and definitions prior to the lecture." "I think the journals are a good way to help encourage the reading and also a way to learn the theorems in the book. I found myself more willing to do calculus homework after I did the journal because it made sense to do the exercises after reading the section. The journal definitely helped facilitate me doing the homework."

"I like that they grade boosters but I don't consider them extremely useful."

"I wish there had been a shorter one or that we had to do each section's journals. They were helpful but I never had the motivation to do both sections."

Conclusions and Room for Improvement:

Overall Conclusions:

While we were disappointed that our intervention did not make a statistically significant impact on student performance, we still believe that the use of journals in mathematics education is beneficial. The reason for this is partially explored in the discussion of our qualitative data.

We still believe that improving conceptual understanding will improve performance, and this correlation was evidenced with our data. While in this case they were not proved to do so, we still believe that journals could improve conceptual understanding.

Possible Explanation for our Results:

It is possible that the intervention was not strong enough. Each student only had the opportunity to do 4 journals throughout the course of a semester. The journals only counted for a total of 8 out of 650 points.

Moreover, the Math 150A course is standardized away from conceptual type exam problems (towards computationally heavy tests). Therefore, the lecturers were forced to spend most of their class time preparing students to do heavy computations. The emphasis on concepts, logic and proof was therefore absent. This could explain a lack of motivation to think hard about the journal questions, or a simple lack of ability and practice thinking through difficult, open-ended math problems.

Another possible explanation is that perhaps all students looked at all journals. Although we asked about this on the exit surveys, not all students answered, and several indicated that they looked at or partially completed all journals, but only did a formal write-up on the ones they were required to turn in.

Directions for Future Improvement:

We believe that with some of all of the following improvements, the journals would have a more significant impact.

- Include small discussion groups regarding how to answer the journal thought question.
- Give journal assignment more frequently—for example, every other day a different half of the class will need to do a journal. (We believe that the data we collected was good, so getting similar data would be nice.)
- Make the journals count for more points—Vanderbilt students are motivated by grades.
- Put more conceptual points on the tests. This will make students more interested in doing journals and learning how to increase conceptual understanding.
- Grade the journals more carefully, instead of just on effort. For instance, some students notes on the text would include just important theorems, formulas and definitions, while others would include absolutely everything. Part of the aim of the journals is to teach them to read the book, so if they are doing so in a way that is not optimal, we can encourage change by assigning points via journal.
- Provide some journal assignments that are perhaps more difficult or in depth. We want to help those stronger students too! Such questions will help everyone to benefit from more conceptual understanding—as well as serve to challenge people who are already good at basics. This could also promote office hour attendance.

We would like to thank CIRTl for their support, our faculty mentor, JoAnn Staples, Derek Bruff and the Center for teaching, and Jim Davis for statistical assistance.