

Thinking Statistically in Writing: Journals and Discussion Boards in an Introductory Statistics Course

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This action research combined qualitative and quantitative techniques to investigate two different types of writing assignments in an introductory undergraduate statistics course. The assignments were written in response to the same set of prompts but in two different ways: homework journal assignments or initial posts to a computer discussion board. A survey at the end of the semester elicited student reactions to writing in a statistics course, as well as to the two different types of writing they were asked to do. A majority of the students felt that the addition of writing to the course was beneficial to their learning. Student writing was analyzed to identify the types of writing found. Both forms of writing investigated allow students to engage in reflective thinking about statistics and to communicate their questions to their instructor. Both forms of writing helped students to improve their understanding of mathematics and their ability to communicate mathematically. The discussion board, however, engaged students in a dialogue, which allowed them to build on one another's thinking. The identification and classification of types of writing found in different kinds of student responses will allow future instructional decisions and point to further research.

For many college undergraduates, Introduction to Statistics is a scary course. This is true even for the students who one might think would see the study of statistics as useful or interesting, such as sociology or political science majors. One reason may be that most introductory statistics courses are taught within mathematics departments. Unfortunately, that means that many students who might otherwise be attracted to statistics let their fear or lack of confidence in mathematics "spill over" into their Introduction to Statistics classes (Conners, Mccown, & Roskos-Ewoldson, 1998; Onwuegbuzie & Wilson, 2003.) When students are interested and engaged in the material, however, they are less anxious (Mitchell, 1997; Conners, Mccown, & Roskos-Ewoldson, 1998; Kirk, 2002; for example); their instructors are better able to help them (Grossman, Smith & Miller, 1993; Shibli, 1992; Drake & Amsbaugh, 1994); and, perhaps even more important, the students learn more (Conners, Mccown, & Roskos-Ewoldson, 1998; Geisbrecht, 1996; Shibli, 1992).

Hence, it makes sense to find ways to make the Introduction to Statistics course more interesting and engaging for students. One method is to focus on applications (Bessant, 1992; Kirk, 2002; Mitchell, 1997.) Providing opportunities for students to apply statistical concepts to real-world situations makes those concepts more meaningful to students. As Mathew Mitchell (1997) points out, "Students know they live in a complex world where consensus is an ideal rather than a reality" (p.11). Statistics can offer students a way to "make sense" of the world as they already perceive it. Another method is to ask students to write. In Mitchell's study (1997), writing assignments that asked students to use statistical concepts to write about topics

that interested them were "perceived as highly relevant (or meaningful) by students" (p.11). Writing assignments can be intricately tied to applications-oriented methods, in that they often ask students to consider how the concepts they are learning in class apply to the world they live in and then to articulate their understanding in writing. Beins (1993), for example, identifies writing "press releases" about statistical data sets in laymen's terms as a form of active learning that uses real-world applications to help students learn statistical concepts. Beins concluded that students who wrote about statistics in lay language acquired better interpretative and computational skills. The range of writing assignments that statistics instructors have used is huge, and it includes term papers, short essays, notes, press releases, position papers, and journals.

The action research presented here combined qualitative and quantitative techniques to investigate two different types of writing assignments in an introductory undergraduate statistics course with an applications-oriented approach. The assignments were written in response to the same set of prompts but in two different ways: as homework journal assignments or as posts to a computer discussion board on a Blackboard course web site. Student writing was analyzed to identify the types of writing found, and a survey at the end of the semester elicited student reactions to writing in a statistics course, as well as to the two different types of writing they were asked to do. Identifying the types of writing students do in response to these assignments can help determine both the strengths and weaknesses of each as well as the ways in which students are using writing to learn statistics.

Writing for More Than Writing's Sake

Writing has been identified by key organizations as an important skill for all math and statistics students (ASA, 2005; NCTN, 1989, for example). One reason that the national organizations recommend integrating writing into mathematics and statistics courses is that writing assignments will make students better writers or mathematical communicators, and it is clearly the consensus of the field that statisticians need to be better writers (Beins, 1993). Samsa and Oddone (1994) point out, "Many people's first encounter with a statistician is through the written word; thus, the more clearly and persuasively we write, the more positively will our profession be viewed" (para 1). Stromberg and Ramanathan (1996) contend that it is "both easy and vital to include writing in the general statistical curriculum given the interdisciplinary nature of the subject" (p. 161). The more practice students have in writing about statistics, the better statistics writers they will become.

Integrating writing into statistics courses, however, is not only important because it gives students practice writing. There are several other reasons that may be just as important. For one thing, writing assignments have been shown to increase students' confidence as statistical thinkers and to alleviate some of the anxiety of taking statistics (Dillon, 1982; Smith, Miller & Robertson, 1992; Sgoutas-Emch & Johnson, 1998; Pan & Tang 2004). Kathleen Dillon asks her students to do a short piece of anonymous writing at the beginning of her undergraduate statistics courses, specifically about how they feel upon entering a statistics course, as an introduction to a discussion of math anxiety (Dillon, 1982). Researchers and instructors Pan and Tang (2004) combined two approaches to reducing statistics anxiety for their graduate students: a series of methods to increase the instructors' awareness of the students' anxiety and application-oriented teaching methods which involved both writing to lay audiences and writing journal article critiques (pp. 152-3). Their study indicated that these methods did have a statistically significant effect, as shown with pre- and post-test measures of anxiety. According to Pan and Tang (2004), anxiety about learning statistics may be due to a lack of mathematical background or skill, but it may also be due to misunderstandings about what the study of statistics is about (p. 149). Writing about why statistics might be useful, or why it is important to be statistically literate, may help students begin to connect to the subject matter in new ways.

Another good reason to integrate writing into the statistics curriculum is that reading what students write about statistics helps instructors understand when students are learning and when they need more help (ASA, 2005; Grossman, Smith & Miller 1993; Samsa &

Oddone, 1994; Stromberg & Ramanathan, 1996, Drake & Amsbaugh, 1994). For example, Stromberg and Ramanathan (1996) demonstrated that short in-class writing at the beginning or end of a class period and "writer-based" informal journals can help an instructor evaluate students' understanding of the course material (1996, p. 160). Samsa and Oddone (1994), after teaching a course in statistically based scientific writing, concluded that "writing is an excellent mechanism for identifying students' strengths and weaknesses" (section 6, para. 2). Because writing exposes what students can and cannot explain, it also helps us discover what they still need to learn.

Most importantly, however, writing can improve students' statistical thinking and learning. Scholars in composition (Emig, 1977; and Berthoff, 1982; for example) and in WAC (writing across the curriculum) studies (Fulwiler, 1987; for example) have recommended writing as a way to develop and extend thinking. The American Statistical Association (2005) recommends written assignments as a way to assess statistical thinking. According to Grossman, Smith, and Miller (1993), when students write about statistics, "Writing becomes the means for translating the strange into the familiar and the seemingly foreign or new concept into a comprehensible or understandable idea" (p.2). Powell (1997) describes the usefulness of writing about mathematical experiences this way: "Writing, because the writer and others can see it, allows one to explore relationships, make meaning, and manipulate thoughts; to extend, expand, or drop ideas; and to review, comment on, and monitor reflections" (para. 11). Articulating thinking in writing, especially in informal writing assignments like learning logs or journals, can help clarify and extend that thinking.

Though there are many examples of informal writing as a teaching method in statistics, including journals, learning logs, dialogue journals, and informal writing turned in with homework, one of the two types of assignment in the current study consists of posts on a discussion board, and discussion posts are treated more often as verification of technology use than as a writing assignment in the literature. Comunale, Sexton, and Pedagano Voss (2001), for example, studied discussion boards as part of a larger study of the effectiveness of course web sites in a business statistics course. They found that students who used the course web site and found the discussion board useful also thought that the web site helped them learn. Krentler and Willis-Flurry (1999) found significant correlation between the amount of thoughtful posting a student did on discussion boards in a marketing course (with thoughtfulness assessed by the course instructor) and the student's learning (measured by course grades.) According to Marra, Moore, and Klimczak (2004), very little work has been done with content analysis of

discussion boards – that is, with looking at discussion board posts as writing, rather than evaluating user satisfaction or counting posts or numbers of words.

One problem, of course, is that it is difficult to decide whether learning has, in fact, taken place. Krentler and Willis-Flurry (1999), after pointing out that student reports of whether a tool helped them learn was an inadequate measure of learning, used course grades as their measure; it certainly can be argued that grades are a better measure than student reports, but neither one is complete. In the current study, we did look at course grades, in which we found no measurable differences, and we did also ask for students' self-reports (see findings below), but one of our main focuses was not on summative measures of learning, but instead on characteristics of student writing that may indicate a potential for student learning.

Methods

In the current study, students in two sections of the same introductory statistics course were given the same writing prompts, but asked to reply in two different ways. We relied primarily on the collection and qualitative analysis of the writing done by students, but also investigated students' response to the assignments with a final survey. We believed that the prompted writing would promote student learning and statistical thinking, whether they were writing journal assignments or participating in a discussion board. We hypothesized, however, that students would get more benefit from the discussion board, as it allows for interactive discussion, collaboration, and debate. We were also particularly interested in determining what kind of writing students were doing in each case.

Prior to this study, the Introduction to Statistics course at the college included a homework journal assignment that allowed the instructor to gauge students' understanding of the material, as well as to gain insight into how they were feeling about the course, and to adjust her instruction accordingly. Along with each homework assignment, the students would write a short paragraph in which they could ask

questions relating to the content or the course as well as express their feelings about the course. This journal, however, did not specifically require students to think about, and write about, statistical content. Although journal writing has been shown to alleviate statistical anxiety, as has been noted, writing about more than just their feelings may also prompt students to think about statistics, so the instructor decided to create ten prompts, based on class content, to which the students would respond. Some of these prompts asked students to apply their new understanding of statistics to real-world applications. Table 1 contains four examples of prompts used. Some of the prompts, the first and third in the table for example, asked open-ended discussion questions about statistics, and others, like the second, asked students to apply the new concepts they were learning.

The fact that the instructor taught two sections of Introduction to Statistics created an opportunity to compare two different methods of asking students in each of the two sections to respond differently to these prompts. In one section, all the students would simply write a 250-word journal response to each prompt and turn it in on a weekly basis. In the other section, all the students would answer the same prompts by participating in discussion forums in Blackboard. For the latter method, which placed an emphasis on the use of technology, each student was required to post an initial response to the prompt as well as at least one response to another student. The course structure for the two sections was identical in all other ways.

Across the two sections, 38 students participated in this study. Out of the original 23 in the discussion board section, 3 stopped coming to class, and 2 declined to participate in the study, leaving 18 participants. Of the original 24 students in the prompted journal section, 2 stopped coming to class, and 2 declined to participate in the study, leaving 20 participants. Each section had both high achieving and low achieving participants. A t-test of final course grades yielded no significant difference between the two sections ($t = -0.20, p = 0.84$). Herein, the discussion board section will be referred to as Section A and the prompted journal section as Section B.

Table 1
Some of the Prompts Used for Journal Assignments

Example	Prompts
Example 1	What does "statistically literate" mean and why is it important to be "statistically literate"?
Example 2	Get on to the Gallup Poll website (via External Links). Pick one of the articles (there may only be one that you can access) and discuss one or two of its results. There is no need to discuss all the results. Be sure to describe the survey methods. What does 95% confidence mean?
Example 3	The numerical aspect of statistics can be described as "numbers with social context." What does this mean to you?
Example 4	Charts and graphs are seen quite frequently in newspaper articles, magazines, books, etc. There are pros and cons to using such visual representations. Describe one pro for using a chart or graph. Describe one con.

Table 2
Items on the End-of-Semester Surveys

Question	Section A: Discussion Board	Section B: Prompted Journal
1)	I believe that participating in the Discussion Board forums on Blackboard was beneficial to the learning process.	I believe that writing the prompted journals was beneficial to the learning process.
2)	I enjoyed participating in the Discussion Board.	I enjoyed writing the prompted journals.
3)	I would recommend that the Discussion Board be a permanent part of MAT 2021.	I would recommend that the prompted journals be a permanent part of MAT 2021.
4)	The Discussion Board WAS NOT too much extra work in addition to the other course requirements.	The prompted journals WERE NOT too much extra work in addition to the other course requirements.
5)	I would have preferred to write a weekly 250-word typed response to the prompts instead of participating in the Discussion Board forums.	I would have preferred to participate in forums in the Discussion Board in Blackboard instead of writing the weekly 250 page typed response to the prompts.
6)	Reading other students responses helped me to think about statistics in a different way.	I believe that being able to read how other students responded to the prompts would have helped me to think about statistics in a different way.

All journal assignments and discussion board entries written by participating students were collected and analyzed. The analysis began after the semester had ended and some time had passed, when both investigators independently re-read and coded journals and discussion board entries, and then met to discuss patterns identified and further questions to ask. In a content analysis of qualitative data, it is expected that the data itself will provide some of the coding categories and that the identification of these categories which arise from analysis is, in fact, one of the important outcomes of the research. The categories themselves provide insight into the phenomena being investigated and point to opportunities for future research. In this research, we searched the writing samples, both prompted journals and discussion board dialogues, for types of writing that could be divided into clear categories.

At the end of the semester, participating students in each section were given a short survey which used a Likert scale. Table 2 shows the items for each section.

The statements on the two surveys were worded slightly differently in order to relate to the discussion board or the prompted journals, but the items matched up one to one, which can be seen in Table 2 by reading across rows; for example, Item 1) for section A is about discussion boards and learning as they posted their responses, whereas Item 1) for section B is about journal entries. It should be noted that not every student responded to every item.

Findings

The writing assignments in both sections appear to have value as tools for teaching statistics. One difficulty in attempting a comparison of the two types of writing is that they are very much two different types; the rhetorical situation in a discussion board is entirely different than the one a writer is in when she writes a journal assignment she knows will only be read by the

teacher. Particularly key is a primary difference between discussion board posts and journal entries: the audience of a journal entry is perceived by the writer to be the professor, or in rarer cases, the writer himself, but the audience of a discussion post is much broader. Audience makes a difference in many aspects of student writing.

Accordingly, when we analyzed the students' writing for themes, we actually arrived at two overlapping sets of themes for the two types of writing. One theme found in both sets of writing samples was example. Students used examples, both short and extended, to illustrate the statistical concepts they were writing about. Student writers pulled examples from the world as they see it. For example, in answer to the question, "What does it mean to be statistically literate?" one student posted, "Statistics are used all around us: the car insurance companies use statistics to figure out [whom] to charge what, the sports teams determine their players' salaries with statistics, [and] colleges use statistics to determine how they can attract more students." Another student used marketing firms as an example in a journal entry, writing, "Often marketing firms or political groups will do this to make their cause seem better and their opponent's worse. It is not misrepresenting the data, but transforming the way it is viewed..." Concrete examples appear to be a way that students can pin down knowledge about statistics for themselves, and in the case of discussion posts, for their classmates, through their writing.

A second theme found in both sets of writing samples was personal connections. Students made personal connections to the concepts they were writing about in both their journal entries and in their discussion board posts. These personal connections may help students become more engaged. For example, students asked to investigate the Gallup poll web site will choose to write about polls to which they feel some connection. One student wrote in a journal response, "I had a deep interest in the brief section on sham

surgeries involving experiments on Parkinson's disease. My grandfather has Parkinson's, so it caught my eye." Another posted that, "My math teacher from high school worked for the state in the summers, and he took his class on a field trip so that we could actually see this at work. This is the first time it dawned on me that numbers could be so loaded with meaning." These personal connections are an important theme in the data because of the way people learn: ideas and concepts that can be linked to already existing interests will make more impact.

A third theme was questions, though students asked far fewer questions than we expected; questions were found predominantly in the discussion board. It may be that students asked questions less frequently in their journal entries because, even though they knew their instructor would be reading and returning the work, the answers were likely to be delayed by several days. A student writing in a journal entry, for example, "...the statistics book mentions tossing a coin to choose a simple random sample, is that the right thing to do?," is probably expecting a response, but not a quick one. On the other hand, the student who posted, "I don't understand the part about seventeen polls taken over a period of three months. Were they all the same questions done by the same pollers?," on the discussion board knew that even the instructor did not respond right away, a classmate might. The prevalence of questions in the discussion board, versus a relative paucity in the journal entries, is one place where the difference in audience may be playing a role.

The writing that students did on the discussion board showed a wider range of types of writing. One theme in the data from the discussion boards was validation. Students often validated one another's responses through praise, agreement, and restatement. When students wrote, "Wow...that's crazy...but interesting," or "I think your topic sounds interesting," they were validating with praise and expressions of interest. They also validated by agreeing with their classmates, as in, "I think this is true," or "I agree with your response," and through praise: "I thought that your response was very observant...Good point, really added to the discussion." Students also frequently re-stated one another's contributions and sometimes expanded on what others wrote, as when a student posted, "I think this would be an interesting topic to run a survey on. You could find out if people went to places around the world with their parents or actually set off by themselves. You could also compare where people live and where they have traveled to."

Another theme that arose in the discussion boards and not in the journal was debate. In the discussion boards, students occasionally corrected, or debated, other student's contributions; for example, one student wrote, "I didn't read the poll you responded to, but

wouldn't a voluntary response survey be one in which the people called in to give their opinions not the other way around?" Because the journal entries had such a narrow audience and were written only in response to the prompt, and never in response to another student's ideas, these themes of validation and debate were not found in the journal writing. An important value of the discussion board, in fact, seems to be that the students were engaging in a dialogue. When students became engaged in responding to one another about the topic at hand, they appeared to be able to extend the whole group's understanding of statistics.

Nudging or extending another student's understanding of statistics doesn't necessarily take a long response. One student might, for example, rephrase what a classmate says using statistics vocabulary and thereby help the first student, or perhaps even others in the class, become more comfortable connecting that vocabulary to already existing schema. For example, regarding the use of graphs in general publications, one student wrote the following:

There are plenty of pros and cons of using graphs. When they are used in magazines, newspapers, and other media related documents, they can be very misleading. The information that they represent may be the truth, but the information that is presented in the graph may not be what they are really trying to prove. The anti-tobacco [ads] are very good for this. [They] use graphs to show how many people [die] each year from smoking, but they never [seem] to show how many people actually smoke overall; therefore, their information should be presented differently.

Another student wrote this in response:

I thought that your response was very observant. I had never even thought about the fact that they have all these statistics about smoking, but have never stated the sample size or the population size that they are using. Good point, really added to the discussion.

Here we see the second student not just validating the contribution of the first with "very observant," and "good point," but also rephrasing the example about anti-tobacco advertisements using the terms "sample size" and "population." We can't know, of course, whether the second student is using the terms because she is experimenting with them herself, or because she wants to help her classmate learn them (which would be perhaps more altruistic a motivation than most students might have!), but one way or the other, the collaboration serves to create a co-authored text that

encapsulates one part of the growing knowledge of the group.

In the following exchange, several students worked together to clarify terminology they have learned in class. One student wrote a post about a Gallup poll in which she brought up a concern about whether the poll was flawed because it was a voluntary survey, of which this in an excerpt:

In three weeks time Bush's approval rating has increased from 51% to 57%. This was found by conducting a telephone survey of 1,010 american [sic] adults over the age of eighteen... This was a telephone survey which can make the results bias [sic] because not everyone has a phone. Also it is a voluntary survey which usually people who only care about the topic answer. 95% confident means that 95% of the time Gallup falls within the M.O.E.. They are 95% confident they are within the M.O.E.

Another student responded by tactfully questioning the first student's use of the term "voluntary survey": "I didn't read the poll you responded to but wouldn't a voluntary response survey be one in which the people called in to give their opinions not the other way around?" This question may be the writer's gentle way of correcting the first student. A third student chimes in with a reinforcement – "This was also my understanding, thank you for bringing it up" – and then a clarification or re-phrasing of the first respondent's correction:

I thought that the selection of telephone survey participants was random and that any non-answer was factored in as part of some math business. That if someone did not participate then they were a loss, and Gallup could not choose another participant. Right?

The value of the journal entries seems to be that the students are able to engage in reflective thinking about statistics. When asked to respond to the journal prompts, students asked questions, created their own examples of key concepts, connected the material to their prior knowledge, and corrected their understanding as they wrote. But when students wrote to one another and then wrote responses, there seemed to be added benefits. The re-phrasing function of student responses was key to the social construction of knowledge that appeared to happen in the discussion board exchanges. In addition, there were several conversational features here which demonstrated that during this discussion, knowledge was experienced by the students as negotiable. The writers couched corrections as questions, qualified their contributions

with phrases like "I didn't read the poll you responded to, but..." as well as invited correction and rephrasing with questions like the "Right?" at the end of a student's response.

This re-phrasing and negotiation were qualitatively different than simply asking the teacher for a definition or clarification, and they may have helped student writers as they constructed their own growing knowledge. At the same time, the teacher was able to read the discussion, at her convenience, and intervene when it seemed that a little nudge might help. For example, here the teacher added a fairly long explanation of the term "voluntary response." Although there was surprisingly little misuse of statistical vocabulary in either the discussion board or the journal entries, the journal entries allowed the instructor the opportunity to correct what misuses there were. In the discussion board, however, because the instructor's contribution came after the students' discussion, and because it responded to the students' concerns directly, it became part of the negotiation context, rather than simply instruction aimed at filling a student's head with the right answer. The discussion board also offered another advantage: speed of intervention. Both forms of writing allowed the instructor to "take the pulse" of the class, to see where the group as a whole might need more instruction. "In class, I talk about misconceptions," the instructor reported, "and I also correct them on papers." But the discussion board allowed intervention the next time she logged on, so that misconceptions could begin to be corrected more quickly.

More Findings: Survey Results

The survey at the end of the semester provided insight into how the students viewed the writing assignments in the context of their introduction to statistics and their learning in the course. Table 3 summarizes some of the results of the survey, comparing how students from the two different sections, the A section that wrote on the discussion board and the B section that wrote journal entries, responded to statements in that survey.

In our study, more students appeared to enjoy the discussion board than the solitary journal writing. In Section A, 56% enjoyed participating in the discussion board, while in Section B only 40% of the students enjoyed writing the prompted journals. Only two students in each section, however, indicated they did not enjoy the activity. A majority of the students thought the writing assignments were worth keeping. Sixty-seven percent of the students in Section A would recommend the discussion board become a permanent part of the course. In Section B, 55% recommend keeping the prompted journals.

Table 3
Percentages of Students Who Responded “Agree or Strongly Agree” to Selected Statements from End of the Semester Survey

Item	Section	
	A: Discussion Board	B: Journals
Enjoyed writing assignment	56	40
Recommend writing assignment become a permanent part of course	67	55
Writing did not add too much extra work	82	74
Participating in the discussion board was beneficial to learning	61	50
Would have preferred the other type of written assignment	6	33
Reading other students’ responses [might have] helped think about statistics in different ways	72	53

A major concern for many instructors trying to introduce more writing into their courses is the workload that it adds, both for instructor and for students. However, 82% of students in Section A indicated that the discussion board did not add too much extra work, and only one student indicated that the discussion board was too much extra work; 74% of students in Section B indicated that the prompted journals did not add too much extra work. Most of the students surveyed agreed that the writing assignments did not add excessively to the course workload.

Perhaps more importantly, most of the students felt that the addition of writing to the course was beneficial to their learning. In Section A, 61% of the students agreed or strongly agreed that participating in the discussion board was beneficial to their learning, and fewer than 6% disagreed. In addition to the six statements using the Likert scale, students were asked for general comments, and some of the narrative comments in this section may provide some specifics about why the students saw the discussion board as beneficial. One student wrote, “It seems like a lot of busy work, and time consuming but in the end it paid off.” Another commented that the discussion board posts “were actually quick and easy and helped my understanding of the material.” It’s important that writing in a math or statistics course be more than busy work; at the least, it should give the students practice communicating about the subject material, but if it can also help them learn or understand the course material, then it truly is not “busy work,” and worth integrating into the course. Seventy-two percent of the students in Section A indicated that reading other students’ responses helped them think about statistics in a different way.

Journal entries were not seen by students as being quite so beneficial. In Section B, only 50% of the students agreed or strongly agreed that writing the prompted journals was beneficial to their learning, and 25% of the students in Section B disagreed. And although one student wrote, “Journals

were not too difficult; they helped me learn the material,” and another commented that, “I think it is good to have prompted journals because people learned more,” there were fewer positive narrative comments overall (two positive and two somewhat positive, versus the six strongly positive comments in the other section), and some students were downright disenchanted. One student in this section commented that the journal assignments “seemed tedious,” which is a far different attitude than the one expressed by the student in the other section who said of the discussion board assignment, “Love it!”

When asked if they would have preferred to write prompted journals, 94% of students (all but one) in Section A indicated they would not. In contrast, only two-thirds of the students in section B indicated they would not have preferred the discussion board. Four students in the latter section actually indicated they would have preferred the discussion board. For this survey question, a non-parametric test was used to compare student responses in Section A to student responses in Section B. The results of this analysis support the overall preference for the discussion board.

Lastly, 72% of students in Section A believed that reading other students’ responses helped them to think about statistics in a different way. Even without having the opportunity to share their thoughts with their fellow students, 53% of students in Section B believed that having the opportunity to read other students’ responses would have helped them think about statistics in a different way. Table 4 shows the results of non-parametric Mann-Whitney U tests on each of the six survey questions

Question 5, regarding the preference for the typed journal responses versus the discussion board, was the only question to show statistical significance. It should be noted that for each survey item, the responses of students in Section A were overall slightly more positive. While most of these differences were not statistically significant, it does lend support to the authors’ hypothesis.

Table 4
Mann-Whitney U Test on the Survey Questions

Question #	U	Exact p-value
1	154	.422
2	158	.495
3	145.5	.281
4	108	.069
5	80.5	.004
6	137.5	.283

Discussion

Asking students to write in a statistics course does, of course, add to the instructor's work load (Stromberg & Ramanathan, 1996). We believe that the writing we saw students doing during this study, however, justifies the extra work for the instructor. The grades in the two sections were representative of previous semesters' grades, and this study did not attempt to measure actual learning or achievement, but it is clear that both forms of writing allowed students to engage in reflective thinking about statistics and to communicate their questions to their instructor. The discussion board, in addition, engaged students in a dialogue, which allowed them to build on one another's thinking. It is probable that both forms of writing helped students to improve their understanding of mathematics and their ability to communicate mathematically.

The differences in achievement between the two groups were not clear enough to indicate that one type of assignment is preferable to the other. In terms of actual grades in the course, on average the two sections didn't differ significantly. Section A, the discussion board section, performed better overall on Test 1 and on the final exam. On Test 2, Section B very slightly outperformed Section A. We feel, however, that the project was beneficial, both for the students and for the instructor. It is evident that overall, the students believe that they benefited from the process of writing in their statistics course.

The journal entries were typically longer than the discussion posts and replies, partly because the instructor set a required length for that assignment and not the other. The required length may have allowed for more extended individual thinking. The type of discussion that happens in the discussion boards, however, because it allows students to build on one another's thinking, by providing examples, correcting when necessary, or connecting to already existing knowledge, may be more valuable in some ways than the solitary journal writing read only by the teacher. It provides the students with validation from their peers, building their confidence as statistical thinkers during the process of the actual thinking. The survey data

also shows an overall preference for the discussion board over the prompted journals. The instructor is planning on continuing to use the discussion board in future sections of Introduction to Statistics.

The analysis of writing in the statistics course presented here shows that writing assignments prompt students to articulate their increasing understanding of statistics in several important ways. Both the journal entries and the discussion board posts show evidence that students are able to articulate some of the concepts they are learning in the statistics course, to produce examples, and to connect those concepts to their own lives. In addition, the discussion board writing allows students to interact and to negotiate meaning in a social context, which may further their learning even more. Students also feel that the discussion board assignment helps them learn the material. Because writing in the statistics course appears to help students learn, it would seem important to continue to find ways to integrate writing into statistics instruction and to further evaluate its effectiveness as a pedagogical tool.

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