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Paper Title: **WRITING TO LEARN STATISTICS: MAINTAINING LEARNING JOURNALS IN ORDER TO IDENTIFY AND ADDRESS UNDERGRADUATE STUDENTS' MISCONCEPTIONS**

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Abstract: This workshop focuses on the use of writing to learn statistics. In particular, it concentrates on the role of the three-column divided page learning journal within the undergraduate introductory statistics course as a means by which instructors can identify and then address students' misconceptions.

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Whenever appropriate and for illustrative purposes, verbatim-transcripted excerpts from actual student journals are included in the discussion. The journal excerpts included in this document represent the variety of samples discussed during the interactive workshop.

The names of the student authors of the journals have been changed to provide these individuals with anonymity. Furthermore, any implication that gender is an important issue or a mitigating variable for this research is unintentional. Most, if not all, of the journals discussed at this workshop were written by women; this scenario arguably reflects only the prerogative of the presenter in selecting exemplary material, as well as the demographics of Centenary College, the small private Liberal Arts college at which all of the research subjects studied statistics. At the time the journals were written, Centenary was in transition from single-sex (i.e., an all-female full-time student body) towards truly co-educational status, so male students were clearly in the minority in all classes.

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# WRITING TO LEARN STATISTICS: MAINTAINING LEARNING JOURNALS IN ORDER TO IDENTIFY AND ADDRESS UNDERGRADUATE STUDENTS' MISCONCEPTIONS

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## PREFACE

This workshop focuses on the use of writing to learn statistics. In particular, it concentrates on the role of the three-column divided page learning journal within the undergraduate introductory statistics course as a means by which instructors can identify and then address students' misconceptions.

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body) towards truly co-educational status, so male students were clearly in the minority in all classes.

## INTRODUCTION

How can the premise of journal writing to learn statistics better enable college professors teaching undergraduate introductory courses to discover and address mathematical misconceptions held by their students? First, consider the broader issue of writing to learn statistics in general. Writing papers in a statistics class satisfies two general educational goals: primarily, learning statistics, and, secondarily, learning how to write (Iverson, 1991). Not only does writing within the context of a statistics course help students meet broad educational objectives (e.g., improve writing skills, foster creativity, and increase ability to communicate effectively), but it also provides opportunities for students to internalize class concepts more fully and easily (Radke-Sharpe, 1991). Radke-Sharpe further argues for the inclusion of "writing assignments as a routine part of statistics courses," and for the use of "writing to measure the understanding of statistical concepts" (p.292). By writing about a problem or topic, students take ownership of it (Countryman, 1987). Conversely, when students formulate an inappropriate representation, writing activities may provide the necessary means by which to access the misconception and construct a more adequate conceptual knowledge (e.g., Swinson, 1992).

Options for incorporating writing into statistics courses can include the "short answer" essay exam, the 25-word precis or the concise definition of a concept, and the formula notecard with a verbal explanation on the reverse side (Peterson, 1988). In fact, Peterson claims that such efforts "will deepen [the students'] level of understanding of statistical concepts and broaden their perception of what statistics is all about" (p. 191).

A few general variations on writing journals to learn the mathematical sciences and its cognate fields exist (e.g., Bagley & Gallenberger, 1993; Gordon & MacInnis, 1993). However, any means of using writing to learn statistics, let alone journal writing, is apparently a relatively atypical method with which to teach statistics, even when considering other unconventional or nontraditional teaching techniques. According to one pair of researchers (Stout & Smeltz, 1982; Smeltz & Stout, 1983), a list of some common alternative strategies would include self-paced modules, multi-media

approaches, computer-based instruction, case study approaches, and learning contracts, but not writing to learn statistics. In fact, of the more than 450 academic statisticians who responded to this inquiry regarding additional methodologies (e.g., research projects, group projects, or acting as consultants), only six expressed interest in one aspect of the topic: critiquing articles in publications! Maintaining learning journals was not considered.

## JOURNAL EXPLANATION

The premise of the three-column divided page learning journal has essentially evolved from three sources. The first was the general curricular movement advocating writing across the disciplines (e.g., Watkins, 1990). Undoubtedly this premise can pertain to statistics as much as to any other field of study. The second and third sources were the mathematics education scholars, Sheila Tobias and Robert B. Davis. Tobias (1988) devised a divided page exercise as a means of eliminating math anxiety as an impediment to scholastic success in mathematics. This concept could be considered the predecessor of the two-column journal, with the summary column analogous to the math work space and the reaction column corresponding to the space for thoughts and questions. The insertion of an intermediary column for interpretation between cognition and affect resulted from a consultation with Davis (personal communication, March 31, 1992).

The journal format has experienced a transformation over the past several years into its current three-column configuration. First, the structure was single-column entry, with de facto primary emphasis on psychological or emotional issues -- affect -- and secondary emphasis on content summary – cognition; next, it was double-column entry, with one column intended for affective domain concerns and the other for cognitive domain matters; finally, it was triple-column entry, where the left-hand column was for content summaries, the middle column was for interpretative statements and questions, and the right-hand column was for reactions and reflections. This third format stands as an adaptation of the second, with the outside columns still intended for recording cognitive and affective domain matters, and the middle column serving as a bridge between the two, in the form of personal interpretations.

Connecting arrows were also introduced in the three-column format, so that entries in one column could be visually correlated with pertinent entries

in other columns. For instance, a student might paraphrase the measures of central tendency in the summary column, comment on how easy it is to confuse them in the reaction column, and draw a double-headed arrow between the two column entries to indicate the connection.

Maintaining a learning journal allows for the continuous improvement of both teaching and learning; it keeps in line with current interest in quality management concerns regarding the classroom (e.g., Hillenmeyer, 1993). Indeed, it fosters continuous improvement in two primary ways. First, the periodic review of the students' journal entries by the instructor, which can be done on a daily, weekly or other regular basis -- but should happen as frequently as is feasible --provide instructors with greater access to both the conceptual structures formulated by and the personal reflections of their students. Second, clinical-type interviews, or even some less formal variation on that theme, where the professor or some other appropriate instructional staff member has the student solve a problem based on an issue or concern raised in a previous journal entry, are another option. These and other strategies permit professors to identify the misconception or error in reasoning presumably while it is still in its earliest stages of development, and then to assist the students in constructing more appropriate representations. In addition, this approach of supplementing the classroom activities with journal writing provides more continuous formative, rather than discrete summative, feedback on the effectiveness of teaching by verifying that whatever the professor is teaching essentially corresponds to what the students are learning.

The journal provides students with the following opportunities: (1) to reflect on their progress to date, (2) to document their success as well as their failures, (3) to summarize or paraphrase the main topics discussed in class, thereby supplementing their conventional notebooks, (4) to raise questions that they either hesitate to ask in class or cannot formulate coherently given the time limitations of a class period, (5) to strengthen their written communication skills, and (6) to vent anxieties and frustrations. Also, the use of journal writing to learn statistics offers accessibility, even if only in perception, to those students who view themselves as preferring verbal or qualitative, rather than numerical or quantitative learning styles. In general, they can be incorporated into any environment, no matter what the learning styles of students or the teaching styles of professors. In addition, not only

the professors but also the students themselves can self-improve; either by rereading previous entries or critically reflecting on each entry as written, they can identify gaps in knowledge, points of confusion, or misconceptions. In other words, students might realize that they know something less well than they thought they did.

The evaluation of the learning journal as part of the course requirements assures compliance with this writing project, as does the periodic review by the instructor or other teaching staff member, so that the students do indeed benefit. The grade is based on (1) the apparent effort spent in maintaining the journal (e.g., Do the entries seem thoughtful, reflective, not too brief, etc.), (2) satisfying assignment criteria (e.g., using the required number of columns, connecting the material entered in different columns whenever relevant, etc.), and (3) responding appropriately to the comments posed by the faculty reader after reviewing the journal (Hammett, 1992).

## JOURNAL EXCERPTS

In a relatively unique manner, the learning journal serves as written, self-generated documentation of the adequate representations, as well as the misconceptions, each student constructs. Perhaps without realizing the significance of their entries, the students may reveal how well or poorly developed their mathematical and statistical concepts really are.

The journal can reflect how thoroughly a student has taken full ownership of a concept. In a 1992 entry, Maryellen C. indicated that she was able to appreciate the basic similarity and subtle difference between t- and Z-scores:

(see Figure #1)

This entry demonstrates some level of critical thinking on Maryellen C.'s part, and serves as testimony to her successful, meaningful construction of various statistical concepts.

On the other hand, the journal can also reveal misconceptions of which the author is wholly unaware. Entries can attest to a lack of comprehension, or even fundamental awareness, on the part of students by virtue of what is, or perhaps more tellingly is not, written. In a 1992 entry, Nadia D. confessed that she "was a little confussed [sic] ... but by the end of the class [she] was doing just fine." This statement was written mistakenly in the summary

column; however, it is worth noting that she did not offer any form of synopsis of the course content discussed that day in class. She merely described the activities. This omission or oversight on her part would tend to exemplify her apparent lack of clarity regarding the main concepts of the class period.

In the interpretation portion, she included the following example:

(see Figure #2)

Her comment that she could "finally figure out how to find the answers to each coloms [sic]" reveals that she apparently has no truly suitable understanding of the meaning of this computational device. The table to which she refers could conceivably be viewed as a statistical algorithm: a formalized structure with which to compute, in a procedural manner, the standard deviation for repetitive or grouped data. It seems indisputable that there are many intermediate computations necessary when calculating the final value manually, and it is possible to obtain "answers" to various questions, as it were, throughout the procedure: the total frequency, the mean (by dividing one column sum by another), the sum of the frequency times deviations column equalling zero as a check, and the sum of the squared deviations. However, Nadia D. does not suggest any sense of recognizing the merit of the overall process as a whole. She apparently views the chart as containing isolated pieces of information, and does not appreciate the intention of generating a final value from which to compute a measure of dispersion or variability regarding her sample. Indeed, she has seemingly labeled even the data set itself (i.e., the x column) as answers rather than as values that signify starting points for her analysis. She has constructed a superficial, incomplete representation that regarded the chart as an end rather than as a means. She does not even mention the phrase, standard deviation, at all during the entry, and only includes it as one of several problem types discussed in the previous entry. This, too, is a misconception; standard deviation should more appropriately be viewed as an instrument with which to solve statistical problems.

The aforementioned entry was made by Nadia D. towards the beginning of the term. Her apparent confusion persisted throughout the term. In what was her final regular entry, prematurely written several class periods prior to the end of the term, she said she "forgot everything [she]

learned" about Z-scores. The manner in which she denoted the formula acknowledges her lack of comprehension:

(see Figure #3)

This entry, inappropriately placed within the interpretation column rather than the summary column, has the mean (i.e., m) and the standard deviation incorrectly interchanged. She did not, however, question the accuracy of her formula. She only admitted being "confused about the way the problems read."

Just as Nadia D. had no apparent appreciation of the purpose of a data-based table used to compute standard deviation, Bertha J. seemingly had no meaningful understanding of the concept of combinations:

(see Figure 4)

Her jumbled 1992 entry also substantiates that she was more confused than she realized, again as was Nadia D.

In both of these cases, the regular journal review by a faculty member would mitigate these circumstances, presumably in a positive vein. The instructor would know of these weak representations, and would begin to assist the students in bolstering their conceptual knowledge. Subsequent journal entries would help assess the effectiveness of such improvement strategies.

On other occasions, the students may appear acutely aware of their own misconceived concepts. In a 1993 entry, Darcell K. seemed to solicit assistance emphatically without ever asking directly for help when she was unable to differentiate randomness and representativeness:

(see Figure 5)

The proper response on the part of the instructor involves simply offering some assistance, perhaps by inquiring if the student is still confused.

Taken from a slightly different perspective, the journal entries can help instructors identify when students possess superficial knowledge of concepts. For instance, the explanations Bertha J. gave for certain variability measures appeared too ambiguous:

(see Figure 6)

At least she conceded that she must "review again because [she doesn't] understand it."

Similarly, Bobby P.'s 1992 entry on the graphing of frequency distributions identified only an inconsequential difference between histograms

and polygons, and did not acknowledge greater representational similarities and differences:

(see Figure 7)

In both cases, clinical-type interviews conducted by the instructor with the students would seem suitable interventions. Bertha J. could be asked to compute manually standard deviation for a population or the coefficient of variation, all under the observation of the professor, who may opt to interject as needed while Bertha solves the problem. Bobby P. could be asked to sketch both a histogram and a polygon for a frequency distribution on separate pieces of paper, again under similar circumstances.

## CONCLUSION

The current state of the pedagogical mainstream of statistics education reflects the limited attempts made to improve how well undergraduates conceptualize statistics as they learn. Efforts --- such as introducing relevant, entertaining examples or upgrading the curriculum -- are often narrow in scope. Furthermore, centering course content around applications that appeal to sports enthusiasts (e.g., Lackritz, 1981; Schwertman, McReady, & Howard, 1991) or criminology buffs (e.g., Shuster, 1991) is only a partial solution to the problems students encounter when studying statistics; customizing course content to meet the specific needs of medical technology (e.g., Paselk, 1985) or geography (e.g., Burn & Fox, 1986) majors is also only a partial solution.

Statistics is a difficult subject to learn, perhaps even worse than calculus, because, according to Watts (1991), "the important fundamental concepts of statistics are quintessentially abstract" (p. 290). Therefore, any and all improvements in the teaching and learning of statistics would likely be effective if and only if they assisted students in constructing better conceptual knowledge of statistics. The learning journals are such an instructional tool. Given the aforementioned support for the two relatively separate curricular initiatives to keep journals in mathematics classes and to use writing to learn statistics, a fusion of the two premises is appropriate, reasonable, and a complete solution to the problem.

(Figure 1)

Maryellen C. -- Day 27 of 30, 1992

| Summary: | Interpretation: | Reaction: |
|---|---|---|
| We learned about T scores with small # of samples The formula is | this formula is just like what we were doing before with the bigger samples but we used a Z. | Does not seem that hard. So far so good. |

$$t = \frac{\bar{x} - m}{\frac{s}{\sqrt{n}}}$$

(Figure 2)

Nadia D. -- Day 5 of 30, 1992:

| f | x | fx | $x-\bar{x}$ | $(x-\bar{x})^2$ | $f(x-\bar{x})^2$ |
|---|---|---|---|---|---|
| | | | | | |

(Figure 3)

Nadia D. -- Day 26 of 30, 1992:

$$z - \frac{x - \sigma}{m}$$

(Figure 4)

Bertha J. -- Day 15 of 30, 1992:

| Summary: | Interpretation: | Reaction: |
|---|---|---|
| Combination | to find the probability of a group through nCr which is the total multiplyed [sic] by the outcome then divided | Since I missed class for two days I found this to be difficult at first once he went over it became understandable. |

(Figure 5)

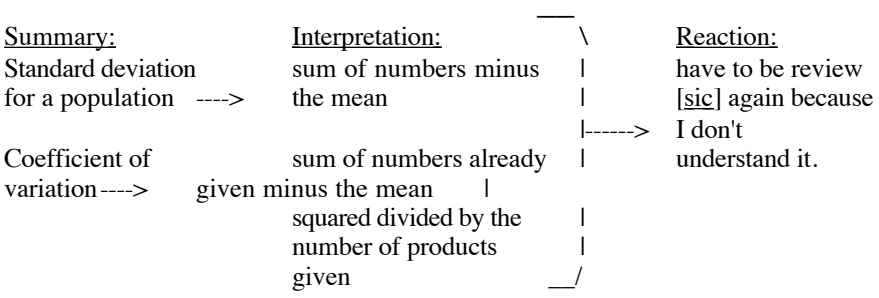
Darcell K. -- Day 4 of 30, 1993:

| Summary: | Interpretation: | Reaction: |
|---|---|---|

| | | |
|---|---|---|
| ... random sampling | I'm not sure how to make sense | I am confused |
| and sampling techniques and we talked about random | out of it, I find it alittle [sic] confusing between representive [sic] and random | on the difference between random |
| and representative and the difference of the two. | selection. I guess you just have to have examples [sic] and know the definition | and representive [sic] selection |

(Figure 6)

Bertha J. -- Day 4 of 30, 1993:



(Figure 7)

Bobby P. -- Day 10 of 30, 1993:

| Summary: | Interpretation: | Reaction: |
|---|---|---|
| Discussed histograms & frequency distribution. Mostly the polygon. | The polygon is the same as a histogram but the verticle [sic] lines are dots | Polygons are very interesting and alot [sic] of fun. |

## REFERENCES


Bagley, T. & Gallenberger, C. (1992). "Assessing students' dispositions: Using journals to improve students' performance," Mathematics Teacher, 85(8), 660-663.

Burn, C.R. & Fox, M.F. (1986). "introducing statistics to geography students: The case for exploratory data analysis," Journal of Geography, 85(1), 28-31.

Countryman, J.C. (1987, December 3-5). "Writing to learn mathematics: Some examples and strategies," Paper presented at the Northeastern Regional Conference of the National Council of Teachers of Mathematics, Uniondale, NY.

Gordon, C.J. & MacInnis, D. (1993). "Using journals as a window on students' thinking in mathematics," Language Arts, 70(1), 37-43.

Hammett, J.E., III (1992, November 5-7). "Writing to learn mathematics: Using student journals as a learning tool in an introductory statistics course," Workshop presented at the Annual Conference of the Institute for the Study of Postsecondary Pedagogy in The School of Education at The College of New Paltz/State University of New York, Albany, NY.

Hillenmeyer, S. (1993, June 23-25). "TQM and Teaching," Workshop presented at the Annual Institute of the Board of Higher Education and Ministry -- United Methodist Church, Nashville, TN.

Iverson, G.R. (1991). "Writing papers in a statistics course," Proceedings of the 1991 Meeting of the American Statistical Association Section on Statistical Education, 29-32.

Lackritz, J.R. (1981). "The use of sports data in the teaching of statistics," Proceedings of the 1981 Meeting of the American Statistical Association Section on Statistical Education, 5-7.

Paselk, R.A. (1985) "An experiment for introducing statistics to students of analytical and clinical chemistry," Journal of Chemical Education, 62(6), 536.

Peterson, R.S. (1988) "Writing across the statistics curriculum," Proceedings of the 1988 Meeting of the American Statistical Association Section on Statistical Education, 190-191.

Radke-Sharpe, N. (1991). "Writing as a component of statistics education," The American Statistician, 45(4), 292-293.

Schwertman, N.C., McReady, T.A., and Howard, L. (1991). "Probability models for the NCAA Regional Basketball Tournaments," The American Statistician, 45(1), 35-38.

Shuster, J.J. (1991). "The statistician in a reverse cocaine sting," The American Statistician, 45(2), 123-124.

Smeltz, W.J. & Stout, D.E. (1983). "A content analysis of the advantages and disadvantages of selected nontraditional teaching techniques in statistics," Proceedings of the 1983 Meeting of the American Statistical Association Section on Statistical Education, 97-100.

Stout, D.E. & Smeltz, W.J. (1982). "An examination of the usage and perceived effectiveness of nontraditional teaching techniques in statistics," Proceedings of the 1982 Meeting of the American Statistical Association Section on Statistical Education, 103-107.

Swinson, K. (1992). "Writing activities as strategies for knowledge construction and the identification of misconceptions in mathematics," Journal of Science and Mathematics Education in Southeast Asia, 15(2), 7-14.

Tobias, S. (1988). "Dealing with math/science blocks," Liberal Education, 74(2), 20-23.

Watkins, B.T. (1990, July 18). "More and more professors in many academic disciplines routinely require students to do extensive writing," The Chronicle of Higher Education, A14-A15.

Watts, D.G. (1991) "Why is introductory statistics difficult to learn? And what can we do to make it easier?", The American Statistician, 45,(4), 290-291.