Writing to reduce anxiety and improve outcomes in introduction to statistics for psychology majors

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PSYCHOLOGY ranks fourth on the list of most common undergraduate majors and is increasing in popularity (McFarland, 2018). The most recent American Psychological Association (APA) guidelines for the undergraduate psychology major list scientific inquiry among its most important goals. In order to demonstrate literacy in psychological science, the APA recommends that students learn to interpret and communicate statistical findings as well as interpret, design, and conduct basic psychological research (American Psychological Association, 2016). To that end, statistics for behavioural sciences is often a required course in undergraduate psychology curricula.

Teaching statistics to an undergraduate population of non-math majors, such as those studying psychology, poses challenges, including negative beliefs and attitudes about statistics (Freeman et al., 2008 Gal et al., 1997; Holmes, 2012). Students tend to lack confidence in their statistical abilities and believe that they require a certain level of previous knowledge or mathematical competence in order to succeed in a statistics course (Fielding et al., 2015). Even students with strong backgrounds in mathematics and sciences report reluctance about statistics (Hannigan et al., 2014). Negative beliefs and attitudes surrounding statistics are closely linked to negative affective experiences. Statistics anxiety is well documented (for review, see Chew & Dillon, 2014) and refers to 'feelings of anxiety encountered when taking a statistics course or doing statistical analyses'(Cruise et al., 1985, p.92). Statistics anxiety has been found to relate inversely with academic achievement such that greater anxiety predicts poorer performance in statistics courses (Galli et al., 2008). Negative experiences surrounding statistics can impact student outcomes via the known deleterious effects of anxiety on learning (Linnenbrink & Pintrick, 2002), as well as diminished engagement in and out of the classroom (Hannigan et al., 2014).

Undergraduate statistics is often the only quantitative course required of many psychology majors, and, in light of negative perceptions and anxieties, it may be the only such course they complete throughout their undergraduate education. Accordingly, course objectives should be carefully considered to maximise student benefit and reduce negative experiences (Garfield, 1995). Primary aims of a statics course for psychological sciences could include: (1) preparing students to competently engage with the statistical concepts and applications that they are likely to see in other classes; (2) familiarising students with the key research and statistical methods used in the discipline; and (3) teaching students how to be responsible consumers of quantitative information they are likely to encounter outside of school.

We propose that utilising best practices drawn from the Writing Across the Curriculum (WAC) tradition can address the above aims, reduce negative classroom experiences, and lead to improved learning outcomes in introductory statistics courses for psychology majors. WAC practices involve the use of two general categories of writing assignments to further learning: informal (low-stakes) and formal (high-stakes) (Bean, 2011). Informal writing assignments can be conceptualised as process-oriented in that

the goal of writing is to deepen conceptual understanding and promote critical thinking rather than produce a polished piece of written work. In order to immerse students in complex material in a non-threatening manner, these assignments are often low-stakes and are only graded based on completion or effort. The goal of formal writing assignments is to have students produce a piece of writing that is representative of formal work in a given field. These assignments typically require multiple drafts, are graded according to a predetermined rubric, and contribute more heavily towards students' grades. Writing is most effective at promoting critical thinking when the assignments are well designed (Bean, 2011). Assignments are strongest when they revolve around a particular question or argument that allows for an analytical response as opposed to rote recitation of terminology or regurgitation of ideas presented in class. All assignments should be designed with consideration of RAFT criteria: Role, audience, format, theme/task/topic. Clear and thorough grading rubrics should be presented in advance of the assignment to provide structure and explicitly state expectations. Revision and feedback are crucial components of formal writing, as requiring multiple drafts facilitates scaffolding that allows students to refine and re-conceptualise thoughts. Higher-order concerns, such as those that relate to the clarity of the argument, the correct use of evidence, and the organisation of the paper should take priority when revising papers over lower-order concerns like grammar, spelling, and punctuation.

Informal writing assignments to engage with course material

Entrance and exit slips/minute papers
Proposed by Stromberg and Ramanathan (1996), entrance and exit slips are simple methods for increasing student writing. The instructor poses short questions to be answered on index cards at either the begin-ning or end of class. Questions can cover course material, such as 'provide an example in which the median would be a more appropriate measure of central tendency than the mean,' or 'identify three primary distinctions between independent and repeated measures analyses.'

The questions can also probe for student understanding in the form of minute papers. Students are asked to spend approximately one minute writing the main idea of that day's lesson, stating any concepts from that day's lecture they don't understand, and/or asking lingering questions. This feed-back will help the instructor gauge students' understanding and progress and inform future lessons. Further, this format may feel more approachable for students who are uncomfortable addressing areas of confusion during class. By writing in the small space allotted in an index cards, students will also become more adept at conveying ideas with brevity.

Compare and contrast assignments
One of the common points of confusion in statistics classes surrounds terminology. What is the difference between Type I and Type II error? How does the alpha level relate to the critical regions? Writing is a wonderful tool for detangling complex relationships among concepts. Holmes (2012) recommended brief in-class writing assignments in which students are asked to spend five minutes identifying the similarities and differences between related concepts. Students can swap assignments and engage in peer review followed by a plenary discussion during which the instructor reviews the correct answers to ensure accurate comprehension.

In-class debate
The class is divided into two groups that are each assigned a concept or term (e.g. the independent variable group v. the dependent variable group) and asked to list factors that identify their unique group. The students can then engage in a debate about their rela-tive value. By personalising the material, this

active-learning strategy flips the classroom format, such that students are teaching one another, while bringing the material to life and making it more memorable.

A meaningful paragraph

First proposed by the entomologist Elaine Backus, writing a meaningful paragraph involves crafting a paragraph that coherently incorporates several key terms (Jordan, 2008). For example, ask students to write a paragraph using the following terms: Variance, standard deviation, degrees of freedom, sample size and population. It is beneficial to have students couch the paragraph in a real context (e.g. in reporting on a recent study). It may be helpful to provide a clear structure defining the process students can follow to succeed in this assignment. For example, Wagaman and Brookes (2018) suggest an outline which prompts students to familiarise themselves with relevant terms, identify relationships and differences among them, and give criteria necessary to accommodate them.

Six o'clock evening news assignments

One reason that students offer for feeling disengaged from statistics courses is that they cannot see how the material is relevant beyond the classroom. To help underscore the ubiquity of statistical analyses in day-to-day life, find a newspaper article or news clip that cites statistical findings pertaining to contemporary and salient issues. Provide a concurrent dataset with similar variables to those described and ask students to perform the appropriate statistical analyses to answer the empirical question from the news report. Asking students to work backwards from hearing the findings to identifying the research question will encourage deeper conceptual understanding of the material. Identifying the appropriate statistical analysis to address the question will require students to integrate material from across the course. The exercise will highlight that statistics are pervasive and encourage students to be critical consumers of statistical information in their daily lives. As a follow-up, have students prepare a one-page press release free of statistical terminology intended to be reported on the six o'clock evening news. Clearly defining the audience and setting will help students minimise jargon and recognise their role as daily consumers of statistical information.

Persuasive letter

Another method for increasing student engagement is to embed statistics practices into assignments that feel relevant to their college experience. Students can be asked to collect (or find) and analyse relevant datasets and then write a persuasive letter based their findings. One topic about which students often hold strong opinions pertains to food options in the dining halls on campus. Students can survey their classmates about their food choices and preferences, and the resulting data can be analysed and serve as the basis for a persuasive letter written to the college president regarding the quality and variety of on-campus food options. A modification of this assignment is to form an informal 'learning community' between a statistics class and an English composition class. Statistics students can share their data and/or reports with the English composition students, who can then incorporate the statistical evidence into a persuasive letter. This would simultaneously teach students how to clearly and succinctly present data, underscore the relevance of statistics outside of the classroom, and foster multidisciplinary cooperation.

Formal writing

Many statistics courses include a formal paper assignment that involves conducting or proposing an experiment and writing an APA-style laboratory report. Stromberg and Ramanathan (1996) found that while poor grades in such assignments were at times related to poor understanding of the material, more often, grades suffered because students did not read the instructions carefully, presented opinions rather than arguments, and failed to formulate facts into a coherent thesis.

Assignment example

To address these issues, in the following section, we provide a concrete example of a semester-long group project appropriate for an introductory statistics for behavioural sciences course that draws on WAC best practices for effective assignment design. We provide example prompts for illustrative purposes that can be altered to accommodate the course content. This project is scaffolded to include a brainstorming session, several low-stakes writing opportunities, a peer review session, opportunities for multiple drafts, a formal written assignment, and a group presentation. The components may be used individually or in their entirety over the course of a semester. Here is a broad overview of the project components:

Part I of the assignment involves providing students a prompt for the project and asking them to form groups. This is followed by an in-class 'brainstorming' activity in which students work together to provide definitions of terms and identify their focus. They are asked to consider qualitative and quantitative aspects of their definition.

Part II of the assignment may be conducted as a continuation of Part I in class or as a homework assignment outside of class. The goal of Part II is to have students consider logistical components of designing and executing their group project.

Part III of the assignment requires students to submit a project proposal to the instructor. Students are tasked with building upon their brainstorming session to write a concrete project plan. They are required to formulate a hypothesis statement. It is suggested that this portion of the project be 'low-stakes' and feedback be provided promptly. Part III is intended as a dialogue between the instructor and student groups to assist with conceptualising the project structure.

Part IV of the assignment asks students to collect their data and identify a plan for data

analysis. This requires students to synthesise course content and clearly articulate how they plan to apply it practically. It is suggested that this portion of the project be 'low-stakes' and that feedback is provided.

Part V of the assignment asks students to write a draft of a research report requiring them to draw from previous sections of the assignment. Students should be provided with a clear prompt detailing what is expected in their final reports along with the rubric or evaluation matrix that will be used to grade the paper.

Part VI of the assignment asks students to participate in an in-class peer review in which students will review one another's work using the same general rubric/criteria with which the final paper will be graded (see Figures 1 and 2 for samples) this is considered 'low-stakes.'

Part VII of the assignment asks students to submit a formal report and present their findings to the class as a team. It is suggested that the reports and in-class presentations be 'high-stakes.' It is also recommended that both students and the instructor use the same scoring guide for peer review and to grade papers and/or presentations (see Figures 1 and 2).

Notes to Instructor:
- With regards to grading, we recommend a scoring scheme designed following WAC best practices. Earlier sections of the project in which students are developing ideas/plans and drafting their papers should be 'low-stakes,' where points are assigned mainly for participation and completion as opposed to content. 'High stakes' portions of the assignment include the final project paper and presentation and should contribute a significant portion to the project grade.
- For many students in introductory statistics courses, this may be the first time they are tasked with data collection and formal-

ising a concrete hypothesis. While it may be time-consuming for the instructor to provide regular feedback throughout this process (e.g. revising hypotheses, reviewing drafts) the effort will be rewarded as the expectations for the project will clarified, resulting in overall better products.

- Depending on time constraints, it can be helpful to hold an in-class 'norming session' in which students are provided with model papers and a scoring rubric. Students can then work together in small groups to reach an agreement as to how they would grade the papers. If this is not feasible, posting model papers with corresponding grades (including the scoring rubric) on the class website can be helpful.

- Given the importance of the peer review process, we offer the following additional thoughts. During peer review, encourage students to identify whether basic criteria for the paper are met, ensure the structure is sound, and point out major errors. Emphasis should be placed on these higher-order concerns as compared with issues such as spelling and grammar, though these can certainly be mentioned as well. This process can be taken further by using Calibrated Peer Review (CPR), a free web-based programme that allows students to review their classmates' works-in-progress by having them first grade model papers provided by the instructor so as to 'calibrate' themselves. See http://cpr.molsci.ucla.edu/Home.

Group project outline
The following section is written in the format of a handout that students may receive to explain the components of the assignment.

Prompt
Psychology research at universities is often conducted on undergraduate students. These studies inform the field's understanding of commonly studied topics like cognitive functioning, prejudice, and personality. In what ways might conducting research on an important subject, such as cognitive ability, from a sample of college students affect our understanding of the topic?

Part I. In-class brainstorming session
1. Please form groups of four. In the event that there is an excess number of students, I will decide how to arrange the final group(s).
2. Your goal as a group is to study the ways in which conducting psychological research on college students may affect understanding of cognitive ability. There are many ways to measure cognitive ability. For example, there are verbal (e.g. reading comprehension, verbal conceptual reasoning) and non-verbal (e.g. mental arithmetic, design fluency, non-verbal conceptual reasoning) abilities. You can also consider abilities such as processing speed, learning/memory, visuospatial abilities, and higher-order functions (e.g. problem-solving). Select one facet of cognition that you would like to be the focus of your project. Conduct some research on that facet (e.g. processing speed) and determine a definition for your term. While your definition should be described in words (qualitative), also be sure to identify a definition that can be measured with numbers (quantitative). For example, a qualitative definition of processing speed could be 'the amount of time it takes to process information,' while a quantitative definition could be 'how long (in seconds) it takes to complete arithmetic computations.' These definitions will help guide your project.
3. Once you have determined specific ways to describe and measure your term, brainstorm differences you might see in cognitive ability between a sample of college students and a sample of individuals who are not current college students. Try to be specific in your hypotheses. For example, you may hypothesise that college students have faster processing speed than individuals who are not in college, because college students have more practice taking timed tests.

Part II. At-home group work

Consider ways that you might collect data about the cognitive ability you selected from both a sample of college students and a sample of individuals who are not currently in college. Consider the following:

1. Sample – who will comprise your samples? How will you recruit them for your study? What information will you provide participants about your study? How many subjects will be appropriate to include in each sample?
2. Tests – what types of tests are appropriate for capturing or measuring the cognitive ability you selected? What kind of scale(s) will you use? Will the data be nominal/ ordinal/interval/ratio? What form will your variables take (e.g. raw numbers, percentages, averages)?
3. Hypothesis – what do you predict your data will show regarding the cognitive ability you're studying in your samples?
4. Methods – how do you plan to go about collecting these data from your samples? Where will you conduct your research? Will it be conducted in person or online? What exact procedures will your participants follow? How will you collect, organise, and store your data?

Part III. Project prospectus summary email

Please email the instructor with the following information. One email should be sent per group. Be sure to include a list of all group members.

1. Which cognitive ability you plan to study and the definitions (both qualitative and quantitative) that you determined.
2. How do you plan to study this ability? Which specific measure(s) will you use? What kind of data will you collect?
3. Describe the samples from whom you plan to collect data.
4. Clearly state your hypothesis regarding how this cognitive ability may differ between a sample of college students and a sample of individuals not in college.
5. Describe how your group would go

about collecting these measures from both samples. Consider and provide the following information: where will you conduct your research? Will it be conducted in person or online? What exact procedures will your participants follow?

Please note, this will only be graded on completion of each item. You will not be assessed on grammar or punctuation, but please make an effort to write clearly, as this will save you time down the road.

Part IV. Data collection and analysis

For the next part of the project, you are tasked with creating a statistical analytic plan, executing your study design, and collecting data. Describe your statistical analysis plan. Include the following information:

1. How will you organise and present your data? For example, will you present your information in a histogram, chart, graph etc.? Provide specific descriptions of your axis labels and/or row and column headings. Why did you select that format?
2. What kind of inferential test do you plan to run? For example, if you plan to conduct group comparisons, will you use a t-test or ANOVA? Support your reason for selecting that analysis.
3. What are your specific hypotheses? State the null and alternative hypotheses.
4. What is the cut-off for statistical significance? Provide both alpha level and cut-off values (e.g. cut-off t-value or F-value) for determining significance.

Part V. Individual Report Draft

Please create a subsection in your draft for each of the following items. This will provide the structure for your paper as well as your upcoming presentation.

1. **Introduction:** Provide the appropriate background to set up your paper. What motivated you to study this topic? How is it relevant? To whom is it relevant? Define the study terms/concepts determined by the group. What were the project goals? (Note: this section could be further subdivided into relevant categories as appropriate)

2. **Hypothesis:** Provide a clear and fully developed statement(s) that predict study outcomes.
3. **Measures:** Clearly state and describe whichever measures you have chosen. The type of data collected from each measure (e.g. normal v. ratio) and the form in which they are measured (e.g. raw v. percentages) should be clear. Key variables should be described. Provide justification for why particular measures were chosen.
4. **Data collection:** State all data collection methods including details of study procedure and data procurement.
5. **Sample characteristics:** Provide information about how samples were created and recruited. Provide sample sizes and characteristics (e.g. age, gender, education). Consider the following questions: do you feel your sample is a good representation of the population of college students? Does it represent individuals not currently in college? Why or why not?
6. **Statistical analysis:** Describe the analyses that were performed. How was data organised and presented? The use of particular inferential tests should be justified. Be sure to provide statistical cut-offs you use.
7. **Results:** Present results in appropriate statistical summary format as well as appropriate charts, diagrams, etc.
8. **Conclusions:** Findings should be summarised in plain English and related back to the original study goal/purpose. Have you found sufficient evidence to support your hypothesis statement(s)?
9. **Implications:** Provide a discussion about what these findings suggest and how they can shape our understanding of the topic. If you could change anything in a future study, what would it be? How can

future work build on your project?

Part VI. In-Class Peer Review
We will conduct an in-class peer review of a draft of your paper several weeks prior to the final report due date. Please bring two copies of your draft to class (one for the instructor, one for your classmates). I will randomly disseminate the papers.

You are to review a classmate's draft using the same criteria that will ultimately be used to grade your paper. The overarching goal of this review session is to help your peers refine their papers by identifying whether basic criteria for the paper are met, ensuring the structure is sound, and identifying errors. Your peers' comments should, in turn, be helpful in providing you with particular instructions about how to improve your paper in advance of submission.

Please refer to the attached rubric when reviewing your peer's paper. Assign a score of 2 (very clear), 1 (present but missing some information) or 0 (absent, highly unclear) for each criterion. Include comments throughout to justify your score. Completion of this in-class assignment will count toward your overall grade.

Part VII. Final Presentation and Paper
The final paper should reflect a final draft that incorporates the feedback provided during the peer review. The presentation should be approximately 10 minutes, and every group member must participate. It is suggested that you prepare a slideshow using the outline for your report as a guide to ensure that your presentation is comprehensive.

Please use the attached scoring guide to score the presentations of your fellow classmates, one for each group (see Figures 1 and 2).

Figure 1: Peer review rubric.

	Introduction	Hypotheses	Measures	Data Collection	Sample description	Statistical Analysis	Results	Conclusions	Implications
Points									
Total Score:						**KEY:**			

KEY:

0 = Not included

1 = Included but requires clarification/ elaboration

2 = Clear and complete

Figure 2: Detailed scoring rubric.

Points	Introduction	Hypotheses	Measures	Data Collection	Sample description	Statistical Analysis	Results	Conclusions	Implications
0=Not included	No clear description of study or terms/ concepts. Unclear what the report discusses and why.	No statement about predictions.	Study measures are not described clearly. No quantitative description of key variables.	No description of study procedures is included or else the procedures are weakly described and unclear.	No information about study sample or else very vague information.	No information about statistical plan and/or justifications.	No statistical results provided.	Lack of clear description of study findings.	No discussion on the utility of the study. No mention of future work to expand on the current project.
1=Included but requires clarification or elaboration	Describes elements of study without integrating into a clear cohesive picture of goals. Some terms are defined but not entirely clearly. Purpose of study is not clear.	Half complete prediction statements.	Some study measures are provided but not all. Measures are not clearly described. Key variables described but quantitative measures are not entirely clear	Some information provided about study procedures but not comprehensive.	Aspects of study sample are provided but not in entirety.	Some detail of the statistical methods provided but missing information including data organisation or summary, inferential methods and justifications.	Results are provided but not in clear statistical summary format.	Some findings are described but without clear relation to the original study question.	Incomplete discussion on the implications of the study findings. Some discussion of how future work can expand on the current project.
2=Clear and complete	Describes the over-arching goal of the study. Provides clear qualitative descriptions of terms/ concepts. Explains overall purpose and relevance of project.	Fully developed statements predicting study out-comes.	All study measures are provided and clearly described. Data type (e.g. normal v. ratio) and the form (e.g. raw v. percentages) are clear. Key variables are described and clear methods for quantitative assessment are proposed.	Data collection methods are clearly stated including all details of study procedure and data procurement.	Information is clearly stated about how samples were created and recruited. Sample sizes provided.	Clear information provided about how data will be organised and presented, which inferential tests will be used and why. Statistical cut-offs are provided.	Results are provided in appropriate statistical summary format.	Findings are clearly summarised in plain English and related to study goal/ purpose.	A clear discussion about what these findings suggest and how they can shape our under-standing about the topic. A clear description and plan for how future work can build on the project.
Total Score:									

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References

American Psychological Association (2016). Guidelines for the undergraduate psychology major: Version 2.0. *American Psychologist, 71*(2), 102–111. doi: 10.1037/a0037562

Bean, J.C. (2011). *Engaging ideas: The professor's guide to integrating writing, critical thinking, and active learning in the classroom.* San Fransisco, CA: John Wiley & Sons.

Chew, P.K.H. & Dillon, D.B. (2014). Statistics anxiety update: Refining the construct and recommendations for a new research agenda. *Perspectives on Psychological Science, 9*(2), 196–208. doi.org: 10.1177/1745691613518077

Cruise, R.J., Cash, R.W. & Bolton, D.L. (1985). Development and validation of an instrument to measure statistical anxiety. In *American Statistical Association Proceedings of the Section on Statistical Education, 4,* (pp.92–97).

Fielding, S., Poobalan, A., Prescott, G.J. et al. (2015). Views of medical students: What, when and how do they want statistics taught? *Scottish Medical Journal, 60*(4), 164–169.

Freeman, J.V., Collier, S., Staniforth, D. & Smith, K.J. (2008). Innovations in curriculum design: A multi-disciplinary approach to teaching statistics to undergraduate medical students. *BMC Medical Education, 8*(28), 1–8. doi: 10.1186/1472-6920-8-28

Gal, I., Ginsburg, L. & Schau, C. (1997). Monitoring attitudes and beliefs in statistics education. In I. Gal & J.B. Gar-field (Eds.), *The Assessment Challenge in Statistics Education* (pp. 37–51). Voorburg, Netherlands: IOS Press. doi: 90 5199 333 1.

Galli, S., Ciancaleoni, M., Chiesi, F. & Primi, C. (2008). Who failed the introductory statistics examination? A study on a sample of psychology students. In *11th International Congress on Mathematical Education*, Monterrey, Mexico.

Garfield, J. (1995). How students learn statistics. *International Statistical Review, 63*(1), 25–34.

Hannigan, A., Hegarty, A.C. & McGrath, D. (2014). Attitudes towards statistics of graduate entry medical students: The role of prior learning experiences. *BMC Medical Education, 14*(70). doi: 10.1186/1472-6920-14-70

Holmes, K.Y. (2012). Tips for incorporating writing into an introductory statistics course. Retrieved 13 April 2018 from www.psychologicalscience. org/observer/tips-for-incorporating-writing-into-an-introductory-statistics-course

Jordan, J. (2008). Writing assignments in an introductory statistics course. In CAUSE teaching and learning webinar series; May 13, 2008. Retrieved 18 April 2018, from www.causeweb.org/ webinar/ teaching/2008-05/.

Linnenbrink, E.A. & Pintrick, P.R. (2002). Achievement goal theory and affect: An asymmetrical bidirectional model. *Educational Psychologist, 37*(2), 69–78. doi: 10.1207/S15326985EP3702

McFarland, J. (2018). National Centre for Education Statistics: Undergraduate degree fields. Retrieved 16 April 2018, from https://nces. ed.gov/programs/coe/indicator_cta.asp

Stromberg, A.J. & Ramanathan, S. (1996). Easy implementation of writing in introductory statistics courses. *The American Statistician, 50*(2), 159–163.

Wagaman, A. & Brookes, K. (2018). Writing assignments in a second statistics course. In *United States Conference on Teaching Statistics.* Retrieved from www.causeweb.org/cause/uscots/uscots17/posters/1-14