# STATISTICS PROJECTS AND THEIR IMPORTANCE IN DEVELOPING WRITTEN COMMUNICATION AND DISSEMINATION SKILLS

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*Higher education is changing with soft skills being implemented into the curriculum to prepare students for life after university. Students can be taught some of the soft skills by using a final-year, project-based assessment. One of the most valued soft skills by industry is communication. A statistics project is an essential component in ensuring that students have mastered communicating statistical findings in a non-technical manner suitable for a general audience. Students can become engaged in learning about communicating statistical results with carefully planned learning activities and project assessments. In this paper, we present scaffolded learning activities for improved statistical communication skills along with examples from student assessments.*

## INTRODUCTION

Governments focusing on graduate employability with funding implications is forcing universities to rethink how they teach and what they teach to their students (Bolton, 2019; Husbands 2017). In some European countries, professional experience is built into degree programs (THE Student, 2021). Most developed countries are also shifting their teaching to address industry needs and to improve their students' employability after graduation. One of the most important employability (soft) skills is *communication.* Communication can be included as part of discipline-specific learning instead of as an *add-on* course delivered in isolation of the discipline by language experts. The most beneficial way of teaching *statistical communication* or *written communication skills for statistics* is using statistical reports as assessments.

Problem-based learning (PBL), the precursor to authentic problem solving, arose in medical education in the 1950s (Hung, 2015). Authentic learning was introduced into higher education in the late 1980s (Simpson, 2015). Roach, Tilley, and Mitchell (2018,) state that "While there is much overlap between authentic learning and PBL, not all forms of PBL are authentic" (p. 497). However, introducing authentic learning or problem solving into mathematical classes is not that common. Sawalha (2018) likens most mathematics education to a toolbox; students learn the mechanism of each tool until they become proficient in operating each tool but what is missing is knowing how to use these tools to fix anything. The same applies to how statistics is still mostly taught, as a grab bag of techniques, especially at school level where mathematics teachers with minimal experience of statistical analysis teach statistics. As attested by Marshall (2019) this approach "often results in students struggling to apply their statistics knowledge in practical and authentic contexts particularly within final year projects and in the workplace" (p. 75). The increased use of statistical software in classrooms has advantages when dealing with complicated calculations and modeling; however, it also brings disadvantages such as the *use of statistical techniques without understanding why*. In other words, not just statistical techniques are added to the *toolbox* but also *how to use them by utilizing software*. Fortunately, some software tools prevent students from being able to apply statistical techniques without proper knowledge, but most do not. Statistical software produces output that a student cannot make sense of without sophisticated knowledge and understanding of assumptions and techniques. As suggested by the American Statistical Association (ASA) Revision Committee in their Guidelines and Assessment for Statistics Education (GAISE) College Report (2016), carefully designed assessments are required to improve and evaluate student learning.

GAISE recommends teaching statistics "as an investigative process of problem-solving and decision making" (2016, p. 6), where students are exposed to experiencing multivariable thinking with the expectation that students' statistical thinking skills will improve. They emphasise that conceptual understanding should be the focus, with active learning activities. Use of real data with a context and purpose, no doubt will increase the engagement of students with the subject matter, which could lead to easily transferable skills. Statistics can be thought of as a *problem-solving process* that starts with formulating and clarifying a research question that can be investigated by appropriate collection of suitable data. The data needs to be analysed and interpreted within the real-world context in light of the

In S. A. Peters, L. Zapata-Cardona, F. Bonafini, & A. Fan (Eds.), *Bridging the Gap: Empowering & Educating Today's Learners in Statistics. Proceedings of the 11th International Conference on Teaching Statistics (ICOTS11 2022), Rosario, Argentina.* International Association for Statistical Education. iase-web.org 

original research question motivating the investigation. Writing the results and interpretations of the results for a general audience is a highly important part of becoming a statistician.

Most textbooks in statistics deal with theory and application(s) but ignore how to report results (Francis, 2005). The delivery of many courses in statistics mirrors this and assumes that students will pick up report writing in other courses. Unfortunately, "report writing does not come easily to students; it needs to be taught explicitly, and as an integral part of the process of performing a statistical analysis" (Francis, 2005, p. 1). Our experience is that report writing goes hand in hand with final year projects, both at the undergraduate and postgraduate level. Francis (2005) states that authors who "do comment on how to develop writing skills emphasise the need for students to practice, to receive feedback on their initial attempts and to see example of 'good' reports" (p. 4). Close to two decades ago, the importance of project work and statistical communication was discussed by MacGillivray (2005) for introductory statistics students. Prvan and Ascione (2005) reported on enabling students to communicate statistical findings in an introductory, general education statistics course "The World of Chance," where students worked on a group project that required them to come up with their own research question, collect the data themselves, and produce both a website for their project and a written report.

There are many publications on project-based learning in the statistics education literature; however, learning activities to promote communication of statistics and improving students' communication skills are not specifically explained. In this paper, we provide examples for designing learning activities for improving students' communication skills in statistics, which could be useful for adoption or adaption by academics planning to implement project-based assessments. We also provide examples of student work to show that carefully designed activities are useful for teaching students how to communicate statistical results.

## DESIGN OF LEARNING ACTIVITIES

We implemented project assessment in an undergraduate (UG) course and in a masters (PG) course. Learning activities are more structured at the UG level whereas at the PG level, they are more like mentoring or supervision. In both units, students develop statistical communication and dissemination skills while analysing a substantial, authentic data set (Bilgin & Prvan, 2021).

### *Scaffolding Activities in an Undergraduate Unit*

In the UG unit a series of interactive learning activities are used during lectures where students answer various questions and observe how their peers are answering the same questions. The activities help students to see variability in the class and to give them an opportunity to think about what needs to be considered when they are writing their project reports. We present three activities modified from Melton (2004) with student responses across different years.

"*How many pages*?" is an activity where the definition of '*pages*' is not specified (Melton, 2004). Students are required to count the number of pages in a specific book and record their answers. When answering the question, students only see their own answer. The variability of the student answers for a book by Derr (2000) is displayed in Figure 1(a). In this activity, students learn the importance of describing variables clearly so that readers do not need to make any assumptions about what writers mean. They learn the importance of communicating their definitions of variables for their own reports.

In the "F test" activity, students are required to count the letter "f" (upper or lower case) (Melton, 2004). The "F Test" activity is used to show that clear definition of variables might not be sufficient to eliminate variability. Students realise by observing the variability of the answers in class (Figure 1(b)) that even if variables are clearly defined, there will always be variability when measurements are taken. Therefore, the variability should be presented and explained in their report.

The "Some" of the time activity is used to teach students the importance of avoiding weasel words in a statistical report (Melton, 2004). After completing the activity and seeing the variability of their peers' thinking about the word "some" and the distribution within their classroom (Figure 1(c)), they are more aware of the importance of clearly communicating their statistical results. Instead of writing "some of the participants," they know that they need to include either ($n$ = xx) or (xx%) in their reports to make sure what they mean by "some" is correctly understood by readers.

Examples of current news articles with weasel words, such as many, some or few, lots or little, high or low, and often or seldom are given in lectures along with their weblinks. Some examples from 2020 are "Covid-19: Oxford University vaccine is highly effective" from the BBC (Gallagher, 2020);

"Third major COVID-19 vaccine shown to be effective and cheaper" from 9News in Australia (Associated Press, 2020); and "Moderna's coronavirus vaccine is highly effective, final analysis shows" from LiveScience (Saplakoglu, 2020). The examples help lecturers to show students the need to be critical of what they are reading and to be as clear as possible when they are reporting their statistical analysis to avoid misunderstandings.

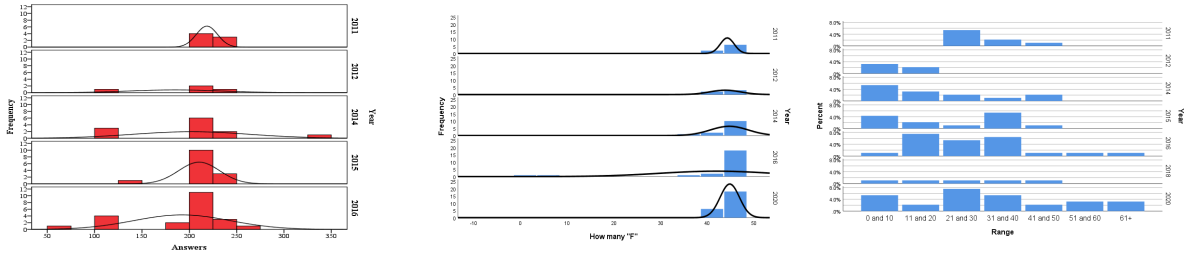



Figure 1. Distribution of student answers for multiple years to (a) number of pages in *Statistical Consulting* (Derr, 2000), (b) number of "F"s in a given text, and (c) numbers associated with "some"

The "How many pages?" activity can be performed in a class by passing a physical book from student to student and using paper and pen to record an answer or online by downloading a pdf book from a learning management system and using Google forms to record an answer. Similarly, the "F test" activity and the "some" activity can be carried out in class by writing students' answers on a whiteboard or blackboard or online by asking students to enter their answers to a Google form or in Zoom chat.

*Scaffolding Activities in a Postgraduate Unit*

In the PG unit, a mentoring or apprenticeship approach is used to improve students' communication skills. Students have weekly meetings with the lecturer to discuss their progress and ask any questions that will help them to move their project work forward. They submit a project plan in which they need to clearly articulate two of their own research questions. Thus, individual students choose topics that most interest them for the survey data used for their project. This, in turn, keeps students motivated and results in individual students taking ownership of their learning.

Feedback provided by the lecturer on students' proposed research questions ensures that students are working towards answering two research questions that are worthwhile and can be successfully answered within a semester of learning. Submission of two draft project reports and an initial write up, while not counting towards the final mark, are formative assessments that enable providing detailed feedback. This carefully provided feedback includes feedback on improving the presentation of tables and figures and the choice of figures; whether the analyses are appropriate; and how the results are presented. Overall presentation is also considered. For example, one frequent problem is the inconsistent number of decimal places used throughout reports, which might be related to students approaching the writing of their reports similar to the way they write assignment solutions.

Most students find the actual organisation of the report to be challenging. Therefore, example(s) from previous reports are shared with students for students to see how to handle aspects of professional reports, such as clearly labelling sections and subsections and consistently numbering figures and tables so that they can easily refer to them as Table X or Figure X in the main text. In the initial draft, one of the common problems encountered is the use of the variable names from the data file and not the concept being captured (e.g., using A170 instead of "How satisfied are you with your life?"). Students who are working in industry and studying part time are better attuned to how important report writing is; some full-time students who have not had full-time jobs requiring a statistics background have difficulty seeing why it matters. Regardless, many students enjoyed the opportunity to analyse real survey data.

## EXAMPLES OF STUDENT WORK

Are carefully designed learning and assessment activities making a difference with how well students communicate in project reports? If we have no evidence, what we are doing is wishful thinking that what we do makes a difference. Looking at student work provides us with evidence to show that

students benefitted from our classes and can be better communicators of statistics in the future. We provide examples here from students' submitted project reports.

To maintain confidentiality of student work, variable names or some words are deleted from the UG project examples because some of the students were working on the real industry projects (work-integrated learning) (Bilgin et al., 2018). Examples of text from UG students' projects follows.

- The most frequent pool type was … pool (18 cases, 29.5%).
- In both datasets, the percentage of compliant cases was found to be reasonably high (at least 65%) for all … variables except …, where only 47.5% and 11.8% of cases were compliant in … and … respectively.
- Most frequent were days where a link post was made (17.3% of days), and least frequent were days where a status post was made (2.3% of days).
- Most of the respondents (99.30%) are "good" in at least two of the ….
- Data analysed in more detail revealed that most of the respondents know about condoms (50.30%), contraceptive injection (45.70%) and the oral contraceptive pill (41.50%).
- The majority of individuals are split between North America (32%), Europe (31%) and Asia (27%).
- The top educational programs are students enrolled in are undergraduate program leading to bachelor's degree (17%) and graduate program leading to master's degree (14%).
- The top 3 Industries are Business or Financial Operations (23.6%), Computer or Mathematical (14.1%) and Education, Training or Library (10.3%).

In the master's unit, students submit an initial write up of the report, which is not expected to be in the format of the final report, at the end of week 5. This activity is to ensure that students are making good progress and to identify any problems with their initial analysis or presentation of data. If the student wrote a draft of the final report, then the style of the written content was also commented upon. An example of feedback given for the use of inappropriate graphics is shown in Figure 2.

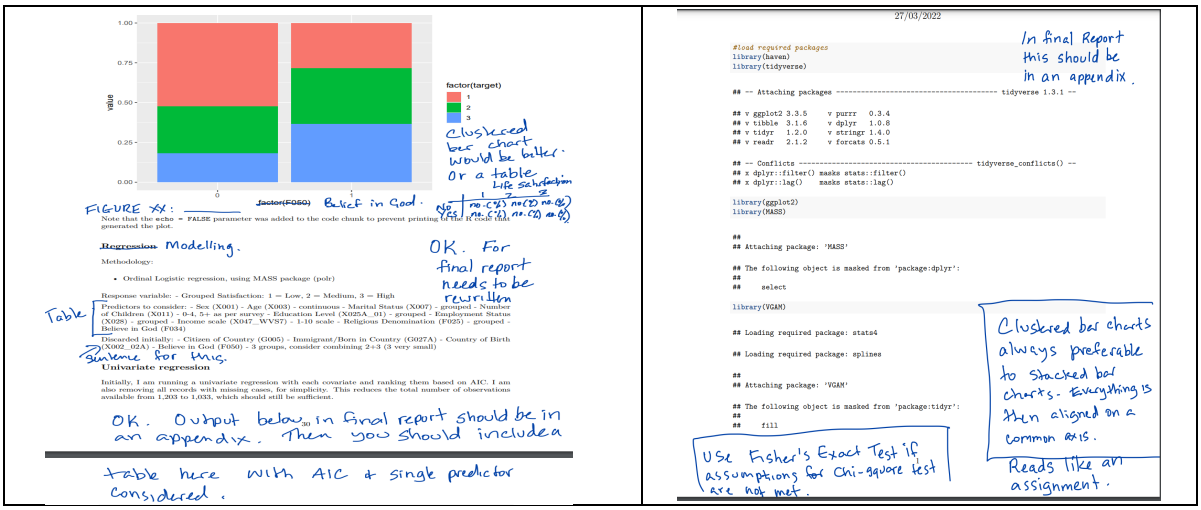



Figure 2: Some advice given on Initial write up of report for one student.

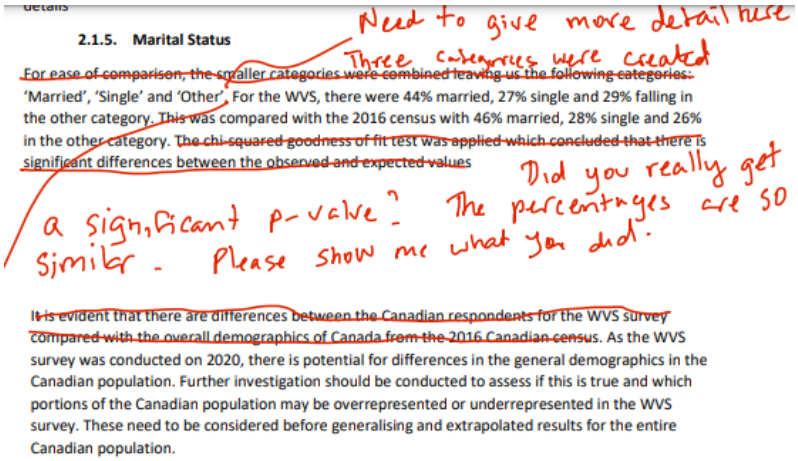
By the end of week 10, students submit the first draft of the project report, with the expectation being that it includes at least 75% of the material that will be included in the final report. Figure 3 displays an example of feedback for one section of the first draft of the project.

At the end of Week 11, students submit the second draft of their project report, with the expectation that it includes at least 90% of the material that will be included in the final report. Figure 4 shows how the feedback given in the first draft of the project report (Figure 3) is addressed by student(s) and how the writing has improved.

## CONCLUSION

Although report writing skills are highly valued by industry, some students treat writing a report like writing an assignment solution. In this paper we provided evidence for how students could become better communicators from two different statistics units which use different scaffolded learning activities

and assessment tasks. We would like to emphasise that clearly articulated learning outcomes are important to motivate students to invest time in improving written communication skills in statistics.




**2.1.5. Marital Status**

~~For ease of comparison, the smaller categories were combined leaving us the following categories:~~ 'Married', 'Single' and 'Other'. For the WVS, there were 44% married, 27% single and 29% falling in the other category. ~~This~~ was compared with the 2016 census with 46% married, 28% single and 26% in the other category. ~~The chi-squared goodness of fit test was applied which concluded that there is significant differences between the observed and expected values~~

~~It is evident that there are differences between the Canadian respondents for the WVS survey compared with the overall demographics of Canada from the 2016 Canadian census.~~ As the WVS survey was conducted on 2020, there is potential for differences in the general demographics in the Canadian population. Further investigation should be conducted to assess if this is true and which portions of the Canadian population may be overrepresented or underrepresented in the WVS survey. These need to be considered before generalising and extrapolated results for the entire Canadian population.

Figure 3. Example of feedback on one section of first draft of the project report

**2.1.5. Marital Status**

The marital status categories used in the WVS and 2016 Canadian Census are exactly same with 'Married' and 'Single' making up majority of the categories from both data sources. Three categories were created by combining the smaller marital status categories. The following categories remained as a result: 'Married', 'Single' and 'Other'. For the WVS, there were 44% married, 27% single and 29% in the other category. This was compared with the 2016 census with 46% married, 28% single and 26% in the other category. It was concluded that there were significant differences between the observed and expected values (~~with a~~ p-value ~~of~~ 0.0126). See Appendix A1.3 for more details.

Figure 4. Action taken by student(s) in second draft based on earlier feedback

Some students were sceptical about learning communication skills in a statistics unit at the beginning of a semester; however, towards the end of the unit, many begin to realise the importance of being able to communicate effectively in writing. In our classrooms, students valued the experience gained and acknowledged the improvement of their communication skills. Students realised that statistics is not just calculating or applying statistical techniques to a data set because "numbers do not speak to strangers" (Mackisack & Petocz, 2002, p. 1). Context needs to be understood and explained in a coherent piece of written work such as a report where the connection between the data set and the real-world situation is maintained.

We conclude that teaching statistical communication is not easy; however, it is an essential skill for our students. Many workplaces require reports to be written, and some reports are for a more general audience who might not have a statistics background. Better equipped students will have greater chances of successfully transitioning to work after graduation. Also, having written reports during their university studies in a safe environment with the guidance of their lecturers might improve students' confidence, and the reports could be used as part of their job application. Undoubtedly, for some students, learning soft skills, such as communication in a statistics classroom, is creating discomfort. However, after their learning as apprentices and learning by doing (Kolb, 1984), they appreciate the outcomes that they achieve, such as a professionally written project report and/or presentation.

This paper contributes to informing academics of ways of developing resources to teach statistical communication in their classrooms. We documented the learning and assessment activities and provided student work as evidence for the usefulness of the pedagogical design.

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