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Written Communication to Achieve Data Literacy Goals in a Probability and Statistics Course

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Abstract
Educational best practices indicate that engineering students learn professional communication skills most effectively within their engineering courses. To provide for this practice and document its accomplishment, the College of Engineering at University of South Florida has leveraged an opportunity provided for through the University's General Education program to build communication competencies into several general-audience Engineering courses.
The *Probability and Statistics for Engineers* course, which is taken by most engineering students, is approved as an Information and Data Literacy (IDL) course in the University of South Florida General Education program. The certification stipulates specific learning outcomes in information and data literacy that demonstrate communication, critical thinking, and problem-solving competencies, based on competencies highlighted in the AAC&U Value Rubrics.

Probability and Statistics for Engineers has now been taught as a General Education offering for four years. During that time, we have made significant changes to the IDL assignments to better focus their learning objectives on enhancing students' ability to use probability and statistics professionally. Incorporating communication competencies into such a quantitatively rigorous course requires an understanding of the IDL objectives and the types of communication strategies that can be particularly valuable in this type of course. Additionally, at a practical level, it has required developing material accessible to students in all college majors and at all student progression levels.

This paper outlines the implementation and evolution of the IDL approaches in *Probability and Statistics for Engineers* through the experiences of three of the faculty teaching the course, a TA who has been grading student deliverables for several semesters, and an educational practice specialist assisting with the course. The paper also discusses practical course challenges, and how our understanding of the AAC&U rubrics and their use has challenged and enriched our approach. Our paper also discusses the learning outcomes possible for integrating writing assignments into a quantitative course. These include 1) clarifying the role of this vital core topic in students' professional futures, 2) developing student competencies in reading data representations, 3) learning to read and interpret problem statements to devise quantitative strategies for addressing questions, and 4) understanding how to speak as a professional engineer to various audiences about issues of probability and statistical data generally. The paper takes us to where we are to date, preparing us for a full evaluation of the course. Our integration of information and data literacy into a foundational quantitative course has allowed us to build in specific and unique learning outcomes critical to students' future professional life.

Introduction
Course-level andragogical innovations oftentimes result from a bottom-up approach, in which faculty deliberately and proactively alter their individual courses to improve learning outcomes. In contrast, there are instances when course-level andragogical innovations are a response to university- or college-wide changes that are administered in a top-down manner. These innovations often require faculty to significantly rethink and retool courses to incorporate these changes in a meaningful manner, across content, context, and tools.

Such was the case with the initial andragogical choices made to alter how *Probability and Statistics for Engineers* was (and is) taught at the University of South Florida to explicitly include information and data literacy as a core learning outcome. In this instance, course level changes came because of new university-wide general education requirements for all undergraduate students initiated by the University of South Florida General Education Council (GEC). Faculty saw this as an opportunity to make changes to the course that were perceived as needed to improve students' critical thinking and communication skills. This paper discusses how writing assignments are being used in a probability and statistics course to aid in meeting this data literacy goal for students by integrating several writing-across-the curriculum approaches into the course.

Literature Review

Data Literacy

Data literacy is a type of numeracy literacy that has evolved from the umbrella category of information literacy. D'Ignazio and Bhargava [1] defined data literacy as "the ability to read, work with, analyze and argue with data as part of a larger inquiry process." Prado and Marzal [2] recognized that a part of numeracy is "the ability to communicate quantitative information to others in speech and writing". However, unlike many other aspects of numeracy, communicating data depends a great deal on presenting it in context. How and why specific data elements are selected and defined, why a specific methodology was chosen, and how the data are presented can affect how audiences interpret the data. Hence, discussions on developing data literacy communication skills emphasize a contextually-based disciplinary perspective and an understanding of the audience and purpose for which the information will be used [2], [3], [4]. Communicating data requires building adaptive reasoning skills to link context and content, procedural fluency to address methodological expertise, and critical analysis [5], [6]. These competencies are necessary for students to be able to critically evaluate and communicate to both expert and naïve audiences about data-based questions, and to solve problems using data.

The demand for data literacy

Two technological developments have reframed the probability and statistics skills professionals need: 1) the development of fast and accurate computational tools, reducing the need for humans to complete calculations by hand; and 2) the more recent advances in data collection (Big Data) made possible by the Internet of Things. Both changes have resulted in statistics educators evaluating how statistics education can best prepare students for current professional demands. Peck [7] highlighted the need for changes driven by the computational tools stating, "these days, if all a student can bring to the table is the ability to perform the computational aspects of data analysis, they can be easily replaced by an inexpensive calculator." Her explanation continues by pointing to the change in student learning that is needed,

> "To actually make an intellectual contribution to the data analysis process … they must be able to draw meaningful conclusions that connect context and the analysis and communicate those results to others (p. 1)."

However, part of this need, connecting context, analysis, and recommendations, is a student weakness that Read and Mathison [8] documented in interviews with faculty, who noted that students had difficulty with complex problems, drawing conclusions from their work, and

making recommendations. In their *Guidelines for Assessment and Instruction in Statistics Education,* the American Statistical Association [9] responded to this by indicating that statistics should be taught to allow students to focus on conceptual understanding. This poses another challenge for writing assignments in probability and statistics: if students do not understand the context of the problem or the probability and statistics they are writing about, they will have difficulty writing about it.

Writing Across the Curriculum in Probability and Statistics

Communication is a primary skill of data literacy [1]. When students become professional engineers, they will need to convey messages about data analysis that assures their readers that what they have done and found can be relied upon. This requires moving students beyond recording their calculations and numbers to presenting narratives that readers can understand and believe. Morrow [10], writing about data literacy, indicates "our minds do better with stories than with data. We need to empower people to share stories and communicate the results, analyses and insight found in the data" (pp. 47-48). However, these stories will need to be told to a range of audiences. This range of audiences is broadening as the practice of engineering is moving increasingly toward interdisciplinary projects and global work and work teams [11], [12].

The adage to *know what you write* can be perceived in two ways when examining writing in probability and statistics. First, students will need to have a better understanding of statistics to write well about it. Emig [13] states, "The medium then of written verbal language requires the establishment of systematic connections and relationships. Clear writing, by definition, is that writing which signals without ambiguity the nature of conceptual relationships" (p. 6). Emig points out that this process for clear writing is also a process of learning. Therefore, by writing in engineering courses, in this case probability and statistics, students can both learn about the course material and learn how to present it as a professional [14]. However, a second consideration comes from the faculty side when developing assignments. Paretti, Eriksson, and Gustafsson [15] state that:

> Faculty and communication faculty alike would benefit from a more concrete understanding of the ways in which communication instruction can simultaneously foster critical technical engineering skills rather than "taking time" from content coverage (p. 30).

Choices to use problems that require students learn material not core to the course or major falls into this "taking time" category. While there is a recognition of the importance of learning in the field you are studying [15], it is perhaps the case that for technical courses, choosing appropriate problems built around topics that are familiar enough to students for them to write about is important.

Two writing across the curriculum approaches form the framework for the assignments discussed in this paper: writing to learn and writing to engage [16]. Writing-to-learn (WTL) assignments are low stakes assignments that focus on students thought processes rather than right or wrong answers or polished communication. Skills these assignments develop are remembering, understanding, and reflecting. Writing-to-engage (WTE) is a process of getting students to

critically engage with the material they are learning. Skills these assignment types develop include reflecting, applying, and analyzing [17]. Use of these two approaches for writing assignments provide students the ability to engage with assignments in diverse ways, with different feedback and with different stakes.

Implementing Data Literacy Writing Assignments in Our Course

Probability and Statistics is a course that has been taught as a strictly quantitative course at University of South Florida for decades. Therefore, implementing writing assignments to add information and data literacy learning outcomes required developing significantly different types of course material, integrating the material into existing course structures, and communicating an approach that students would perceive as enhancing their learning of the course material.

To design the initial course approach, assignments and grading went through a significant review process to address enhanced general education requirements. The new material had to demonstrate communication learning outcomes with a minimum of 2000 written words and integrate in key critical thinking and problem-solving learning outcomes. Faculty agreed to add assignments to the course that would advance two specific competencies in information and data literacy:

1. Critically interpreting quantitative evidence (i.e., graphs, tables, charts), and
2. Critically comparing and contrasting opposing claims regarding the same fact or hypothesis.

Engineering faculty felt there was a clear need for someone with a communication background to be responsible for this part of the course. Faculty with this expertise joined the College in the fall of 2018.

A key complicating factor in this effort is the large number of faculty teaching the quantitative sections of the course, with whom the communication faculty member interfaces. Six different Industrial and Management Systems Engineering (IDMS) faculty regularly teach the course, with three assigned to teach sections each semester. Graduate students are assigned as instructors in the course in the Summer and sometimes in Fall. Each faculty member has their own approach to the course, based on years of teaching the material. Thus, the new material has had to fit into different course structures and teaching approaches. Another complicating factor is student numbers: 400 take the course each Spring and Fall, and 150 students take the course in the summer term. The large numbers of students present a significant challenge in providing meaningful feedback.

Where We Started

To gain approval of the course as an information and data literacy offering in the Enhanced General Education program, the Engineering faculty developed six writing assignments aligned with the progression of topics in the quantitative part of the course. The problems were selected based on available data sets, scaffolding across the course's statistical topics, and connections to one or more engineering fields. (Problems 2 and 4 are shown in Appendix A).

These new writing assignments underwent evaluation and revision over the first several years of the course. We have sought to hone the initial approach (see Table 1) to ensure that these materials were integrated into the course in a meaningful and effective way. This process has led

us to modify the course assignments, teaching approaches, grading, and assessment to complement and advance the learning outcomes for the primary course material, as well as to fully meet the specific information and data literacy course learning outcomes.

Table 1: Initial Assignments

#	**Problem**	**Audience and Document type**	**Specific Extraneous Technical Knowledge Required to Address the Problem**
1	Using soldier fatality data to determine intervention strategy	Your Government, Memorandum	Historic perspective on military fatalities, interventions required for each fatality, speaking to culturally diverse government officials
2	Exploring ongoing 'experiments' around you	None (faculty) Question/answer	Identification of 'experiment' and outcomes for which Bayes' rule assist addressing
3	Selecting a major vendor through comparative analysis	None (faculty) Question/answer	Understanding of production accuracy and knowledge of what a steel shaft for a gearbox is and how it works
4	Report to the Mayor requesting expanding ambulance services	Mayor Report	Identify standards on ambulance response time
5	Objectively verify liability for a claimed catastrophic machine failure	Expert witness report	Knowledge of internal combustion engines, with copper lead bearing material on shafts, class action lawsuits, and the US legal system
6	R^2 value of a regression equation: Why is it drawing everyone's attention	None (faculty) Question/answer	Knowledge of how regression equations are used in engineering decision making

Assignment and Instruction Challenges

As we implemented the new assignments, we recognized several challenges that required us to modify or change the assignments over time: 1) students complained that writing elements of assignments offered them no opportunity to improve their work. 2) The data literacy writing goals were not clearly identified or scaffolded. 3) Each assignment required that students have specific technical knowledge in one or another engineering subfield to write clear responses. 4) The assignment rubrics did not provide students with meaningful feedback on their work.

- ***Learning progression through the semester***. Students did not like working on writing assignments when they felt they had no opportunity to improve their work. While the initial assignments were scaffolded to progress in the quantitative part of the course, they did not effectively scaffold for learning in the data literacy. Ultimately, tying data literacy assignments into student efforts to learn specific quantitative concepts in the course both distracted them from the writing and limited their ability work on data literacy skills. These challenges suggested the need for phased assignments and scaffolding across assignments.

- ***Focusing student effort***. At University of South Florida many of the College of Engineering departments had ideas about what they felt students needed to learn in probability and statistics as well as in professional writing. Early on, as we tried to adapt the assignments, we believed we could meet all these requested learning outcomes, but we were wrong. In our attempts we overloaded the students, and we ultimately had to eliminate some requirements and move other competencies to extra credit options. We had to match the concept of information and data literacy, the experience and knowledge level of the students and the specific general education commitments to develop a reasonable set of objectives that could be advanced through each assignment.
    - ***Knowledge required***. Many of the initial writing assignments required students to have field-specific knowledge, an understanding of standards and testing, and exposure to professional writing. However, this class is generally taken by students before they have taken discipline-specific technical classes. Additionally, because we teach across the College, field-specific knowledge varies considerably. Most students opted not to research the product or process they were discussing, which meant they wrote about it poorly. As an example, few students had been exposed to the idea of product performance standards, knowledge of which was needed in several problems. Adding these layers of needed understanding was prohibitive given the time allocated to work with the students on data literacy and communication assignments. To address this, we developed problems relevant to students' learning in the course using broad topics that crossed disciplines. Doing so also gave us the opportunity to develop problems without one specific answer, thus reducing the opportunity for cheating.
- ***Providing student feedback***. Our first semester in the course involved the communication instructor grading about 2,400 writing assignments without TA support. Barebone rubrics required instructors to develop a large menu of freeform comments, which were pasted in as assignment feedback. The grading was time consuming, and students were not receiving the level of feedback they expected or needed. We recognized the need to develop more detailed rubrics and to streamline feedback communication with the students

One additional issue we faced was explaining the integration of this new material into the course. Initially we attempted to present many expert sources to students as evidence of why they needed this component of the course. However, the students just saw it as more work in a course that already had a reputation for being difficult. Additionally, many students believed the course was unimportant to their professional future. We now present the information and data literacy aspects, including the ability to communicate about data, as skills critical to their professional lives. Then we use the first two assignments to aid them in documenting for themselves how important probability and statistics are in current engineering practices.

Assignment Approach Modifications

We knew we needed to reduce the number of unique assignments, create a phased approach to the assignments, increase their scaffolding with course specific learning goals, limit the non-course specific knowledge required, and develop a more effective strategy for feedback for the large numbers of students taking the course. Our goal in our assignment modification process has been to focus on a specific set of information and data literacy skills, and to give students

practice with these skills within assignments, as well as to advance these skills over the course of the semester.

We reduced the information and data literacy component to three distinct assignments, each with a preliminary low-stakes phase to the assignments where students work on reading and then interpreting data, and on developing a component of their communication skills. This allows students to do preliminary work on the assignments without worrying about 'getting it right'. To provide timely feedback, we developed review workshops for the preliminary assignments. Initially, we tried student peer reviews, but found that the feedback students gave each other was inadequate to their needs. Our observation has been that students are much more comfortable sharing and learning from what they have done rather than providing critical feedback on something they are not sure they have mastered.

Table 2: Assignment Phases for All Assignments

Assignment Phase	Evaluation	Purpose
Introductory Workshop	No stakes	Introduces writing and data expectations for the assignment, presents and discusses audience and purpose, includes practice exercises
Preliminary Assignment	Low stakes	Complete preliminary data analysis and writing work on the assignment
Review Workshop	No stakes	Small groups compare their content approach for writing and data use in that writing
Final Assignment	High stakes	Students must communicate effectively about data they have interpreted within the context of a specific communication to an assigned audience for a designated purpose

The Enhanced General Education assessment implemented in the fall of 2019 focused us on the general and specific objectives of information and data literacy, as well as on what students need to be able to communicate in this area. The generality of the assessment language pushed us to find a definition of data literacy as a starting point for making our changes. D'Ignazio and Bhargava's [1] definition of data literacy provided us with the elements around which we have focused the IDL course learning objectives: "the ability to read, work with, analyze and argue with data as part of a larger inquiry process." Below are the goals and focus of the assignments we developed to advance the specific learning goals we had defined.

- ***Reading and analyzing data.*** Goal - Over the course of the semester, you will learn to read and analyze data in different formats: tables, charts, and text.

  Focus - An important part of this goal is carried out in the core quantitative part of the course where students learn to examine and evaluate raw data. For this part of the course, we focus on teaching students about working with visual and textual data accessed from external sources. The students have two goals in this part of their work. First, they learn about reading and using data from tables, graphs, and text. Second, they learn about reading a problem and

deciding what quantitative tools can be used to address the problem. We use Pólya's [18] *How To Solve It* as a frame for this.

- ***Critical thinking and problem solving*.** Goal - You will learn how to interpret data presented in different formats to determine how that data is of value to the problem you are addressing. While you will be doing a significant amount of problem-solving in the math part of the course, you will have a problem to address as part of the final IDL assignment. As part of this work, we will discuss how to interpret a problem you might be presented professionally to determine what math tools can help you address it.

  Focus - Many of our students are at a stage of their education where they are moving from memorizing and reciting information to having to engage with material and develop their own thinking. By providing a preliminary assignment that requires students to think about the inputs into the problem and how they will use them in the assignment, students have dedicated time for documenting their thinking about how to address the problem presented. For the final part of the assignment, students must demonstrate they can apply information and data to a problem.

- ***Argue with data for a specific audience and purpose*.** Goal - You will develop clear written documents to the specific assigned audience for a designated purpose. This part of the course will focus on clear organization and wording of the arguments you will make with data.

  Focus - In pulling back to three assignments we have time to spend examining how to understand and address different audiences. Students start with addressing other students, then executives, and finally a naïve audience - a jury. The first two assignments have similar purposes but for different audiences. Their first audience, other students, supplies an opportunity to describe what they know and discuss how to approach an audience that is familiar. The second audience, executives, was requested by our advisory council members, and gives us a chance to talk to students about communicating with this important professional audience. By using a similar purpose, students learn about why presenting material on the same project to different audiences will require unique messages and language. The final audience, a jury, is selected to help students think about communicating statistical methods effectively, as they must present the logic of what they are doing rather than walking people through a verbal description of their math. In the preliminary assignments, students show how the information and data they have used can support a conclusion they will make. For the final assignments, they must synthesize the information and integrate the data into a cohesive argument.

Three areas in which we pulled back in our teaching are: 1) specific professional document formatting, 2) creating basic data visualizations (e.g., tables, graphs, charts), and 3) using field specific technical problems. Students come into this course without background in formatting professional documents or in producing data visualizations. Our limited time with them did not allow us to provide the support they needed for them to learn how to format documents or produce data visualizations. To mitigate this, we have provided professional document templates structured for students with the important formatting and organizational elements of this type of

communication. Students can include graphics as extra credit on the second assignment, providing more advanced students the opportunity to work on data visualization skills.

The first two assignments relate to students' professional aspirations in general rather than specific technical problems. These new assignments remove the need for students to invest time in learning about a product, system, or process that is unfamiliar to them and unrelated to their core learning in the course. This approach is particularly important because of the breadth of technical knowledge required across the various engineering fields of our students and their range of academic experience, from freshmen to sixth year seniors. For both assignments students are provided with an introductory article on the use of probability and statistics in engineering and computer science and are expected to find several other sources to help them write about what probability and statistics is used for in their field. Additionally, in the first assignment we provide data on the importance of probability and statistics to their professional future. For the second assignment, we provide information about the importance of the use of data to organizational success. We discuss how to read and use these data in the assignments. They practice reading, interpreting, and arguing with data in the preliminary deliverable. For both final deliverables they discuss the importance of probability and statistics and apply the data they must present to these two different audiences.

Table 3: New Assignment Overview

Summary of the Assignment Progression
IDL 1 (1st Enhanced General Education requirement) *Topic:* Probability and statistics is important for your professional career. *Data:* Read tables and identify and isolate the data relevant to the argument [19] *Audience:* First year students in their field. *Writing:* Practice integrating data into an argument; revise writing for a professional audience. *Final Document Type:* Handout
IDL 2 (1st Enhanced General Education requirement) *Topic:* Probability and statistics (data literacy) are important to the success of businesses. *Data:* Read graphs and identify data in text to support their arguments [20] *Audience:* Executives. *Writing:* Organize an argument with supporting data; develop a document with tone and content appropriate for executives. *Final Document Type:* Memorandum
IDL 3 (2nd Enhanced General Education requirement) (see Appendix B for assignment details)
Topic: Analysis using hypothesis testing [21] *Data:* Raw data set. *Audience:* Jury (naïve audience). *Writing Process:* Use Pólya's [18] *How to Solve It* method to interpret a writing problem; effectively communicate data in context to a naïve audience *Final Document Type:* Memorandum

The final problem is a more traditional engineering word problem. Students must complete a statistical analysis using hypothesis testing and they are expected to present both the data and the

significance of what they did and found to a jury (a naïve audience) in an abbreviated legal memorandum. Because this is an engineering problem, we spend time on making sure students understand the specifics of the problem, and how to read problems to identify a statistical approach to answering them, using techniques from Pólya [18] as part of the preliminary deliverable.

The assignments we developed to address the identified challenges are summarized on Table 3. The preliminary and final deliverable assignments for the IDL 2 are included in Appendix B.

Grading and Feedback

Efficient grading and effective feedback are always in opposition. This is especially true for large classes with students across multiple sections, in multiple modalities, as we have. The initial grading rubrics, which related directly to AAC&U Value Rubric categories, did not provide students with actionable feedback (see Appendix A for assignment rubric examples). With the volume of assignments to be graded each semester, the rubric became the primary tool for student feedback. Providing that feedback was the goal of our rubric revision.

Table 4: Initial Rubric Items

Initial Rubric evaluations (not all items were used for each assignment)
• Ability to write • Critical and analytical thinking • Compare and contrast claims and problem-solving approach • Data analysis and data driven decision making

Providing students timely enough feedback for them to revise their approach to the next assignment is a priority. Therefore, we aim to grade all assignments in one week. To accomplish this, graders for this class typically spend 3-6 minutes per IDL submission to give meaningful feedback. Students have potentially worked many hours to create a suitable final product, and it is imperative that they receive prompt and thorough feedback so that they remain engaged and motivated.

We have developed the assignments and rubrics to help the students while minimizing our time spent on grading (see an example in Appendix B). By using succinct document formats that are relevant to students' professional development, such as legal memoranda, students can better focus on tone, flow, and other elements of professional writing. Each of the assignments has two deliverables (see Table 2). The first is an outline of the student's approach and is focused on content. This deliverable is graded based on completion, and graders include feedback only if students appear to be off track. The second deliverable is graded comprehensively, using the revised rubrics which streamline the process for graders and supply feedback to the students. These rubrics include several yes/no components, (e.g., "*The introduction's tone is appropriate for the audience*") which allow for rapid assessment. The grader can quickly select "Yes," "No," or, in some cases, "Partially," which presents the areas for improvement to the student without writing customized comments. Each section is given a numerical grade based on the yes/no components. There are limitations to this grading approach, as students with unique writing or

content issues may require personalized feedback. However, less time is spent re-reading assignments for overall professionalism, tone, and content.

Assessment

Our assessment instrument includes modifications of the AAC&U Value Rubrics for Information Literacy, and Written Communication developed by the University of South Florida General Education Council. For this course, we evaluate these relative to data literacy proficiency. Each semester 10% of two final deliverables from the data literacy assignments are assessed using these benchmarks. At least two different raters conduct the reviews. Review of the data from the first several years of the course are ongoing.

Table 5: **Enhanced General Education Rubrics [22]**

Information and Data Literacy
Specific Course Objectives • Critically interpret quantitative evidence (such as graphs, tables, charts) • Critically compare and contrast opposing claims regarding the same fact or hypothesis
Communication
Primary Enhanced General Education Goal "Students will produce well-organized, well-developed communications that reflect appropriate use of language to achieve a specific purpose and address specific audiences."
Communication Proficiency Benchmarks • Student demonstrates understanding of required context • Student creates a presentation that provides relevant, detailed, and compelling assertions supported by credible and relevant sources

Next Steps

We have several remaining goals for this course. The first is to expand our menu of problems and supporting data to reduce the potential for cheating. Given our large numbers of students, tracking cheating is difficult. Alternative problems and data sets will increase the variety of writing assignments we can offer and make cheating more difficult. A second goal, is to review a statistics specific model for interpreting problems [23] that builds on the Pólya [18] method. We currently use Pólya to teach students to examine text to find math approaches for addressing the problems they describe. We want to evaluate this alternative model as a potentially more effective tool for our students. Finally, as there is a push to increase statistical learning in secondary schools [24], future students may bring more foundational statistical knowledge to the course. This may allow us to raise the level of the material we are teaching in the course.

Conclusion

During the first four years of using written assignments to add data literacy learning outcomes to the *Probability and Statistics for Engineers* course, we have steadily worked on their improvement. Challenges identified in the original assignments included developing clear data literacy objectives and scaffolding them within the course, focusing student learning onto probability and statistics, and providing adequate and timely feedback. Students in the course need to do more than merely learn the mathematical techniques associated with probability and

statistics. They need to understand how to interpret the results of their calculations and communicate the practical implications of those results. The *AAC&U Value Rubrics* corroborated this need and provided broad foundational learning outcomes that students need to demonstrate their proficiency in data literacy, as it will be required in their future professional practice.

Although these andragogical changes were a response to external stimuli (e.g., the General Educational Council), the required changes were embraced by the course instructors and the "problem" was widely viewed as an opportunity for improvement. While the improvement process has not been easy or linear, we have implemented changes that are helping students develop written communication skills that are uniquely valuable to their success in this type of quantitative course. Hence, effective written communication became a cornerstone for our *Probability and Statistics for Engineers* course as we revised it to focus on data literacy.

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Appendix A: Initial Assignment Example

Assignment 2: Exploring ongoing Experiments around you

Question and Answer Problem

Answer each of the following questions in 50 words or less

1. Describe an experiment (e.g., the weather, the traffic, 911 calls) that is ongoing in your surroundings, and state possible outcomes of the experiment.
2. Using the above outcomes, describe two possible events (namely, A and B) and discuss if A and B are 1) mutually exclusive, and 2) independent.
3. Construct a scenario and pose a question where Bayes' rule would be useful to answer the question.

Assignment 2 Rubric

- Ability to write
- Critical and analytical thinking
- Problem solving approach

Assignment 4: Report to Mayor for Improving Fire/Ambulance Services Description

Professional Communication - Report

Learning outcomes: Critical interpretation of data (SLO2) and analytical thinking

Consider a random variable

X = response time of fire trucks and ambulances in a city (that is, time between the events of receiving a 911 call and the arrival of the responders on site). Consider yourself as the Chief of the Fire Services. Critically examine how you might use confidence interval on the random variable X to justify the need for more funding in a report that you writing to the city Mayor. (200 words or so)

Hint: you can consider the following in your report:

1. Examine fire/ambulance response times in various U.S. Cities
2. See if you can get hold of actual response time data for your city (or, any city) (or, assume data)
3. Obtain confidence interval (C.I.) and develop arguments based on the C.I. the lack of desired service to your constituents.
4. You report to the mayor may consider improving efficiency to better the C.I. and also adding more resources to improve C.I.

Assignment 4 Rubric

- Ability to write
- Critical and analytical thinking
- Data analysis and data driven decision making

Appendix B: New Assignment Example with rubric

Assignment 2 Preliminary Description

Answering the questions below is intended to provide you with an understanding of the data in the provided document and space to think about how it can be used to support the argument you are required to make with it for the final phase of this assignment. You will share what you found in small teams during the workshop, where you will help each other hone your thinking on what this data is, tells you, and its utility for making the argument you will make for the final phase of this work. For answers that require more than one or two words or numbers, you must use your own words. Your answers will be presented to your classmates during the workshop (or for those who are asynchronous, on your own time.)

Answer the following questions about *Analytics and AI-driven enterprises thrive in the age of with: The culture catalyst*

1. What do you know about the data that is used to develop the findings and inferences that are being presented in this document?
2. What is the size of the sample?
3. Who were the participants sampled? (What types of organizational roles did they have?)
4. What do you know about the organizations the participants came from?
5. How were the data collected?
6. What is the margin of error for these data?
7. What is the confidence level?

Using the answers from above

8. How would you identify the population the sample these data are intended to represent?
9. How do the sample and population described relate to the hypothetical company you work for?

Go through the document and highlight any place that the data is presented in the text. Then identify the three to five points that are most important to the argument you will have to make and briefly describe how they can be used in your argument.

There are 6 figures in the document, identify briefly what each one tells you. Then identify the two you think are most important to supporting the argument you will be making in the memorandum.

Preliminary Assignment Rubric

This assignment is graded on completion. Students earn full points for a completed assignment, partial credit if the assignment is incomplete and no credit if it was not completed on time. The more detailed review of the assignment is completed in the workshop.

Assignment 2 Final Description

You are working for Rešitel International, a 14,000-person consulting organization. You work in a division of the organization that provides client services in your field. Rešitel markets your field's full range of professional work services to its clients. Your manager has asked you to write a memorandum to your division leaders. This memorandum will make a case that increasing the number of employees in the division proficient in statistics and probability will improve provided services and increase profitability.

He has asked you to address the memorandum to Fiya Basak, Vice President of [your field]; Anozie Nwaike, senior manager of [your field]; and Elizabeth Rice, senior manager of [your field], with a copy to your boss, John Coltrane. These leaders are senior professionals in your field with the required knowledge of the field. Mr. Coltrane is requesting a policy change, so all new hires are proficient in statistics and probability (data literate). He has tasked you with accomplishing this by:

1. Reenforce the many ways your division uses statistics and probability to complete work for clients. Summarize how your division uses statistics and probability for the services identified.
2. The importance to division success of having all employees engaged in data analytics (analyzing data using probability and statistics for increased profitability and meeting division goals). For this part of the work, he provides you with a document summarizing external research data provided by a Rešitel partner, Deloitte, to support this case. He wants you to review this data for:
    - How the data provided can support your argument that more data literate/probability and statistics proficient employees will make the division more profitable, and
    - Is the data Deloitte collected relevant to Rešitel? Are the participants from whom Deloitte collected the data similar enough to Rešitel to suggest their findings would apply to Rešitel? You will include what the data indicates, the source of the data provided, the size and reliability of the study, and how that data source aligns or not with Rešitel as an organization.

After reviewing the data, you will use it to make the case that your division will be more profitable if more employees can engage in data analytics (that is, applying probability and statistics knowledge.)

Document Structure

To complete this assignment, you must use the provided memorandum template. Refer to the memorandum example document for an idea of the length, level of detail, language, and final appearance of your memorandum

Your document will have the following elements:

- Memorandum Header.
- Introduction.
- Probability and Statistics Use in [Your Field] Division Services.
- The Importance of Probability and Statistics Literacy for Our Division's Operational Success.
- Conclusion.
- Reference List.

Rubric (subcategories are included to demonstrate the level of detail provided to students. These categories do not have points associated with them; they are yes/no responses)

- Memorandum Heading is clear, concise, and descriptive
- Introduction – The introduction provides readers with an overview of why readers will find the document important, what the main point of the document is and what you will say about it (thesis statement), and how you will use the document to support what you are saying
    - *The purpose, audience, and value of the document is clear*
    - *Both components of the body of the handout are introduced: probability/statistics in the field and improving business profitability*

- Uses of probability/statistics in the field - This section discusses the purpose of using statistics in your field. How is it beneficial to the field? What kinds of problems can it address?
  - *There are 2-3 specific examples of probability/statistics uses within your field (department)*
  - *The examples are well-explained and the purpose of using probability/statistics is clear*
  - *(Technical) language use is appropriate for the audience*
- Data Literacy Data from the required Deloitte report is included and discussed in the text. After reading this section, the audience understands the potential financial benefits of promoting data literacy in the company.
  - *meaningful statistics/data from the Deloitte report are identified*
  - *The data is used effectively to enhance the argument*
  - *Fit of the data from the Deloitte report is presented in the description of the data*
- Conclusion - In this section, you summarize what you discussed about the use of probability and statistics in your field and how promoting data literacy will improve the company's bottom line.
  - *A brief summary of the document is given, including both components*
  - *A concluding statement is given that restates the thesis/argument*
- Professionalism - The correct template was used, formatting is consistent, and the writing of the document is professional and appropriate.
  - *The handout is well organized with headings and has good flow in every section of the paper*
  - *The tone is professional and well suited for the audience in every section of the paper.*
  - *the paper has been revised for clarity; spelling, and grammatical errors have been eliminated*
  - *The tone is professional and well suited for the audience in every section of the paper.*
- References - References for 4 sources are in APA format. In-text citations are used for each reference.
  - *The required Deloitte report is included and cited*
  - *3 other trustworthy sources are used and cited*
  - *Sources are in APA format*
  - *Sources are in alphabetical order*
  - *In-text citations are used in the format (Author's last name, year) anywhere you have used someone else's ideas or data*
  - *Each source corresponds to at least one in-text citation*