BOARD # 196: Work in Progress: Integrating Information & Data Literacy into a Probability & Statistics for Engineers Course: A faculty-librarian collaborative approach

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Abstract

The ability to think critically and communicate about data is an essential skill in engineering as data availability is exploding. Being able to "run numbers" is no longer sufficient for engineering students. Students need to evaluate datasets, connect data to appropriate statistical tools, and communicate data to a wide range of audiences; they need to be data literate.

At the University of South Florida, students across engineering majors take an introductory probability and statistics course that includes a data literacy module worth twenty percent of the course grade, which meets university requirements for Information and Data Literacy, Communication, Critical Thinking, and Problem-Solving. This course is offered every semester in large blended face-to-face/online sections to an annual total of 1060 students. After teaching the course for 11 semesters, we identified several challenges with the data literacy assignments:

1. The assignments did not have students create data visualizations, an important element of communicating about data.
2. The assignments had too many elements, resulting in students focusing on formulaic assignment elements while avoiding doing the critical thinking to make arguments with data.
3. Assignments developed to address the diversity of student backgrounds and experiences were not engaging to students and often required them to research and learn new topics unrelated to the core course material.

This case study documents a multidisciplinary, collaborative process for revising the data literacy module in this introductory probability and statistics course. The Communication instructor, who teaches this module across all course sections, collaborated with a Library faculty member with expertise in developing and delivering data literacy content through discrete instructional modules. With consideration for the feasibility of scaling across multiple sections and modalities, we had three goals for the redesign:

1. To transition communication activities from a focus on prose-only data messaging to data messaging that effectively integrates prose and data visualizations.
2. To focus students on thinking critically about what statistical parameters indicate in a particular problem.
3. To facilitate students' ability to read and respond precisely to an engineering-related problem.

To develop our approach and content, we drew from literature across multiple fields, including information and data literacy pedagogy, technical writing in engineering, argumentation, and data visualization. The resulting data literacy module comprises assignments paired with applied engineering problems derived from the existing scientific literature and real-world datasets.

We deployed the new assignments in Fall 2024. While we have confidence in the revised module, we recognize that some elements of the assignments will not work as expected. To evaluate the revision successes and identify areas for improvement, the teaching faculty member compiled observations from student workshops, office hours interactions with students, and open help sessions. She also tracked

assignment outcomes to identify ways in which assignments were successful and where students were challenged. We recognize that data literacy is becoming increasingly essential for engineering students, and we hope the embedded data literacy module can serve as a model for other programs.

Introduction

The University of South Florida's Enhanced General Education program includes the requirement for coursework to develop students' information and data literacy competencies. In developing these competencies, students must demonstrate communication, critical thinking, and problem-solving skills. The University has developed a list of standardized indicators of achievement from which a course with this designation must meet at least two. Assignments meeting these requirements need to account for a minimum of twenty percent of the course grade.

To meet the data literacy requirement for engineering students, the Engineering faculty integrated a new data literacy module into the existing calculus-based probability and statistics course that is required in all engineering programs. The course objective for students *to develop knowledge of statistics and probability modeling and their application to solving various societal problems, including in business and industry* aligns well with two of the university's information and data literacy indicators: (1) the ability to critically interpret quantitative evidence such as graphs, tables, and charts; and (2) the ability to critically compare opposing claims regarding the same fact or hypothesis. Integrating this module into the course also provides an opportunity for students to advance their professional communication skills as ABET requires. To accomplish this the College hired Ph.D. level Communication faculty to teach this component of the course.

The original module consisted of six engineering-oriented problems aligned with the topics taught in the math component of the course. Each assignment had a different topical focus, required a different document type, and targeted a different audience, with no scaffolding around the data literacy goals, which left students without opportunities to learn and show improvement in their work. An initial redesign of the module worked to scaffold learning around the data literacy requirements, while considering students' progress in the math part of the course [1]. That module's assignments were organized into three paired assignments, each aimed at a different audience, and structured to minimize the need for extensive engineering knowledge to accommodate students at all stages of their undergraduate program. The first assignment required students to read and interpret tables, the second to read and interpret graphs, and the final to make a textual comparison of two sides of a claim using hypothesis testing.

Based on several years using the revised module, the communication faculty identified several challenges. 1) Students' assignments only required communication via prose; however, visualizations have become an important element of professional communication of data. 2) Students exploited opportunities in these assignments to bypass the critical thinking aspects needed to make arguments with the statistics, instead focusing on formulaic structural elements. Thus, many students were not connecting data to an understanding of a problem. 3) Students from the different engineering degree programs found our original engineering centered problems difficult to understand and write about, as each problem required that they learn about non-course related topics. However, when the problems were made more generic, many students became less engaged. Thus, a second revision of the module's approach and assignments was needed to address these challenges.

All sections of this course are team taught, with one faculty member with an engineering background teaching the statistics skills (80%) and a second faculty member with a communications background teaching the data literacy module (20%). These faculty spent considerable time collaborating on how these two course components would fit together when the first course revision was launched [2]. Building on this established ethos of team teaching, the communications faculty identified a library faculty member at their institution with substantial experience with data literacy ([3],[4], [5], [6]) and invited her to collaborate on the current revision project.

Expected benefits of this partnership included easier access to a wider range of foundational literature, and collaboration on the critical formative review of the assignments as they are developed. Some unanticipated benefits of this partnership included an expansion and refinement of tools and processes for teaching and learning, as the Library faculty's teaching experiences aligned with the embedded module approach that the Communication faculty uses in teaching this aspect of the course. As well, the expertise of the Library faculty member regarding STEM students and how they learn has been invaluable in this work.

The module revision we developed and implemented this Fall sought to address three issues: (1) integrating prose and data visualization in communication, (2) critical thinking to connect statistics to addressing and documenting a problem, and (3) problem solving, including learning to read, seek clarification, and precisely address a specific problem. The case study that follows describes the process we completed, the process benefits, our assignment revisions, and the outcome of the first semester implementation.

Literature Review

To develop an approach and content for this course, the authors drew from literature across multiple fields, including engineering education, statistical education, information and data literacy, and data visualization. The initial focus of the redesign centered on how data literacy is defined for higher education, and how it is distinguished from and is complementary to statistical literacy. Later questions involved identifying pedagogical approaches to teaching data visualizations as complementary and integrated with prose arguments.

Technical Communication

In the field of engineering education, the challenges of teaching communication skills for workforce preparation are well documented; also, faculty have dedicated significant time and effort in identifying effective pedagogical approaches and curricular strategies to train engineering students for communicating in a professional setting with different audiences, primarily in writing [7],[8], [9]. ABET accreditation criteria for Engineering Technology Programs uses the term *graphical* in its communication criteria as follows, "an ability to apply written, oral, and graphical communication in well-defined technical and non-technical environments; and an ability to identify and use appropriate technical literature" [10]. ABET accreditation criteria for engineering, applied and natural sciences give less attention to communication, requiring a more general, "ability to communicate effectively with a range of audiences" [11].

Statistical literacy
In the field of statistical education, statistical literacy has been defined as "the ability to read and interpret summary statistics in the everyday media: in graphs, tables, statements and essays;" while statistical competence has been defined as "the ability to produce, analyze, and summarize detailed statistics" [12]. Schield differentiates statistical "literacy" from statistical "competence" in terms of need; most citizens need some level of statistical literacy, while statistical competence is only needed by data producers, students in STEM and other heavily quantitative majors.

In addition to his work advancing statistical education, Schield also highlighted the commonalities in information literacy, data literacy, and statistical literacy, asserting that the evaluation of information" is central to all three literacies. Also, Schield notes that a key element of both statistical and data literacy is how to present data and statistics. What the authors found most valuable is in Schield's discussion about the interrelatedness and organization of the three literacies, which may vary based on disciplinary perspectives. He states, "Data literacy is needed to access, manipulate, and summarize the data. But statistical literacy is needed to guide in that process while information literacy sets the overall context for evaluating the sources of data and the appropriate manipulations."

Statistical education has long been a component of engineering programs, with a focus on applying statistical techniques to engineering problems [13]. However, as stated by Peck, "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" [14].

Data Literacy
Giese et al. proposed a data literacy framework for the purposes of engineering education that focused on statistical and programming competence as central components, as well as a third pillar to address ethical issues in terms of "transparency and awareness"[15]. However, the scope of this framework does not align with this course redesign because (1) this course does not have a programming component, and (2) the "transparence and awareness" component of this framework doesn't address the competencies needed to productively work with, contextualize, or communicate with data to multiple audiences. As a result, the authors looked beyond the engineering education literature to other fields.

Academic libraries have long offered information literacy services for academic disciplines across the curriculum. While the information literacy standards cited in Schield's 2004 paper have since evolved [16], the challenges of people being faced with "a flood of information in the form of statistics" and related visualizations have held true and are arguably more urgent today with the advent of social media algorithms together with the increasing complexity of data analysis and visualization tools as well as the explosion of AI-based technologies. Library faculty primarily teach information seeking and other research skills as guest lecturers for credit-bearing courses; they also develop a variety of instructional material available through library web sites. The explosion of data availability, including U.S. requirements around publishing federally funded research datasets in open repositories [17], has necessitated expansion of data-focused collections and services, including library instruction. Carlson et al. developed a "data information literacy" framework designed for graduate students and researchers in the sciences; the need for data-focused undergraduate instruction was acknowledged but was outside the scope of that research effort [18].

In the broader context of library instruction serving all types of audiences, Prado & Marzal defined data literacy as part of a continuum with information literacy and covering a suite of competencies focused on understanding, finding, interpreting, managing, and using data [19]. To customize and adapt these data-focused competencies for the undergraduate curriculum, co-author [NAME] and colleagues built on the work of both Carlson and Prado & Marzal to develop a framework [3] and refine the scaffolding to better reflect the disciplinary nuances across the curriculum [4]. [NAME] et al. found that faculty ask students at all levels and in all disciplines to (1) recognize how data is integrated into everyday life, (2) interpret and critically evaluate data and their sources, and (3) analyze data, and (4) communicate data effectively to different audiences, in part using visualizations.

In STEM fields specifically, introductory courses may focus on data competencies including: (1) Read/understand data types and formats, (2) clean/process/convert data, and (3) find, access, use datasets to answer a question; however, STEM faculty tend to wait until students are in the third or fourth years before they focus on (1) ethically collecting/citing data, and (2) synthesizing data into different contexts with other sources and prior knowledge. [NAME] tested this interdisciplinary framework in a mixed methods study investigating data practices used by a cohort of undergraduate researchers and found evidence that students working in a range of social science and STEM disciplines practiced almost all of the data competencies set out in the framework they developed [6], which shows the applicability of this framework across disciplines.

Data Visualization

While data visualization is an essential component of data literacy, data literacy frameworks lack detail on the pedagogical aspects of the individual competencies such as communicating with data. In her information literacy instruction, co-author [NAME] typically relies on Duquia et al. [20] when introducing students to the STEM literature, asking them to critically evaluate scientific figures and tables in terms of best practices in presenting data. Duquia et al. provide a short guide on presenting epidemiological data, along with a useful list of basic rules that are broadly applicable across disciplines. However, this course revision sought to go several steps further, requiring students to apply their statistical competency in creating original data visualizations of summary statistics using Duquia et al.'s best practices. Standard texts for publishing in the academic literature such as *The Craft of Research* [21] and Gastel and Day's *How to Write and Publish a Scientific Paper* [22] offer sound instruction on communicating visual evidence and designing effective tables and graphs, but are both meant for researchers who have completed their data collection and analysis and need advice on clarifying and polishing their visualizations for a research audience.

Advanced theory and multiple types of instructional material are readily available to guide data storytelling, i.e., the creation of sophisticated and aesthetically beautiful visualizations of large, complex datasets using powerful open source (e.g., R) or commercial analytical tools (e.g., Tableau, etc.) [23][24][25]. However, most of this material does not discuss why this is important in terms of professional communication. In addition, many of these resources assume prior expertise with data and statistical fundamentals that undergraduate students often lack and that undergraduate general education courses cannot assume. Stephen Few's classic text provides in-depth guidance suitable for novices on effective communication of quantitative information using tables and graphs, with an emphasis on the concept that "quantitative stories are always about relationships" [26]. Visualizations and the data and statistics they rely on do not stand alone; they are dependent upon context. Instead, visualizations serve to synthesize and effectively communicate large quantities of data; textual communication is also required to bridge the story from one visualization to the next.

Faculty-Librarian Collaboration
The library literature is rich with case studies of instructional collaborations in undergraduate and graduate STEM courses involving library faculty (e.g., [27]). Library faculty have also documented the varied ways in which they support curriculum development, including the development of information and data literacy instructional material meant to plug in to courses via 60-90 minute in person workshops [5], 30-60 minute asynchronous workshops [28], or a hybrid approach as in the flipped library instruction collaborations reported by Maddison and colleagues [29], [30].

Case Study: Data Literacy Module Implementation
The revised module starts with an asynchronous online start up tutorial that provides foundational material for the semester. Following this is a series of three paired assignments where students develop a data visualization (table/graph/diagram) followed by a prose argument that incorporates in the visualization. Each of these assignments is preceded by a workshop where students learn about and practice what they will be expected to do. Appendix A details the assignments, their assessment, and how the workshops are used to assist students.

Two teaching assistants (TA) handled the grading of assignments in the two larger sections, with the teaching faculty member grading a third section. The faculty member developed a grading rubric and provided a short list of potential feedback statements for the TA's. For each assignment the faculty member met with the TA's individually to walk through the grading, working with them on several student assignments as examples. After the semester, one TA collected feedback provided to students for each assignment, to modify the standard feedback for the next semester.

During the semester the two faculty members met periodically to discuss how the course module was progressing. As the librarian involved with the project has taught shorter format data literacy workshops her insights into challenges were invaluable. Finally, a post-semester survey was developed with the primary goal of hearing how students responded to the workshop, assignments, and access to the faculty member to provide support.

The primary review and data collection for the Fall 2024 module implementation has focused on formative evaluation of student performance and direct feedback to identify successful and weak elements of the assignments for revision in the Spring of 2025. These data include:

1. Teaching faculty observations in workshops and open help sessions. These observations were discussed among authors, to develop assignment and workshop revisions for the following semester.
2. Individual student and general section-wide assignment feedback comments provided on assignments. These were assembled and reviewed to determine assignment and workshop revisions for the next semester.
3. Post semester survey – Students completed a survey with a combination of multiple answer questions (where students could select all that apply) and text responses (see appendix B). While the text responses were reviewed for themes, to develop a more detailed evaluation of assignments for future semesters, this work focuses on the multiple answer questions. Of the 390 students completing the course, 288 responded to the survey.

Instructor observations included:

- Student engagement in workshop exercises. These exercises worked well enough, that more of the workshop content has been moved to hands on work, that is then reviewed in the workshops.
- Student understanding of the problems as reflected in their written documents (This data was partly compiled by the third author, who was a teaching assistant for the course.) For this we collected the feedback provided on assignments, and modified the workshops and assignment content to respond to the issues students were having.
    - The most important issue identified was students' inability to interpret the statistics and data within the context of the problems on which they were working. For this we added small group exercises with the data during class.
    - Students' inability to communicate to a 'public audience' seemed to be connected to a discomfort with the meaning of the statistics, so this became part of the in-workshop exercises added.
- Students are not yet engaging in orienting data visualizations to the message required by the assignments. Few students have a working knowledge of the basic tools within the Microsoft software used in class, so open help sessions were used to help students learn the processes of modifying the visualizations they create to make focus on a readable message.

Discussion and Future Work

Engineering Communication and Library Faculty Collaboration

Through the spring and summer, the teaching and library faculty members met to address the challenges the engineering communication faculty identified and to enhance the identified communication, critical thinking, and problem-solving skills students developed in the course. Our collaboration expanded the literature base we were working from and provided for real time critical discussion of our ideas as they were developed. Specific advantages that emerged for the teaching faculty from the librarian's knowledge and experience included:

Expanded foundational literatures – With different academic focus the faculty brought together different literature on the same topics that expanded our thinking. An example is the library faculty highlighting Stephen Few's work on creating data visualizations [26], which has served as an important resource for introducing students to basic data visualization, in contrast to the more advanced professionally oriented data storytelling literature by Nussbaumer Knaflic [23], Duarte [24], and Kazakoff [25].

Developing Semester Topics for Problems – Identifying a topic, specific problems, data sets and enough technical support to prepare students to work with the topic with specific problems takes specific knowledge and expertise. Partnering with library faculty with that expertise enabled the teaching faculty to move the development of the assignments forward much more rapidly than would otherwise have been possible. Ongoing collaboration will make it possible to develop future problems more rapidly.

Refining goals and assessments – Focusing student work on the key module goals, given the limited interaction time, and student's other academic demands puts forward a teaching challenge not faced to the same extent by other instructional faculty but that library faculty deal with regularly. Discussions during assignment development allowed the faculty to refine assignment scopes to assure students focus on what they need to take away from this module.

Building on Existing Tools – The library has been central to developing badged digital modules on a wide range of information and data literacy topics that align with the university's Enhanced General Education requirements [28]. The co-authors modified an existing module to use as a start-up resource to get students familiar with data literacy and the topic of the semester's problems. By doing this the teaching instructor was able to focus student attention on information that is central to this course. As the digital framework and some of the content was already published and in use, this asynchronous workshop was completed more quickly than starting from scratch.

Improving in-class learning – Ongoing faculty-librarian discussions of modeling exercises for students challenges the teaching faculty to develop more brief exercises for students to experience the various choices they will have in assignments.

Continual Innovative Data Literacy Teaching - The final important element of the collaboration is bringing together different literature faculty use from their different scholarly perspectives on the same topic.

From the librarian's perspective, the collaboration was equally valuable. While this co-author had previously been interested in data literacy from a research perspective, this invitation to collaborate brought a new opportunity to learn about the disciplinary perspectives of engineering educators with regard to data literacy. In addition to the benefits listed above, additional tangible benefits from this collaboration included:

Increased Use and Impact of the Library's Instructional Content – Library faculty had just recently overhauled the entire portfolio of self-guided information and data literacy asynchronous tutorials that are hosted on the same Canvas Learning Management System that credit-bearing courses use[28]. These introductory tutorials are meant to be deployed across the curriculum, to support the integration of information and data literacy instruction on a broader scale than would be feasible for library faculty to handle in person. The ability to make minor customizations and serve a course with enrollment of more than 1,000 students per year is an extremely high-impact, efficient use of university library resources.

Improvement of the Library's Instructional Content – Library-faculty instructional collaborations provide opportunities for engaged faculty to provide in-depth information regarding their instructional needs as well as feedback about the efficacy of library instructional materials. Once improvements are made to library instructional materials, they are then more useful to faculty and students in other disciplines as well. Library-developed instructional materials are carefully curated as a university-wide resource, and data literacy tutorials that are useful for engineering students are likely to also be useful to students in other STEM disciplines.

Increased Disciplinary Understanding for Outreach – Academic librarian liaison areas tend to shift according to library personnel needs as well as the continued growth and evolution of the curriculum. While this co-author has extensive experience working with many STEM faculty, the university's consolidation and changing needs has resulted in this co-author adding Mathematics & Statistics to her portfolio, and this particular collaboration will provide her essential context in future outreach to new faculty as well as her work supporting the teaching and research of students.

Progress Toward Revision Goals

Our collaboration on the revisions focused on the following three areas for skills improvement.

Integrating Multiple Modes of Communication – We reconsidered the role of data visualizations in the professional future of our students. Not only would students need to be able to critically analyze and write or speak about data visualizations, but they also need to be able to choose how to present data to create a message for a specific audience. In learning how to effectively communicate data visually, they would also learn about how to look at and analyze data visualizations. Additionally, with the advent of so many visualization tools, this element of communicating is increasingly incorporated into professional correspondence.

Critical Thinking about Data – In order to make an argument with data, students must be clear on what the available statistics represent in the problem they are addressing, and then what the data indicates about that problem [14]. By having one topic to address the entire semester, and making that problem more tangible, students can learn about the topic early in the semester and focus on making arguments with statistics after that.

Problem Solving – As this course is taught across the College to students from first- to fifth year, their specific depth of engineering knowledge varies considerably. Even generic business problems were beyond the experience of most students and the topics held no relevance to them. Our solution was to build all the problems around a single, relevant topic that has potential for application across multiple engineering fields, from which several problems could be developed. This builds on the concepts developed in the engineering education literature [13]. That topic needed to be something that students could engage with and become familiar with over the course of the semester.

Outcomes and Next Steps

Teaching and evaluation in the course module were organized around the three learning objective foci of data literacy: communication, critical thinking, and problem solving. Observations indicate some successes as well as opportunities for continued improvement.

Assignment Outcomes: Communication

The revisions involved students creating effective data visualizations. During the semester students use Microsoft Office tools to develop a table, a graph, a diagram, and an appendix documenting their statistical process. Students approached the teaching instructor with a request to use generative AI to create the diagrams. This unanticipated resource use required students to understand both the statistics and the purpose of the diagram to prompt the tool to develop a diagram that accurately presented the problem and was allowed for any student who opted to complete it that way. The data visualization workshops engaged students in creating the visualizations, and a discussion of the visual elements and conventions that make them readable and effective for various audiences and contexts.

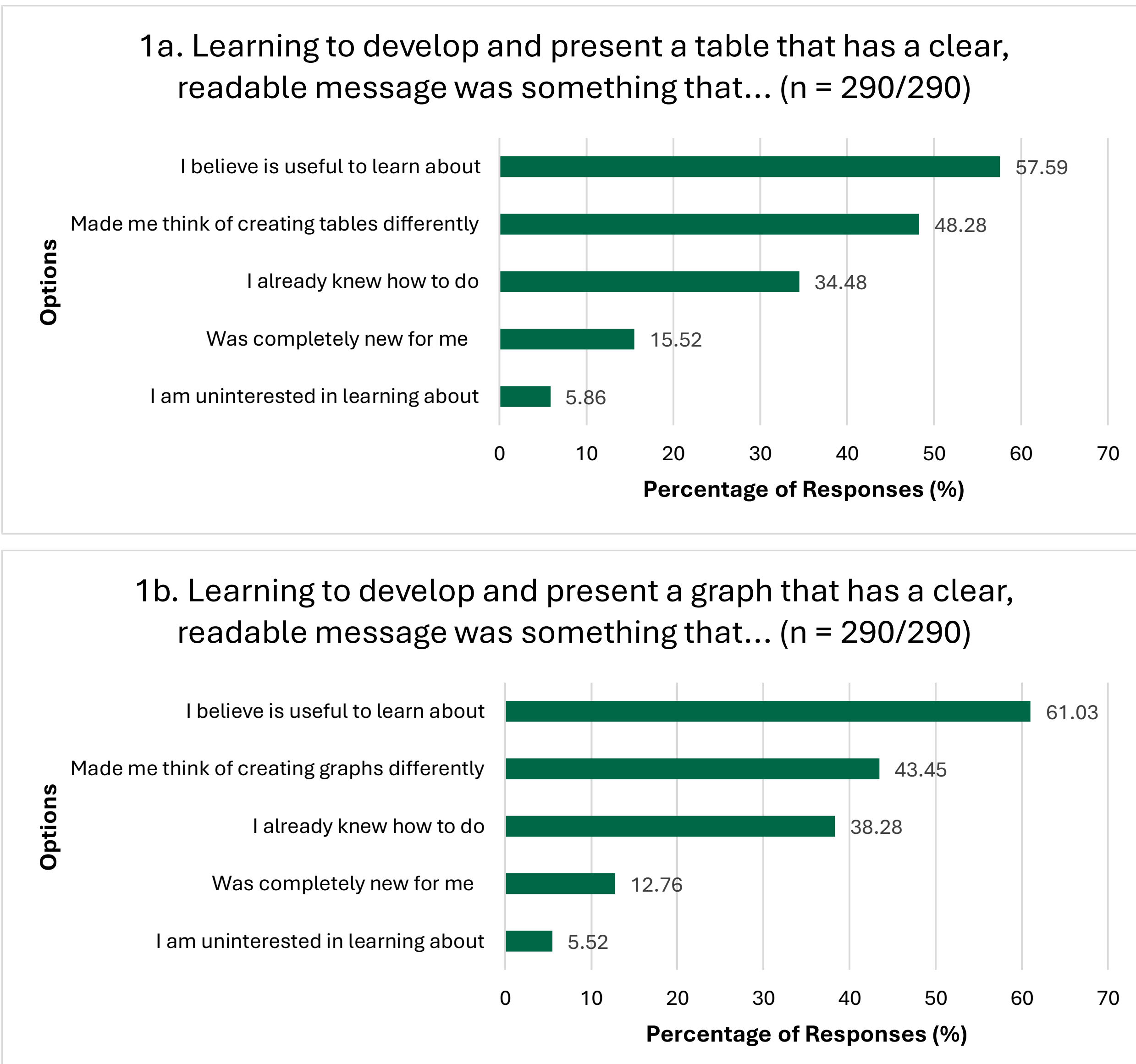

Figure 1a, b. Responses to regarding the relevance of creating data visualizations such as a table (Figure 1a) and a graph (Figure 1b).

While a substantial minority of the students indicated they knew how to create visualizations (see Figure 1a and 1b), many indicated that the course approach of creating a message made them think differently about creating visualizations. However, assignment grading revealed that many students did not go beyond creating the visualization to clearly project a message with the visualization. Many students did not make changes to the Microsoft generated visuals to forefront the data or to make the key data prominent. Therefore, for future semesters, the teaching faculty will use the workshops to engage students in evaluating data visualizations for the message they convey and what they do to convey it. The technical elements of creating the visualizations will be addressed with written or video resources. This approach will focus workshop time on the element of the course that most students do not know and are less likely to think about on their own.

For the argument assignments we focused on types of argument and evidence, integrating visualizations into a text document, and tone for the assigned audience. While one-quarter of the students indicated they knew how to do this before the course, slightly over half of them felt it was useful to learn about.

Future Revisions: Communication

After the semester the faculty discussed the percent of students for whom the focus on learning technology tools was redundant and we decided next semesters workshops should involve students working with data visualizations to evaluate which were easier to read and what message was being conveyed. Students would be provided written or video resources to learn to use the technology or have the option to get help in sessions outside of class time.

For the argument section, providing examples of what makes a good and complete argument will be added to the assignment. For next semester, the workshops need to be spent with students reviewing small documents that integrate prose and visualizations, so they see how they work together.

Assignment Outcomes: Critical Thinking

For this aspect of the visualization assignments, we were looking for students to be able to express why they approached completing elements of the assignment as they did. For the first two visualization assignments students needed to clearly describe how they used the elements of 1) tables and 2) graphs to create a clear visualization. The structure of how this was presented made it too easy for students to complete a write up that looked good but was not actually about what they did.

For the final data assignment students complete a diagram of the problem to indicate what type of hypothesis test they are completing and the critical numbers involved. They also created an appendix that professionally documented their mathematical process, so it could be replicated to be verified as correct. The students that completed the diagram well largely used generative AI to complete it.

To complete the argument assignments successfully students needed to be able to accurately describe what the statistics they were working with represented and its implications for the problem in a clear argument. While this was present in earlier semester assignments, the written element of the assignments is now more focused on the argument. After reviewing students' assignments this semester, it is clear that workshop time needs to be invested getting students to think about what their statistical parameters mean in the context of the problems assigned.

Future Revisions: Critical Thinking

The revision to this part of the course will primarily be in the use of the workshop time. Many students are not thinking through what the statistics mean, and what they suggest about the problem. If they can make that connection the arguments will be stronger. Therefore, workshop time needs to be spent thinking through what the statistical parameters they have or can create mean in various problem contexts.

Assignment Outcomes: Problem Solving

Problem solving is focused on students' abilities to read and accurately interpret what the assignment is asking for. Students must learn to closely read the problem, seek faculty clarification when needed, and use precise language to describe the problem. All new data literacy assignments are developed around an easy to grasp engineering issue. This approach enables students to develop a technical understanding of the issue early in the semester, allowing them to focus on the statistics in the problem as the semester progresses.

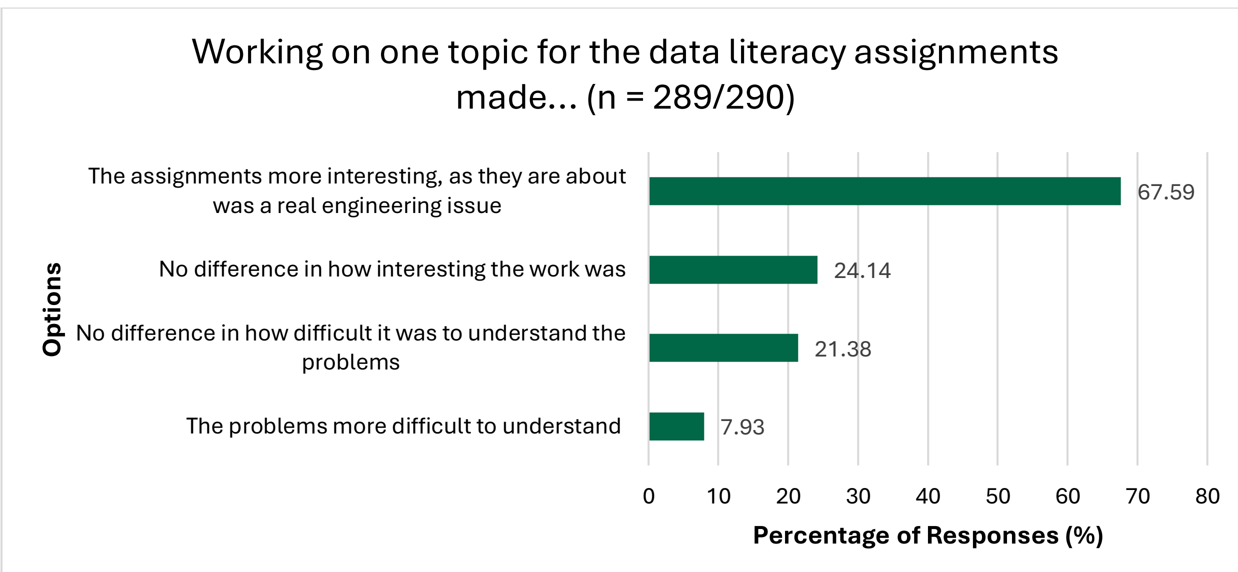

Figure 2. Responses to survey question asking students their perceptions regarding working with one topic for all the data literacy assignments (Total survey respondents, n=288; total # of students completing the semester across all sections = 397). Surveys were available after the final data literacy assignment grade was released, open for several days for each section.

For this semester's topic the instructor wrote problems that had to do with lead levels in the soil, in response to the recently updated EPA standard. The students were provided with a research article that discussed the analysis of urban soil lead levels in Florida, several webpages that discussed the reasoning behind and change to the EPA standard, and for the problem the teaching faculty discussed the EPA method for testing for contamination in the soil as it related to the problem they would complete. The topic was reviewed by the teaching faculty in the workshops where additional input was provided for the specifics of each problem. The self-guided start-up workshop customized for the course included an introduction to navigating the scientific literature. Part of our thinking was to provide input on how to read academic research as part of the start-up module students complete for background on this element of the course, thus preparing them to see examples of the data visualizations they would be creating in an applied context.

Providing reading for students turned out to be problematic. Many students did not develop an understanding of the problem from the literature provided. Even worse, a small percentage of students misread the literature, and ended up not addressing the assigned problem in the work they completed. However, Figure 2 shows that 65% of responding students found the work more interesting with the engineering topic at the center of all problems during the semester. Yet, 8% found the problems difficult to understand, an issue that needs to be addressed with better topic introduction.

Future Revisions: Problem Solving

To get more students to read the problem closely, we will add a downloadable copy of the problem statement and a separate document with the assignment instructions. While we already speak briefly about the importance of reading the assignment early and of asking the instructor clarifying questions, developing a hand out or audio file to provide to students who have this difficulty on early assignments could help prompt them to modify how they work.

Next Steps

Our evaluation of the revised data literacy module during the pilot semester has been observation from the teaching side of the course. We will be developing a pre- and post- course assessment to evaluate if students have made improvements in creating integrated messages using data visualizations and prose that address assigned problems to specific audiences.

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Appendix A: Assignment Evaluation

	Communication	**Critical Thinking**	**Problem Solving**
Workshop 1	Understanding statistics in the problem context and table layout / Grading on presence & submittal of in-class work		
Assignment 1.1: Data Visualization – *Using provided statistics to create a table addressing a problem*	*Message must be clear from the organization of the table for the assigned audience *Table must read **professionally** (use fonts & table well) (must use MS Word)	*Email message must demonstrate that you have considered what the data shows and how to use the table to focus on what is most important on the message and identify any secondary statistical points	* Table and text must address the assigned problem.
Workshop 2	Work on presenting the meaning of the statistics in context and what they indicate about the problem / Grading on presence & submittal of in-class work		
Assignment 1.2: Argument -*Writing an argument to accompany the table*	*The argument and visualization have been integrated to create a strong message *Text is professional in tone and addressed to a public audience	*Student demonstrates an understanding of the statistics presented, and their connection to the problem by making a clear and strong argument with a demonstration of what the statistics represent and what they indicate for the problem	* The argument, the data, and the problem align * Context section presents the problem accurately
Workshop 3	Creating a graph from data and making it effectively convey a message / Grading on presence & submittal of in-class work		
Assignment 2.1: Data Visualization – *Using provided data to create a graph addressing a problem*	Message must be clear in the graph organization for the assigned audience Graph must read **professionally** (use fonts & graph well) (must use MS Excel)	Email message must demonstrate that you have considered what the data shows and how to use the graph to focus on what is most important on the message and identified any secondary statistical points	* Graph and text must address the assigned problem.
Workshop 4	/ Grading on presence & submittal of in-class work		
Assignment 2.2: Argument *Writing an argument to accompany the graph*	*The argument and visualization have been integrated to create a strong message *Text is professional in tone and addressed to a professional non-engineering audience	Student demonstrates an understanding of the statistics presented, and their connection to the problem by making a clear and strong argument with a demonstration of what the statistics represent and what they indicate for the problem	*The argument, the data, and the problem align *Context presents the problem accurately

(Continued next page)

	Communication	**Critical Thinking**	**Problem Solving**
Workshop 5	What does a diagram do & presenting you math professionally for replicability / Grading on presence & submittal of in-class work		
Assignment 3.1 Data Visualization – *Creating a diagram to represent the hypothesis test and an appendix to document the statistical calculation*	Elements address two audiences appropriately– *Appendix – for statistical professional * Diagram – part of explanation Extra Credit - scatter plot and discussion of additional argument	Complete a well laid out documentation of your mathematical process so another person familiar with statistics can replicate it.	The math & visualizations correctly present the statistical outcome
Workshop 6	Understanding and presenting what your statistical calculations accomplish (not the steps of how) / Grading on presence & submittal of in-class work		
Assignment 3.2 Argument *Present what your statistics accomplishes to a non-statistics-literate public audience*	Text addresses the assigned public audience	Demonstrate an understanding of the statistics presented, and their connection to the problem by making a clear and strong argument with a demonstration of what the statistics represent and what they indicate for the problem	Context presents the problem accurately

Appendix B: Survey Questions

*Completing the Quiz is **worth 5 extra credit points** on your IDL assignments.*

1. Working with one topic for all the data literacy assignments
   - ☐ Makes the assignments more interesting, as they are about a real engineering issue
   - ☐ Made no difference in how interesting the work was
   - ☐ Made it more difficult to understand the problems
   - ☐ Made no difference in how difficult it was to understand the problems

2. Learning to develop and present a table that has a clear, readable message was
   - ☐ Completely new for me
   - ☐ Something that made me think of creating tables differently
   - ☐ Something I already knew how to do
   - ☐ Something I believe is useful to learn about
   - ☐ Something I am uninterested in learning about

3. Learning to develop and present a graph that has a clear, readable message was
   - ☐ Completely new for me
   - ☐ Something that made me think of creating graphs differently
   - ☐ Something I already knew how to do
   - ☐ Something I believe is useful to learn about
   - ☐ Something I am uninterested in learning about

4. Learning about developing and presenting my math in a professional document was
   - ☐ Completely new for me
   - ☐ Something that made me think about my math differently
   - ☐ Something I already knew how to do
   - ☐ Something I believe is useful to learn about
   - ☐ Something I am uninterested in learning about

5. Learning to create an argument for a specific audience that integrates a visualization was
   - ☐ Completely new for me
   - ☐ Something I already knew how to do
   - ☐ Something I believe is useful to learn about
   - ☐ Something I am uninterested in learning about

6. The review of Polya’s process for evaluating a problem was
   - ☐ Slightly useful
   - ☐ Moderately useful
   - ☐ Very useful
   - ☐ Extremely useful
   - ☐ Not useful

7. Please provide comments you have on any aspect of the IDL assignment, both what you found useful or what you would like to see changed with the assignments to make this part of the course more helpful. How and why?

8. The IDL Workshops were
   - ☐ Not at all useful
   - ☐ Slightly useful
   - ☐ Moderately useful
   - ☐ Very useful
   - ☐ Extremely useful
   - ☐ I did not attend or listen to them

9. Individual Office Hours were
   - ☐ Accessible, but I did not use them
   - ☐ Accessible, but scheduled at a time I could not attend
   - ☐ Accessible and something I used as needed
   - ☐ Something I could not figure out how to access
   - ☐ Something I would not use
   - ☐ Something I did not need

10. Open Help Sessions
    - ☐ Something I did not need or use
    - ☐ Something I did not use because the time did not work for me
    - ☐ Something I used but were not valuable
    - ☐ Something I used and found valuable
    - ☐ Something you should have more of at different times

11. Please provide any comments you have on the workshops, office hours, and open help sessions, both things that worked well for you and changes that you feel would improve students use of and benefit from these resources.

12. Now that you have completed all the questions, please provide feedback on aspects of the assignments, workshops, resources, office hours access, open help sessions, and Canvas use that you do not feel have been addressed in the questions above.