8.1 “The Data Suggest...” - *Writing in the Sciences*

The following text is mainly taken from chapter 16 (written by Christopher Gillen) in *They Say, I Say*.

[S]cientific writing is fundamentally argumentative. Like all academic writers, scientists make and defend claims. They address disagreements and explore unanswered questions. And they advance certain explanations and reject others.

Despite the importance of argument in scientific writing, newcomers to the genre often see it solely as a means for communicating uncontroversial, objective facts. And because science writers base their arguments on empirical data, a good portion of many scientific texts *does* serve the purpose of delivering uncontested facts.

However, scientific writing often does more than just report facts. Given important new data, scientists access their quality, draw conclusions from them, and ponder their implications. They synthesize the new data with existing information, propose novel theories, and design the next experiments. The thrill of doing science, and writing about it, comes from the ongoing struggle to use data to better understand our world.

**Start with the Data:** Data are the fundamental currency of scientific argument. Summarizing data is therefore a basic move in science writing. Rather than jumping straight to the punchline ... it is important to first describe the hypotheses, methods, and results that led to the conclusion.

**Sample Template:** *To test the hypothesis that ____, we measured ____ and found that ____.* Therefore, *we conclude ____.*

**Present Prevailing Theories:** Readers must understand the prevailing theories that a study responds to before they can fully appreciate the details.

**Explain the Methods:** It’s crucial to explain the methods used to collect data. In order for readers to evaluate a method, you’ll need to indicate its purpose.
Summarize the Findings: Your task when presenting numerical data is to provide the context readers need to understand the numbers - by giving supporting information and making comparisons. Supporting information - such as units of measurement, sample size (N), and amount of variability - helps readers assess the data.

**Sample Template:** We measured ____; and the average response was ____ (mean with units) with a range of ____ (lower value) to ____ (upper value).

You will sometimes need to present qualitative data, such as that found in some images and photographs, that cannot be reduced to numbers. Qualitative data must be described precisely with words.

**Explaining What the Data Mean:** Once you summarize experiments and results, you need to say what the data mean.

**Sample Template:** The data suggest/hint/imply _____. [To signify a moderate level of confidence.]

**Sample Template:** Our results show/demonstrate _____. [To express a greater degree of certainty.]

Almost never will you use the verb “prove” in reference to a single study, because even very powerful evidence generally falls short of proof unless other studies support the same conclusion.

**Sample Template:** The difference between ____ and ____ is probably due to _____.

**Sample Template:** In summary, our studies show that _____. but the issue of ____ remains unresolved.

Before an explanation is accepted, scientists demand convincing evidence and assess whether alternative explanations have been thoroughly explored, so it’s essential that scientists consider possible objections to their ideas before presenting them.

**Sample Template:** Some may argue that this experimental design fails to account for _____.

**Say Why It Matters:** It is essential when you enter a scientific conversation to say why the work - and your arguments about it - matter. When thinking about the broad significance of a study, consider both the practical applications and the impact on future scientific work.

**Sample Template:** These results open the door to studies that _____.

**Sample Template:** Our findings are the first step toward _____.

**Sample Template:** Further work in this area may lead to the development of _____.
When considering the arguments you are presenting, consider the following questions:

1. How well do the results support the stated conclusion?
2. Has the data’s variability been adequately explained?
3. Do other findings verify (or contradict) the conclusion?
4. What other experiments could test the conclusion?
5. Can the results be generalized beyond the system that was studied?
6. What are the work’s practical implications?
7. What questions arise from the work?
8. Which experiments should be done next?

8.2 Questions to Address Before Beginning to Write

Once the work is done, but before the writing can begin, you need to organize your thoughts in such a way that the next several sections will be helpful. The details you should be thinking about as you investigate your problem are as follows:

8.2.1 Who is your Audience?

Somebody cares about what your are planning to write. Who is that person (or people)? *IT IS NOT ME!* What are they interested in learning? The audience really determines the purpose of the paper.

8.2.2 What Should be Presented?

You have done a lot of data analysis. What plots have you created? What technical information have you created/calculated/discovered? Of all of this information, what would be of most interest to your audience? Which plots/calculations/data most clearly address the questions the audience is concerned with?

8.2.3 What are the Questions?

Okay, the previous topics have implied that this report will answer questions the audience is concerned with. Now, explicitly identify those questions! For this course, the lab assignments can help on this topic.

8.2.4 What are the Answers to those Questions?

Taking the information identified in your data analysis, what are the answers to the questions in the previous topic? Which plots/calculations answer which questions? What are the answers?
8.2.5 Where to go from here?

You have done your best to address the concerns and questions of interest to your audience! However, there is never enough time and/or money to do this completely. After attempting to answer the questions with the data available, what suggestions would you make for doing a more thorough job in the future? Compile a list of things you wish you had done (either differently or in addition).

8.3 The Formal Scientific Research Report

This next section discusses the general format of the reports you will need to write in EN455. The ideas are taken from Engaging Ideas written by John C. Bean.

8.3.1 The Introduction

The Introduction is where you briefly explain the purpose of your report/investigation. What problem did you address? Why did you choose to address it? You will need to provide enough background to enable the reader to understand the problem being investigated. Sometimes the introduction also includes a “literature review” summarizing previous research addressing the same or a related problem. In many scientific disciplines it is also conventional to present a hypothesis – a tentative “answer” to the question that your investigation will confirm or disconfirm.

Anatomy of an Introduction

Begin by explaining the problem your paper will address. You want to hook the reader’s interest. Explain why the problem is problematic and what is at stake in solving it. What benefits come from solving this problem? The opening section of the introduction often sets up counterviews that the writer intends to oppose or a gap in knowledge or understanding that the writer intends to fill.

Present the paper’s purpose or thesis. After explaining the problem, state your thesis or goal. “The purpose of this paper is to show...”

Provide an overview or blueprint of your paper. Provide either a brief summary or argument by forecasting the structure. “First, this paper will present...; the second part of the paper explores...; finally, it is shown....”

8.3.2 The Method

This is the section detailing how you did your investigation. It provides enough details so that other researchers could replicate your investigation. Usually this section includes the following subsections: (a) research design, (b) apparatus and materials, and (c) procedures followed.
8.3.3 The Results

This section, sometimes headed “Findings,” presents the empirical results of your investigation. Often your findings are displayed in figures, tables, graphs, or charts that are referenced in the text. Even though the data are displayed in the visuals, the text itself should also describe the most significant data. (Imagine that the figures are displayed on a view graph and that you are explaining them orally. Your written text should transcribe what you would say orally.) I call this the Principle of Independent Redundancy (i.e., the text says in words the same story as told by the graphic). Your figures and tables must have sufficient information to stand alone, including accurate titles and clear labels for all meaning-carrying features.

8.3.4 The Discussion of Results

This is the main part of the report, the part that will be read with the most care by others. Here you explain the significance of your findings by relating what you have discovered with respect to the problem you set out to investigate in your introduction.

- Did your investigation accomplish your purpose?
- Did it answer your questions?
- Did it confirm or disconfirm your hypothesis?
- Are your results useful? Why or why not?
- Did you discover information that you hadn’t anticipated?
- Was your research design appropriate?
- Did your investigation raise new questions?
- Are there implications from your results that need to be explored?

The key to success in this section is to link your findings to the questions and problems raised in the introduction.

8.3.5 The Conclusions and Recommendations

In this last section, you focus on the main things you learned from the investigation and, in some cases, on the practical applications of your investigation. If your investigation was a pure research project, this section can be a summary of your most important findings along with recommendations for further research. If your investigation was aimed at making a practical decision (for example, an engineering design decision), here you recommend appropriate actions. What you say in this section depends on the context of your investigation and the expectation of your readers.
8.4 Guidelines for EN455 Research Report Sections

To be even more explicit in what you are expected to create in your lab reports for this class, I have taken the generalities given in the previous section and created specific bullet points for what needs to be included for each section of your report.

Abstract
Optional, but recommended. Provides a one-paragraph summary of the whole paper (problem, methods, major findings, significance of study).

Introduction
- Explains problem to be investigated
- Shows importance of problem
- Reviews previous understandings of the problems and points to reasons meritng further investigation
- Poses the determinate research question(s) to be investigated
- Presents the researcher’s hypothesis/purpose
- Gives an overview or blueprint of the paper

Method
- Describes how the study was done (enabling future researchers to replicate the study exactly)
- Includes appropriate information in tabular format (referenced in the text)
- Often provides the operative definitions for key concepts in the problem/hypothesis (or more detailed research design information)

Results
- Presents the researcher’s findings or results
- Displays findings in figures, charts, or graphs as well as describing them in words
- Usually does not present raw data or behind-the-scenes mathematics, data focuses on composite results
- Presents any statistical analysis of data to show confidence levels and other advanced statistical implications or meanings
Discussion of Results

- Presents researcher’s analysis of the results
- Interprets and evaluates the collected data in terms of the original research question and hypothesis
- Speculates on causes and consequences of the findings
- Shows applications and practical or theoretical significance of the study

Conclusions and Recommendations

- Summarizes motivation and findings of the study
- Usually includes a section pointing out limitations and possible flaws in the study and suggests directions for future research

8.5 EN455 Lab Report Grading Rubric

When grading reports, I use the following questions to determine the quality of the work.

1. Does the introduction effectively present the issue and the hypothesis/purpose, while evoking the reader’s interest? Is an overview or blueprint of the paper included?

2. Are the ideas sufficiently presented? Are there good reasons in support of the author’s argument?

3. Is the information in the paper clearly stated and congruent with the data presented?

4. Are opposing or alternative views adequately and fairly summarized? Are the responses to these opposing views effective?

5. Is the motivation for presenting new information clear and does the information provided address the motivation?

6. Is the procedure explained clearly enough for replication without being a step-by-step instruction manual?

7. Is the data correctly analyzed?

8. Are the graphics appealing and easy to read? Do the graphics have effective labels and/or legends?

9. Are the graphics (all of them) referenced in the text?

10. Is there appropriate and sufficient evidence?

11. Is the argument well-developed with appropriate details?

12. Does it follow the principle of independent redundancy (tells in words the same story told by the graphic)?
13. Is the paper well organized into a unified whole?

14. Does the organization include all the required sections (title, introduction, methodology, results, discussion of results, conclusion and recommendations)?

15. Is the language style effective? Is the language well chosen for the intended audience? Is the tone appropriate?

16. Are the sentences well constructed? Are there good transitions? Do paragraphs have topic sentences? Is the paper carefully edited?

### 8.6 EN455 Pair Interview Questions

As part of the writing process, you will be interviewing each other to help improve the quality of the final report. As you interview the writer, get him or her to do most of the talking; however, you can respond to the writer by offering suggestions, bringing up additional ideas, playing devil’s advocate, and so forth. The interviewer will ask the author the following questions:

1. What problem or question is this report going to address?
2. What are the approaches taken to look into this question?
3. What is your one-sentence answer to this question?
4. Talk me through your whole argument or at least your ideas so far.

### 8.7 Reflection Papers

There are a few papers in this course that are labeled “Reflection Papers.” These are not minor lab reports, but something specifically different. A Reflection Paper is written in first person and uses an informal style of writing. I want you to explain what you think, even if you are unsure (tell me that, if it is the case). This type of assignment is an opportunity to organize and clarify the information you have been exposed to. One full page is definitely sufficient. Feel free to include thoughts, comments, and questions beyond those listed in the assignment. This type of assignment is your opportunity to show me what you understand and let me know what you don’t understand. Your grade will be focused on the completeness of your thought-process, not on specific answers. The more evidence you present that you have thought things through thoroughly, the better your grade.

### 8.8 Writing Team Lab Reports

Some of the lab reports will be submitted for a group of students, so that report must be written as a team. The common practice of divide and conquer so that each person writes a portion and some noble soul goes to the trouble of cutting and pasting it all together will
not result in a high quality product. Instead, I would like for you to approach these reports as practice for working in teams like you will for your capstone project. A team means every member contributes and is responsible for the final result.

Start by identifying the major tasks that the project or report will require. Agree on who within the team will take responsibility for each task. It is good to have an agreed upon estimate for how much effort each task will require. You should schedule the tasks in layers so as to provide multiple opportunities to comment or revise one another’s work. And do your best to create a balanced workload throughout the team.

Each of these steps is described in more detail below.

- **Identify Major Tasks – scientific research report**
  
  1. Identify report topic
  2. Define audience (who cares about what you are writing)
  3. Collect data
  4. Organize data into a narrative (what does the data collected tell you that you plan to share with your audience?)
     - This section should be broken into multiple sections to account for each part of the data analysis
     - For example, for the Roll Motion Lab:
       (a) Maxsurf roll damping simulation data analysis (What information did you gain from the software? Do you want to use anything for your topic? Do you need to complete more analysis to get the information you need?)
       (b) Roll motion experiment data analysis (What information did you collect? What is the difference between the stabilized and unstabilized conditions? What is the difference in damping factor between the two? How do the natural frequencies compare?)
       (c) Comparison of simulation information and experiment information (What is the connection between the two? Do you need more analysis to answer questions you have about the results of either one when considering the other?)
  5. Report Sections:
     - Introduction
     - Methodology
     - Results
     - Discussion
     - Abstract (optional)

- **Assigning tasks to team members**
  
  - Matching motivation is far more important than matching skills
  - Assign members a **primary task** and a **secondary, advisory task**
  - Assign tasks according to what team members want to learn rather than what they already know how to do (courses in college are about learning – do what you want to learn, not what you are already good at)
- Examine each person’s perceived strengths and learning goals
- Are you going to assign one person to be in charge of keeping the team on schedule? *(RECOMMENDED!)*
- Do you want to consider working with another team to complete data analysis that both teams can use for their respective topics?

- Schedule tasks in layers, providing multiple opportunities to comment or revise one another’s work
  - Refer to team preparation work below
  - Use a Task Schedule spreadsheet to create a rough draft of the schedule plan – be sure to include plenty of opportunities for team members to revise and comment on each other’s work

<table>
<thead>
<tr>
<th>Task Schedule Spreadsheet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task</td>
</tr>
</tbody>
</table>

- Balancing workload
  - To balance the workload fairly, work together to estimate a contribution value for each task
  - Let 5 = difficult, time-consuming task *critical* to group success and 1 = relatively easy, non-critical task
  - Be sure to have firm deadlines that everyone understands and feels they can meet. Consider other deadlines (other classes, for example) that may interfere and try to plan around those
  - Teams tend to underestimate the amount of effort required to produce good writing (which often requires substantial revision)
8.8.1 Team Preparation Work

To determine the best assignments for tasks, consider how each team member answers the following questions\textsuperscript{1}:

1. What strengths do you have relative to this project? For example, some things to consider include
   - above-average writing ability
   - above-average Excel skills
   - above-average Matlab skills
   - above-average Maxsurf skills
   - above-average visual (i.e. plot/figure) presentation skills
   - above-average management or organizational skills

2. What would you most like to learn from this project? For example,
   - improve Excel skills
   - improve Matlab skills
   - improve Maxsurf skills
   - improve writing skills
   - improve data analysis skills
   - improve organization/management skills

3. What is your level of commitment to the project? In this case, select the \textbf{one} of the following that best applies:
   - I plan to get an A on this project and will make whatever sacrifices that are necessary
   - I want an A but am limited in the time/effort I can dedicate to this project
   - I will be satisfied with a B on this project
   - My goal is to simply receive a passing grade on this project

4. What scheduling issues or other commitments do you have that might interfere with this project?

5. What concerns do you have about your skills or abilities that might affect how your team views your performance on this project?

6. Would you like to negotiate an agreement with the team that assigns you less responsibility for the project in exchange for a lower grade?

7. In your opinion, what does this team need to accomplish to make this project a success?

\textsuperscript{1}The following worksheet materials are from \textit{Team Writing} by Joanne Wolfe
If time allows, consider assigning primary tasks to people who would like to improve a skill and secondary, advisory tasks to people already good at a skill who can provide help to the learning partner. If you are feeling time-crunched and are not willing to support the time necessary for a team member to get up to speed on a type of task, consider reversing the roles. In this case you would assign the skilled team member a primary task with the learning team member assigned the secondary task. Regardless of the path your team chooses to take, remember the following rule:

The secondary, advisory task member MUST make suggestions or revisions to the primary task member’s work.

So, if your teammate makes or recommends a change to your work, remember that this is not a personal criticism – that is their job!

Self-Assessment: Problem-Solving Style

Another important consideration as your team gets started is recognizing that each person may prefer to collaborate from different perspectives. The most common problem-solving approaches (that often end up in conflict) are the holistic and action-oriented problem solving styles. I don’t wish to go into the details of how these are different, but it may be useful to recognize when different perspectives may be creating conflict within a team. To determine which style best describes you, take the following assessment:

Each item in the following assessment reflects something that a person might say or think. For each item, indicate how well this statement describes you when you are interacting with teammates. Use the following scale:

1. I prefer that the team think through an idea completely before we start working on it.
2. I quickly become impatient with long team deliberations.
3. I am always willing to consider new possibilities for solving a problem.
4. When my team is given a technical problem, I prefer that we begin figuring out the technical details as soon as possible.
5. When my team is given a technical problem, I prefer that we make sure we completely understand the “big picture” and end goals before we start thinking about the technical details.
6. I prefer that the team focus on getting things done as quickly as possible.
7. I think it is useful to spend time weighing the pros and cons of different ways to approach a problem before the team begins making any concrete plans.
8. Teams that spend a lot of time talking about ideas up front are just wasting time that could be used actually working on the project.

Add up your responses to the odd-numbered statements. If your score is greater than 13, you exhibit characteristics of a holistic problem-solving style.

Add up your responses to the even-numbered statements. If your score is greater than 13, you exhibit characteristics of an action-oriented problem-solving style.
Note: The self-assessment here focuses on styles that sometimes come into conflict and are by no means comprehensive. You may find that you score low on both scales or that you exhibit some characteristics of both the holistic and action-oriented problem-solving styles.

8.8.2 Collaboration Methods

There are several ways you can decide for how the team will work together on a project. The recommendation above is to use a “layered” method, but some aspects of the project are better dealt with using “face to face” or “divided” approaches. Below is a description of each approach and some of the pros and cons for each.

- **Face to Face**
  - **Pros**
    * quickly sharing lots of ideas or information
    * drafting plans, outlines, and schedules
    * discussing graphic design or visual concepts
  - **Cons**
    * difficult to schedule
    * hard to hear all voices
    * ineffective for drafting text – time is wasted and conflict can arise

- **Divided**
  - **Pros**
    * allows optimization of time
  - **Cons**
    * minimal collaboration
    * difficult to repair incorrect, poor quality, or missing work
    * redundancies, gaps, and mistakes
    * inconsistent tone, quality, and format

- **Layered**
  - **Pros**
    * quality improved by multiple reviews
    * maximizes contribution of all team members
    * all team members have ownership of content
    * effective for drafting and revising
  - **Cons**
    * unequal effort may results from team roles
    * advanced planning required
For practice, consider which method works best for each of the following tasks:

- Brainstorming
- Planning a schedule
- Conducting background research
- Collecting data
- Drafting text or analysis
- Talking to 3rd parties
- Discussing a draft
- Resolving disagreements or discussing major changes
- Preparing presentations
- Editing text