

Chapter 8: Writing a formal data report (IMRD)

The previous unit introduced you to different choices you have in visualizing and summarizing data in order to shape the story it tells. This unit will focus on writing a formal data report. The sections of a formal data report typically follow a predictable order. This predictability constrains the writer but gives the reader a lot of freedom to select and choose which sections and content to read. Because readers can predict where certain types of information can be found, they are free to choose their own reading order.

In fact, it is very rare for readers to read every word of a data report: it is more likely that they read selectively and out of order. Our job as writers is to help them with this selective, non-linear reading by making our writing as predictable as possible.

The Default Data Report: IMRD

The most common structure of a data report is known as IMRD, which stands for **I**ntroduction, **M**ethods, **R**esults, and **D**iscussion. Each section of the IMRD report answers a particular set of questions:

I ntroduction	Why is this topic important? Why do we care? What is the purpose of this report?
M ethods	What did we do? What data did we collect? How did we analyze it?
R esults	What did we find?
D iscussion	What do our findings mean? What should happen next?

You will notice that the Introduction and Discussion sections of the IMRD report address broad questions. The Introduction helps readers understand why the topic is important, why readers should care, and what the purpose of the report is while the Discussion helps readers understand what everything means and what should change as a consequence of this analysis. By contrast, the Methods and Results sections are more narrowly focused on describing and analyzing the data that was collected.

Because the Introduction and Discussion sections address broader questions than the Methods and Results section, the overall structure of an IMRD report is often displayed as an hourglass, moving from broad to specific and back to broad again:

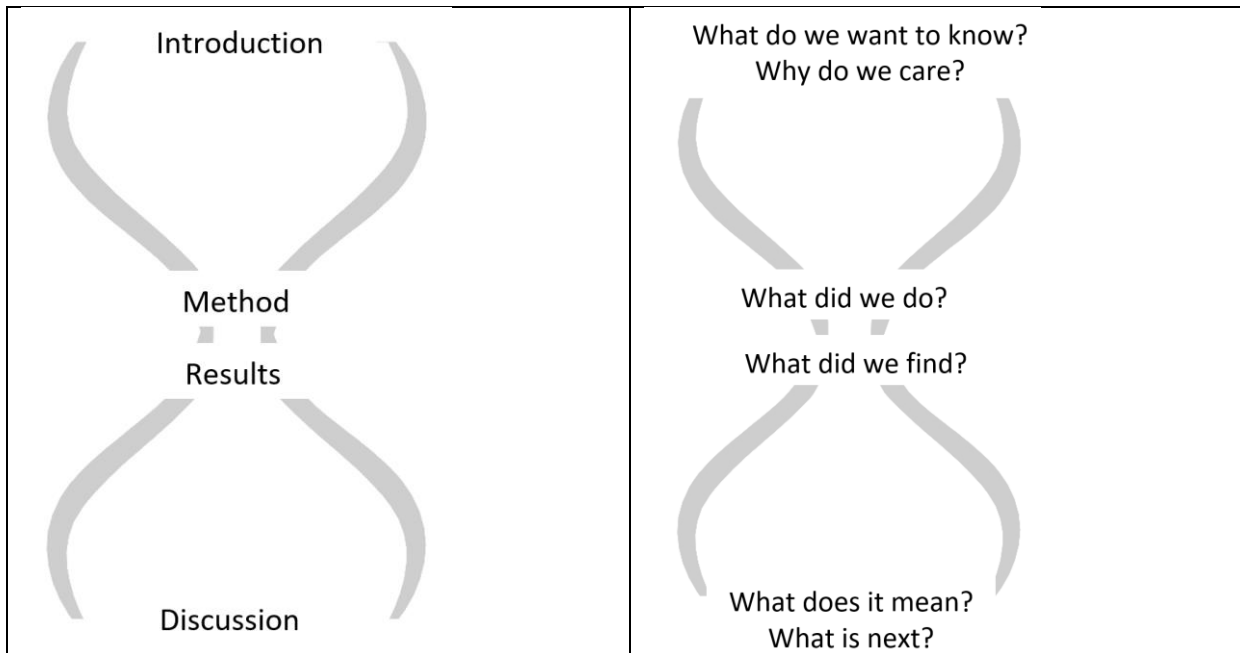
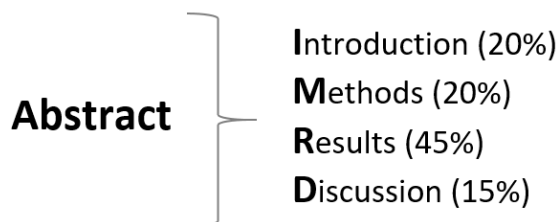


Figure 8.1: The IMRD report is structured like an hourglass, with the Introduction and Discussion sections answering broad questions and the Methods and Results more narrowly focused on the data that was collected and analyzed.

The shift from broad to narrow focus (back to broad again) is reflected in the verb tenses used in each of the sections. The method and results sections typically use past tense verbs to reflect their narrow focus on what the researcher did and found. By contrast, the introduction and discussion section are more focused on what we currently know and what we plan to do. As a consequence, these sections primarily use present tense verbs.

In addition to these four main sections, IMRD reports also have an abstract or executive summary that is essentially a report in miniature. An abstract or executive summary typically includes information on all four of the IMRD sections



Thus, the abstract is a report-in-miniature. It contains all of the sections of an IMRD report in as brief a format as possible.

Following the IMRD structure helps your readers by allowing them to skip and skim various sections. For instance, many readers will choose to skip or skim over the methods section and jump straight to your results.

Other readers may choose to skip over most of the report and jump directly to the conclusion and recommendations. These readers might then read other report sections selectively to fill in gaps or answer specific questions that they have.

Even reports that do not use the conventional IMRD headings follow the general outline of its structure. For instance, a trip report—a document that describes what an employee learned on a trip—follows this structure by beginning with the purpose of the trip, describing the details (who the employee met with, what she or he did), presenting the main lessons learned, and ending with next steps. Following the IMRD order gives readers a schema, or mental model, of how a report or analysis will proceed. This organization allows readers to anticipate the structure of your writing which helps them comprehend what you have to say.

Variations in the IMRD sections

Although most IMRD reports contain the common headings of Introduction, Method, Results, and Discussion, there are many variations. Sometimes you will see “Background” instead of “Introduction;” “Experimental” or “Models” instead of “Method”; “Analysis” instead of “Results”; and “Conclusion” or “Implications” instead of “Discussion.”

Do not become confused by these shifts in names. Different academic disciplines and professions have their own unique conventions. What is similar, despite different naming conventions, is the order in which types of information in the report are presented: from posing an issue or question, explaining how the question was answered, presenting findings, and then discussing the “bottom line” implications.

Snapshot of an IMRD report

Figure 8.2 below is an IMRD report that has been condensed to one page so that you can get a sense of the overall layout of a report and how everything “fits” together. Note how the layout and document design enables skimming.

Take some time to look over this one, noting where different types of information appear in each section. In particular:

- Where do citations and/or references to prior research appear?
- The most important information is what the researchers learned/found. This information appears in three different sections in this report. See if you can find all three places.
- In what section does the visual appear? How does the writer help us understand the visual?
- How does the tense change in each of the sections?

Employer Perceptions of College Graduates' Preparation For the 21st Century Workforce

Abstract

To determine how prepared college graduates are for the challenges of the contemporary workforce, 400 employers were surveyed about the skills they believe are most important for college graduates to demonstrate. Findings reveal that communication, collaboration and problem-solving were ranked as very important by over 80% of employers. However, most employers found graduates under-prepared in these core areas, with the biggest gaps between perceived importance and preparation occurring in communication skills. These findings suggest that colleges need to do more to prepare their graduates in the cross-cutting skills that lead to success in today's economy.

Introduction

The skills needed to succeed in the contemporary workforce are constantly evolving due to rapid societal and economic change. However, it is unclear if colleges and universities are adequately preparing students to meet these changing demands. This report identifies the learning outcomes employers believe are most important for success in today's economy and assesses how well-prepared employers believe recent college graduates are in these areas.

Method

Participants:

Surveys were collected from 400 employers whose organizations have at least 25 employees and report that 25% or more of their new hires hold either an associate's or bachelor's degree. Respondents were executives at private sector and nonprofit organizations, including owners, CEOs, presidents, C-suite level executives, and vice presidents.

Procedures:

Surveys were emailed to over 1,000 employers in November 2014. Reminders were sent until 400 responses were collected, for a response rate of approximately 40%, which is well above the typical survey response rate of 25%.

Surveys:

The surveys asked participants to rate, on a zero to 10 scale, how important it is that recent college graduates demonstrate proficiency in 9 different skill and knowledge areas. They were next asked to rate how prepared recent graduates are in these 9 areas. Finally, participants answered 12 questions about their perceptions of specific learning experiences.

Results

Table 1 indicates that employers rated communication, collaboration, and various forms of problem-solving as the most important skills that college graduates need for success. Regardless of occupation or economic sector, over eight in ten employers rated these cross-cutting skills as very important. Somewhat less likely to be identified as important were innovation, staying current on technology, and the ability to work with numbers, although the majority of employers still identified these as highly important skills.

Table 1 also shows major gaps between the skills employers believe are important and their perceptions of graduates' preparation in these areas. The biggest gaps were in oral and written communication, where fewer than one in three of employers perceived graduates as well-prepared. Graduates were perceived as best prepared in teamwork (37%) and staying current in technologies (37%) and least prepared in applying knowledge to real-world settings (23%).

Table 1: Proportion of employers rating the following outcomes as 8, 9, or 10 in importance on a zero-to-10 scale and proportion agreeing college graduates are well-prepared in these areas

Outcome	% rating important	% agreeing graduates are well-prepared
The ability to effectively communicate orally	85	28
The ability to work effectively with others in teams	83	37
The ability to effectively communicate in writing	82	27
Critical thinking and analytical reasoning skills	81	26
The ability to apply knowledge and skills to real-world settings	80	23
The ability to innovate and be creative	65	25
Staying current on changing technologies	60	37
The ability to work with numbers and understand statistics	56	28

Discussion

This survey demonstrates that employers place great value on skills and knowledge that cut across all majors, particularly written and oral communication, teamwork, critical thinking, and applying knowledge. However, employers feel that today's college graduates are not particularly well prepared in these valued skills. This critique echoes findings from previous employer surveys (AACU 2013). This study suggests that colleges need to do more to prepare their graduates in cross-cutting skills. Additional research is needed to determine the best methods for improving the state of education in these skills.

References

AACU (2013). *It Takes More than a Major: Employer Priorities for College Learning and Student Success*. Washington, DC: Association of American Colleges and Universities and Hart Research Associates.

Figure 8.2: An IMRD report condensed to fit on one page

What goes in the IMRD sections?

The sections of a formal IMRD report can vary greatly in length and detail depending on the length and level of formality of a report and whether it is written in an academic or workplace setting. Let's examine each of these sections in order.

Title

The title of an IMRD report should clearly and precisely state the main focus of the report. Your title should mention major variables tested.

<i>Bad Title</i>	<i>Good Title</i>
ME 441 Project	Strength of concrete cylinders after 7 and 28 days
Photolog report	Evaluation of automated vertical clearance measurement with photolog device
Factors affecting friction	Effects of shoe tread width on the friction of three different surfaces

Abstract or Executive Summary: A report in miniature

Both an abstract and an executive summary are essentially a report in miniature. They both summarize all of the major sections of the report. The difference between these two terms is that abstract is primarily used in academic settings and executive summary is used in professional contexts.

A well-written abstract or executive summary will **briefly cover** the purpose of the report (introduction), how the research was conducted (methods), what was found (results), and what it all means (discussion).

Abstracts are generally a single paragraph (medical abstracts, however, have their own format) and are primarily read by academic researchers who want to understand how the report's findings add to or challenge what they know about a topic.

Executive summaries are generally longer than abstracts and are primarily read by business or government executives who want to understand how the report's findings contribute to the organization's goals or actions. The length of an executive summary is generally proportionate to the length of the report: longer reports have longer exec summaries; shorter reports have shorter ones.

Introduction: Why are you writing this report?

The Introduction section describes the purpose of the report. For academic reports, the introduction should contain citations to prior research on the topic and explain how the current study will add to or extend this research. The goal of an academic introduction is often to explain how the current research project is new and worth doing.

For professional reports, the introduction contains background information that non-technical readers will need to understand the question that the report is intended to answer. A common mistake is to include too much background information: only include what your reader needs and

will want to see.

The introduction can be a few sentences (this is often the case if the reader has specifically asked for the report and is familiar with the topic) or several pages. Generally, introduction sections move from explaining why the topic is important to explaining the specific research question that the report will answer.

Methods: What did you do?

This section explains the details of how you collected data, what types of measurements you took, and how you analyzed the data. The methods section will be read in detail by experts who want to assess the credibility of your data and may be interested in repeating your research. However, non-experts will often skip over this section, reading it only when they have specific questions about how your data was collected or analyzed that they cannot infer from your results.

Because readers often selectively read the methods, this section makes heavy use of subheadings. These subheadings allow readers to skip and skim in order to find the answers to specific questions. Common subheadings in a methods section include

Participants

State the number of people who participated, the criteria for selecting these participants, and relevant demographic information about the participants.

Research sample

If the research involved collecting things—such as water or rock samples—explain what was collected and the criteria for selecting these samples.

Procedures

Briefly describe the steps that you took in collecting your data.

Measurements

Describe what dependent variables—such as time, weight, coefficient of friction—were taken and how these measurements were obtained.

Analysis

Describe how the data was analyzed. Include any statistical procedures, formulas, or equations used for analyzing the data.

Use the subheadings that are most relevant to a particular study. Many other reports use subheadings that are not listed here. The goal of the methods section should be to help readers find the answers to specific questions in as short a time as possible.

Results: What did you find?

The results section presents the findings from your research. This and the executive summary/abstract are the most important parts of your report. You should use tables, figures, and words focus readers' attention on the most important trends and conclusions. The chapters on data visualization (Chapter 4) and analyzing your data (Chapter 5) provide details on what to include in this section.

For complex reports, the Results section may have subsections for the different types of questions that the report is asking. For instance, in a report analyzing user experience with a new website, there may be a subsection for “Errors and completion rates” analyzing whether users were able to complete a task without problems and a separate subsection for “User satisfaction” that measures how much users liked the site.

Discussion: What does it mean?

This last section of your report is the most variable. Although it is most common to refer to this section as the *Discussion*, some reports will label it as *Conclusion*, *Implications*, or *Recommendations*. Many reports will have *both* discussion sections and conclusion or recommendation sections.

In any case, the final section of your report is one of the most important. It should clearly connect your findings to your readers' goals, explaining the bottom line.

For academic reports, the discussion section begins by summarizing the main points of the results section—in other words this section begins by emphasizing the bottom line. Next, this section will generally explain how these findings support, contradict, or otherwise extend what the academic community knows about this topic. Citations are common. Next, the section acknowledges flaws or limitations in the current study and then suggests possible directions for future research.

In professional settings, data reports often end with a bulleted list of recommendations based upon your findings.

Section by section analysis of common problems in IMRD

Abstracts

Compare and contrast the abstracts below to answer the following questions:

- What questions should a good abstract answer?
- What kinds of information are often missing from the weaker abstracts?

Pretty Good Abstract	Definitely Not Good
Although best practices in technical instructions recommend including both graphical illustrations and written instructions, some tasks may not need written instructions. To test whether written instructions are always needed, we asked 40 college students to assemble a simple Lego vehicle using either graphical illustrations alone or illustrations plus written instructions. Results showed that students who used graphical illustrations and written instructions took longer and made more errors than those using illustrations alone. These findings may suggest that in some cases written instructions may not be necessary and may even interfere with successful task completion.	It is important to be able to write good instructions but there is some debate over how much information is necessary in technical instructions. In this experiment, 40 college students assembled a Lego shape with either graphical illustrations alone or graphical illustrations plus written instructions. Time to complete task and number of errors made were collected and computed in an Excel spreadsheet. Results showed that the type of instructions affected task completion. These findings have implications for technical writers.
This experiment tests the effect of choke type and gun selection on target accuracy. Three competent shooters of approximately equivalent marksmanship abilities tested three different choke types (full, modified, and improved) and two different guns (a Remington 11-87 semi-automatic and a Beretta 682 Gold E). With a confidence level of 95%, the gun selection ended up to be the only significant factor. The Beretta was found more accurate than the Remington possibly because the Beretta's weight is centered in the middle of the gun while the Remington is a little barrel-heavy. However, if the confidence level is lowered to 90%, choke type is also significant, with the improved choke more accurate than the modified or full. Thus, for target shooting, the most accurate combination would be the Beretta with an improved choke	The purpose of this report is to comprehensively describe an experiment conducted to identify the factors affecting the chemical reaction rate of a simulated virtual chemical reaction, and to describe the relationship between the reaction rate and these factors in a mathematical form. The organization of this technical report is as follows: section one of the report gives a background about the problem under testing. It acts as a clear statement of the problem, which helps in understanding the problem nature, and in selecting the proper response variable, factors, and design technique. Section two describes the detailed design of the experiment, including the response variable, the factors to be included in the experiment, and the factor levels for each factor. It also describes the statistical approaches as well as statistical software that will be used. This section also describes how to conduct the experiment listing the expected equipment and their specification, and the number of observations to be taken. Section three describes

	how the actual experiment was conducted; listing test procedures followed, actual test equipment, and tabulated experimental data. Section four contains complete analysis for the resulting data using the statistical tools described in the design section. Output from statistical software, analysis of the resulting output, and analysis results are also explained in this section.
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Introductions

Introductions to research reports can range from a single paragraph to multiple pages. Longer introductions often have multiple sections with headings such as *Background information*, *Motivation*, *Related Research*, and *Literature Review*. In this chapter, we will focus on short introductions, saving longer introductions for later.

Compare and contrast the introductions below to answer the following questions:

- What questions should a good introduction answer?
- What kinds of information are often missing from introductions?

Pretty Good Introduction	Definitely Not Good
Our class readings suggest that technical instructions should contain both graphical illustrations and written instructions. However, some tasks are so simple that written instructions are not needed. For instance, instructions for assembling Lego kits typically do not have written commands. These tasks are both highly visual and simple so that written instructions are not needed. This paper investigates the following research questions: how does including a written component to graphical set of instructions affect people's ability to complete a simple task? Do the written instructions help—or are they unnecessary?	Technical instructions use illustrations to help readers see how to assemble materials. Some instructions contain no words at all. This is the case with the instructions that the Lego company includes with many of its products. The goal of this experiment is to see how adding text to these visual instructions affects readers trying to assemble a Lego product.
Southern California has a volatile water supply and planners and policy makers need to be able to predict future water supply in the region. We have data from 1948-1990 containing precipitation and stream run-off volume measurements from six sites in the Sierra Nevada mountains. However, it is expensive to conduct measurements at six sites and so policy makers are considering recording precipitation at only two locations.	Policy makers are interested in predicting the stream run-off near Bishop County, CA (BSAAM). Data is available from 1948-1990 containing measurements of precipitation at six sites in the Sierra Nevada mountains stored in the following variables: APMAM, APSAB, APSLAKE, OPBPC, OPRC, and OPSLAKE. This report will present an analysis of the relevant data to evaluate the extent to which future run-off can be predicted from precipitation measurements.

This report addresses two questions about the relationship between stream run-off in Southern California and precipitation measurements at sites in the Sierra Nevada mountains: First, if we could only choose two sites, which two would best predict stream run off for Bishop County, CA? Second, what is the smallest amount of stream runoff we can expect if a year was as dry as the driest experienced in the past 43 years?

Methods

The methods section is typically the least-read section of an IMRD report and it is often the easiest section to write since the writer just has to describe his or her procedures. For these reasons, we only provide one example of a methods section for you to consider.

Compare and contrast the methods section below to answer the following questions:

- What questions should a good methods section answer?
- What distinguishes a good methods section from a weak one?

Pretty Good	Definitely Not Good
Participants Forty college students participated in this experiment. Of these, 18 were male and 22 female. Procedures Participants received instructions to assemble a Lego Dino Attack Vehicle along with the legos needed to complete the task. Half of the participants received the original instructions from the Lego company. These instructions included only graphics without any written text. The other half received a set of instructions that the researchers wrote. These instructions modified those provided by Lego, adding written commands for each step of the assembly. Measurements Participants were given the instructions and legos and then timed on how long they took to complete the task. Time was reported in seconds. In addition, the researchers counted the number of errors participants made. An error was counted each time a participant picked up a wrong piece or connected a piece incorrectly and	Forty college students were asked to assemble a Lego Dino Attack Vehicle. Half of these students received a version with just pictures and half of received a version with pictures and text. A copy of the two version can be found in the appendix. There were 18 males and 22 females who completed the experiment. Participants were timed on how long it took them to complete the task and on how many errors they made. Their times and errors were recorded in an Excel spreadsheet and averages were reported. This experiment is limited by its small sample size.

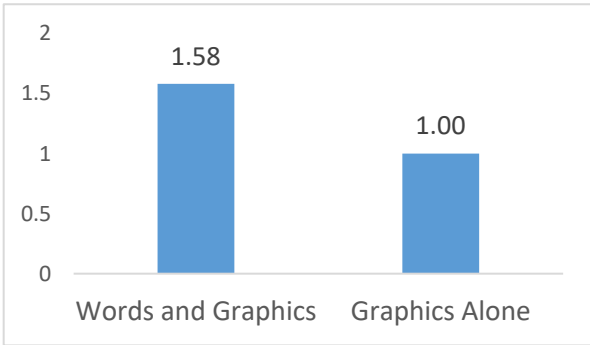
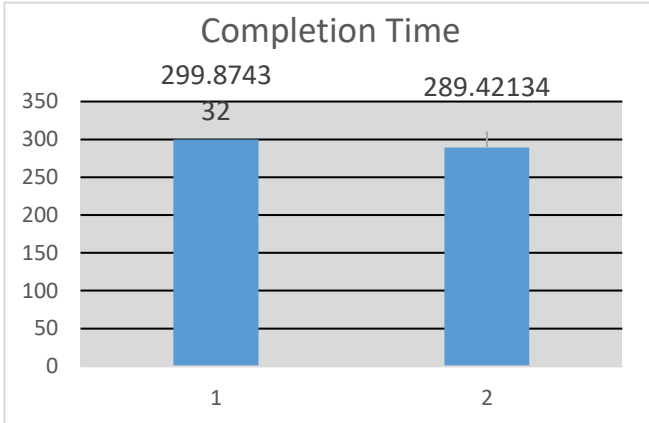
had to undo their action. Time and errors were averaged across all participants.

Results

The results section contains the main findings of the report. This section will contain the majority of the tables and figures.

Compare and contrast the results sections below to answer the following questions:

- What questions should a good results section answer?
- What distinguishes a good results section from a weak one?

Pretty Good Results	Definitely Not Good
Figure 1 shows that participants who used instructions with both words and graphics made nearly 60% more errors than those who used graphics alone. This difference is statistically significant, $t = 2.29$, $p < .05$.  Figure 1. Mean number of errors for people who received both words and graphics vs. those receiving graphics alone. Figure 2 shows that participants who received both words and graphics took slightly longer to assemble the vehicle (300 seconds for words and graphics vs. 289 seconds for graphics alone). Although this is a negligible difference, it does suggest that words did not help on this simple task and may even have interfered.	Perhaps the easiest to interpret indicator of the relative effectiveness of two sets of instructions is the time taken to complete the task. Time was measured on a Nike 300 sports watch. Figure 1 shows the mean time to complete the Dino Attack Vehicle for the instructions with verbal commands and graphics as well as the purely graphical instructions.  Figure 1. Mean completion time. Instruction type 1 includes verbal commands, type 2 is purely graphical instructions. Another easy to interpret indicator of the effectiveness of the instructions is the number of errors made. The mean number of errors is shown in Figure 2.

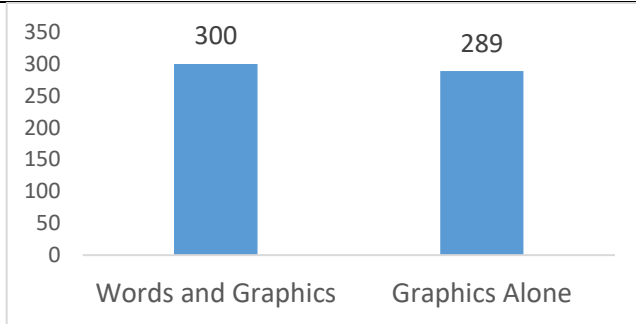


Figure 2. Mean completion time for people who received both words and pictures vs. those receiving pictures alone (measured in seconds).



Figure 2. Here we see the mean number of errors for people with verbal commands and graphical instructions (Set 1) and purely graphical instructions (Set 2).

This difference is statistically significant, $t=2.29$, $p < .05$.

Discussions

The discussion section moves readers from a narrow focus on the researcher's data back to the larger world. Compare and contrast the discussion sections below to answer the following questions:

- What questions should a good discussion section answer?
- What distinguishes a good discussion section from a weak one?

Pretty Good Discussion	Definitely Not Good
The data collected from this small study suggests that written instructions are not needed to complete a simple assembly task and may even interfere with the task. The participants who received words plus graphics made more errors and took longer to complete the task than participants who received graphics alone. This differs from our class readings (LeRoy; Markel) which recommend including written commands. One reason for these contradictory finding may be the simplicity and nature of our task. Future research is needed to see if written instructions accompanying graphics would be more helpful on a more complex assembly task or a less physical task, such as installing and using a software program. Moreover, our study is hampered by the small number of our participants. All of our participants were college students. Additional research might examine whether older	The goal of this experiment was to compare graphical instructions alone versus instructions with verbal commands. Forty college students completed the task with one of two instruction versions. Students who completed the task with verbal commands took over 299 seconds and made 1.58 errors. Students who completed the task with graphical instructions alone took over 289 seconds and made 1 error on average. This experiment was conducted with a small sample size and results were not statistically significant. Future experiments should include a larger and more diverse population.

participants would benefit from written instructions accompanying graphics. Based on this limited analysis, we recommend that instruction writers consider excluding written instructions on simple assembly tasks. Our results indicate that written instructions may in some cases interfere with users' abilities to follow graphical directions.	
Our analysis found that we can effectively predict run-off by considering precipitation measurements at just two of the six sites: OPSLAKE and OPRC. Our model of these two sites accounts for 90% of the variation ($r^2=.90$) in runoff, suggesting that focusing collection efforts on OPSLAKE and OPRC can provide a cost-effective means of predicting future run-off in the Sierra Nevada mountains. However, we should still be cautious when using the model to predict future run-off since it does not fully account for all of the variation. Moreover, our most recent data is nearly 25 years old, and it is possible that precipitation patterns have changed.	The coefficient of determination of our model is $r^2=.90$ for the linear model on OPSLAKE and OPRC. This means that 90% of the variation in BSAAM is explained by the linear model on OPSLAKE and OPRC. However, we should still be cautious when using the model to predict future run-off since it does not fully account for all of the variation. Moreover, our most recent data is nearly 25 years old, and it is possible that precipitation patterns have changed.

SUMMARY