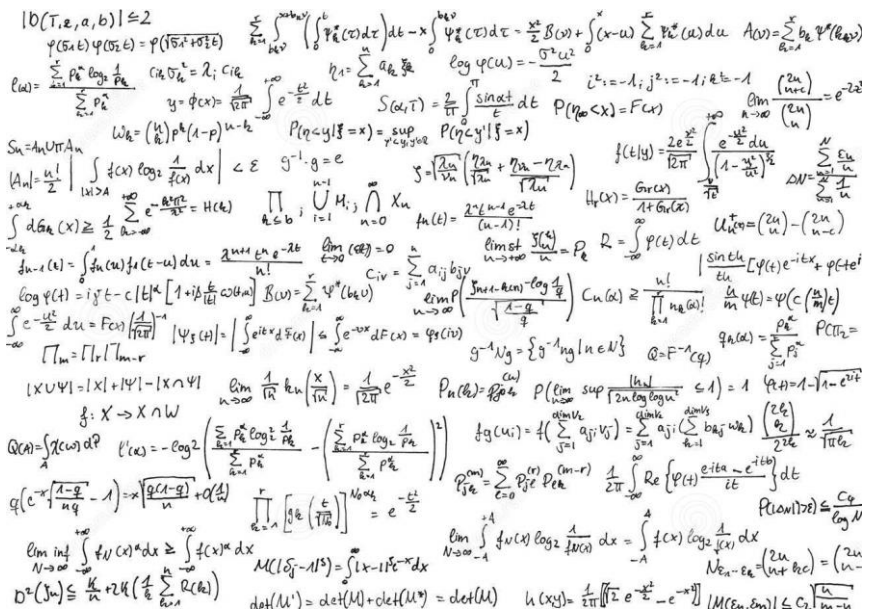

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Best Practices in Teaching Written and Oral Communication Skills to STEM Students

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Introductions

What types of written or oral assignments do students have in your courses?

Writing in STEM??

But wait professor! I am not an English or journalism major. I don't like to write. I'm studying to become an engineer/biologist/

mathematician/chemist…. I won't need to do much writing in my job.

Reality Check

- Employers, professional organizations, universities, accrediting bodies list ability to communicate technical information as very important.
- National Academy of Engineering and National Academy of Sciences reports stress the importance of strong communication skills and the "ability to communicate convincingly and to shape the opinions and attitudes of other engineers and the public." (The Engineer of 2020: Visions of Engineering in the New Century)
- $125M NASA Mars Climate Orbiter (1999)

Reality Check

- Writing is essential to *generation* of knowledge (Winsor, 1990)
- Improved thinking and knowledge acquisition through writing (Bazerman, et al., 2005)
- Increased student engagement related to amount of writing in course (Light, 2004)
- Writing important in many proven pedagogical techniques such as cooperative learning, active learning, and problem-based learning strategies (Wheeler & McDonald, 2000).

Challenges

- Only about 50% of the top U.S. schools require a course in technical communication (SECS does not)
- Budgetary constraints
- Credit hour constraints
- Lack of faculty expertise in teaching technical writing
  - Even more so for graduate teaching assistants
- Time constraints for students and faculty
- Faculty motivation (not our job)

Some Student Challenges

- Intended audience issues
- Focus on minor details and fail to see the big picture or main results
- Focus on facts and details but lack analysis
- Reach conclusions without directly referencing their data or analysis
- Issues with organizing and presenting information in a logical manner
- Generating good quality tables, graphs and figures
- Writing abstracts!
- Writing mechanics problems (spelling, grammar, punctuation); citing references
- Long, convoluted sentences
- Team dynamics
- Non native speakers

Importance

Explain importance of communication skills to students. The more they hear this message, the more likely they are to absorb it

In science the credit goes to the man who convinces the world, not to the man to whom the idea first occurs.

- Sir Francis Darwin

Clear expectations

Provide students with clear guidelines and expectations

- Detailed explanations of what is expected
- Provide students with examples for each section of the report
  - http://www.me.umn.edu/education/undergraduate/writing/MESWG-Lab.1.5.pdf
  - https://owl.english.purdue.edu/owl/resource/647/1/
  - https://owl.english.purdue.edu/media/ppt/20071026015924_706.ppt
  - http://writing.colostate.edu/guides/

Abstract requirements

The Abstract should be a clear and concise summary of the information in the report. It should address an audience that might not read the rest of the report and, for this reason, should

- State the principal objectives and scope of the lab assignment,
- Describe the methods employed,
- Summarize the important results,
- State the principal conclusions.

The abstract should generally be between 200 and 250 words long and should contain highlights of the various sections in the report. The abstract should never include equation numbers or references to tables and figures in the report. It should be self-contained and the text should flow smoothly. Since the abstract summarizes the entire report, it is best to write it last.

Sample Abstract

Experiments were conducted to assess the accuracy of two methods for measuring volumetric flowrate: a method in which the collection-volume was held constant at approximately 900 ml and collection-time was recorded, and a method in which the collection-time was held constant at approximately 7 seconds and collection-volume was recorded. Water flowrates were varied between 14 and 72 ml/s, and the results were compared with direct rotameter measurements taken using a 2 gpm Dwyer VFB rotameter. At each flowrate, the collected volume of water was measured using a 1000± 5 mL graduated cylinder, and time was measured using a mechanical timer with an uncertainty of ± 0.45 s. In all cases, the uncertainty increased with flowrate and the constant collection-volume method proved to be a more accurate way of indirectly measuring volume flowrate. The relative uncertainty of the constant-time method was about ± 4.81%, whereas the relative uncertainty associated with the constant collection-volume method varied from ± 1.48% at a flow rate of 14 ml/s, to ± 3.12% at a flow rate of 72 ml/s. Neither method exhibited sufficient accuracy to calibrate the rotameter to within ± 2% of full-scale reading in the parameter ranges tested. However, increasing the collection-time or collection-volume could improve the accuracy of either method.

What

How

Results

Significance

Show them also examples of poor writing

This Experiment was conducted to introduce us to different flow rates using a orifice plate and a venturi meter . In this experiment we also had to calculate the different uncertainties and error we came across while performing this lab. We measured eight different flow rates. We also had to time how long it took to collect ten liters of water in the take , along with the eight manometer heigh ts. The pressure tappings cause the manometer heights to change due to the varying flow rates. The manometer had an uncertainty of ± 2.5 millimeters .

Note that this sample figure shows two sets of data on the same plot. To show the uncertainty, error bars are used for one set of data and error bands are used for the other to make it easier to read. If you only have one data set, then use either error bars or error bands, not both

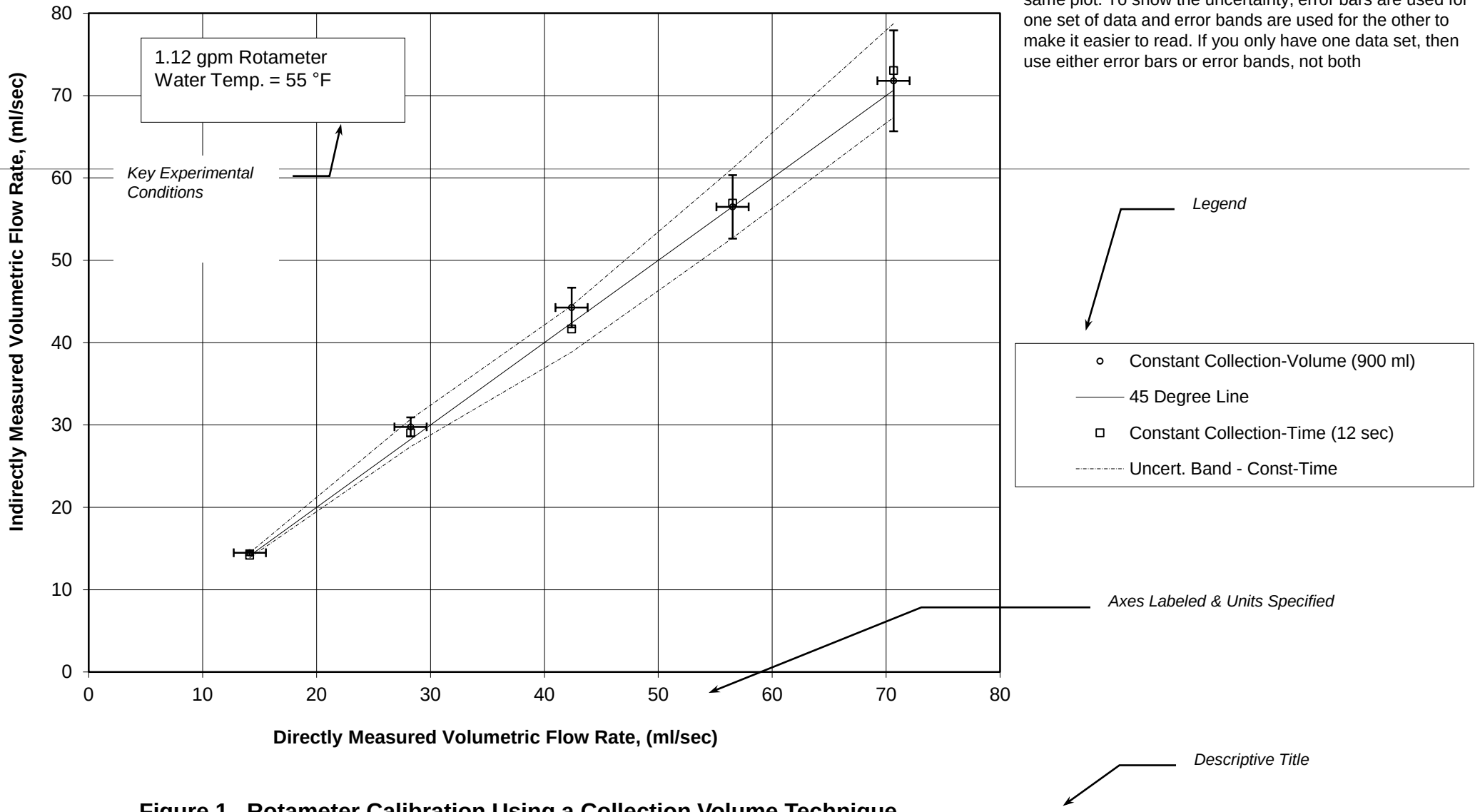


Figure 1. Rotameter Calibration Using a Collection Volume Technique

Key Experimental Conditions

(Sample Table)

Table 1. Experimental Data[1]
Constant Collection-Volume Method

Descriptive Title

Constant Collection-Volume Method Collection Volume = 900 ±5 ml 1.12 gpm Rotameter Uncertainty = ± 1.41 ml/s 3.55 gpm Rotameter Uncertainty = ± 4.48 ml/s											
Water Temperature = 55 °F											
	Directly Measured Flow Rate				Indirectly Measured Flow Rate						
	1.12 gpm Rotameter		3.55 gpm Rotameter		Collection Times for 900 ml			Calculated Values			
Test No.	gpm	ml/sec	gpm	ml/sec	Trial #1 (sec)	Trial #2 (sec)	Trial (sec)	Ave. Time (sec)	Volumetric Flowrate (ml/sec)	Uncertainty (ml/sec)	Relative uncertainty %
1	0.224	14.13	0.284	17.92	62.2	62.0	62.3	62.17	14.48	0.3133	2.16
2	0.448	28.26	0.515	32.47	30.2	30.3	30.2	30.23	29.77	1.1500	3.86
3	0.672	42.39	0.746	47.03	20.2	20.3	20.5	20.33	44.26	2.4227	5.47
4	0.896	56.52	0.959	60.47	15.9	15.9	16.0	15.93	56.49	3.8589	6.83
5	1.12	70.65	1.207	76.14	12.5	12.5	12.6	12.53	71.81	6.1283	8.53

Measurements specified with units

Drafts and incremental reports

- Require students to submit drafts and then revise their drafts prior to final submission.
  - Can use peer feedback if time is limited
  - Helps them develop good writing and editing habits
  - Helps with team functioning
- Particularly in lower level courses, add new elements of a report incrementally
- Provide students with a template, particularly for earlier assignments.

Use grading rubrics

Lab Report Rubric – Adapted from PARCC Expanded Scoring Rubric for Narrative and Analytic Writing

	5	4	3	2	1
Discussion Procedure Conclusions	The response addresses the prompt and provides effective and comprehensive development of the claim, and/or topic by using clear and convincing reasoning, details, evidence, and/or description; the development is consistently appropriate to the task, purpose, and audience. The response demonstrates purposeful coherence, clarity, and cohesion and includes a well-executed progression of ideas, making it easy to follow the writer's progression of ideas. Though there may be a few minor errors in grammar and usage, meaning is clear throughout the response.	The response addresses the prompt and provides effective development of the claim and/or topic by using clear reasoning, details, evidence, and/or description; the development is largely appropriate to the task, purpose, and audience. The response demonstrates a great deal of coherence, clarity, and cohesion, and includes a logical progression of ideas, making it fairly easy to follow the writer's progression of ideas. There may be a few distracting errors in grammar and usage, but meaning is clear.	The response addresses the prompt and provides some development of the claim and/or topic by using some reasoning, details, evidence, and/or description; the development is somewhat appropriate to the task, purpose, and audience. The response demonstrates some coherence, clarity, and/or cohesion, and includes logically grouped ideas, making the writer's progression of ideas usually discernible but not obvious. There are a few patterns of errors in grammar and usage that may occasionally impede understanding.	The response addresses the prompt and develops the claim and/or topic minimally by using limited reasoning, details, evidence and/or description; the development is limited in its appropriateness to the task, purpose, and/or audience. The response demonstrates limited coherence, clarity, and/or cohesion, making the writer's progression of ideas somewhat unclear. There are multiple distracting errors in grammar and usage that sometimes impede understanding.	The response is underdeveloped and therefore inappropriate to the task, purpose, and/or audience. The response demonstrates a lack of coherence, clarity and cohesion. There are frequent distracting errors in grammar and usage that often impede understanding.
Data Table	The table includes all headings, units, and data in an organized way that is easy to understand and analyze.	The table includes most headings, units, and data in an organized way that is easy to understand and analyze.	The table includes headings and data in an organized way that is easy to understand and analyze.	Though present, the data is not in a table, but does include headings and units. It is presented with similar measurements listed together.	Though present, the data is not in a table nor does it include headings or units.
Data Analysis	The data analysis is well-organized and shows all calculations, the circled or boxed answer and a unit.	The data analysis is well-organized and shows most calculations, the circled or boxed answer and a unit.	The data analysis is organized and shows some calculations, the answer and a unit.	The data analysis shows few calculations, the answer or a unit.	The data analysis shows only the answer or a unit.

Use grading rubrics

____/10 **ABSTRACT**

- Does the abstract state the principal objectives and scope of the lab assignment, describe the methods employed, summarize the important results, and state the principal conclusions?
- Does the abstract stand on its own (i.e., not reference figures, tables, equation numbers in the report)?
- Is the organization logical, and understandable to a reader (from outside this course)?

____/5 **INTRODUCTION**

- Does the introduction provide the goals/motivation of the experiment?
- Does the introduction state the *topic and purpose* of the report?
- Does the introduction clearly and concisely state the objectives of the experiment, as well as provide a brief outline of the report?

____/5 **EXPERIMENTAL PROCEDURE**

- Does the procedure section provide a description of the test equipment and detail the experimental procedure used to collect the data?
- Does it include a schematic of the test apparatus with a short narrative describing the various components?
- Does it list the uncertainty of the key pieces of equipment?

Feedback and Revisions

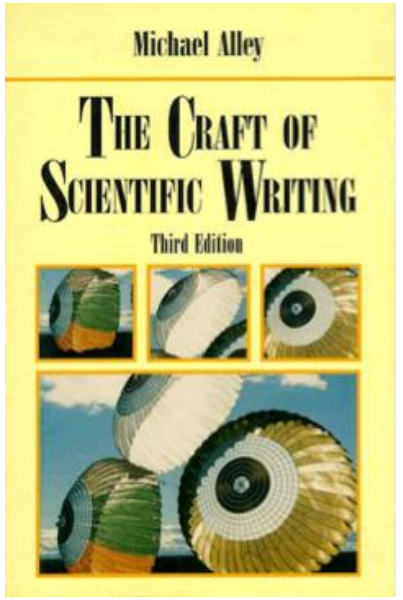
- Provide students with feedback on their writing
  - Challenging in larger courses, but rubrics can help
- If possible, provide some feedback face to face or discuss common mistakes in class
- If the goal is to allow students to improve their communication skills, provide them with opportunities to revise and resubmit their reports.
- Talk about your own challenges with writing to demystify the process.

Other opportunities

- Provide students with other opportunities to practice writing or giving oral presentations in the course:
  - One paragraph answers to a question on homework (e.g., explain how a microwave oven cooks food)
  - Ask students to generate an exam question or prepare a homework problem solution (this latter approach is being tested by an NSF-funded program at Purdue)
  - Have students give two-minute, ungraded lightning talks on a topic related to the course material
  - Ask them to generate a short video demonstrating a concept learned in class

Share help resources with students

- Refer students to the resources available at the OU writing center: https://wwwp.oakland.edu/ouwc/
- Share other resources with them such as:
  - https://labwrite.ncsu.edu/index_labwrite.htm
  - http://writing.engr.psu.edu/writing.html
  - https://owl.english.purdue.edu/owl/
- Discuss some of these common mistakes with class http://web.csulb.edu/~tgredig/docs/TechnicalWriting1.pdf



It takes a village to develop a student's communication skills

- This is not something that can be accomplished by one class.
- It requires practice and more practice to develop the needed skills.
- Discuss issue in your department and school/college to find ways of integrating these skills throughout the curriculum.

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