# Industry Collaboration to Enhance Technical Writing in Engineering Laboratories: A Second Study

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## Introduction

Engineering Laboratories are critical to teaching engineering concepts because they allow students to apply theoretical knowledge and conduct research. Conducting proper research, solving complex problems, and communicating research findings are learning objectives set by ABET, and students must be exposed to these concepts during their undergraduate studies [1].

Literature suggests that engineers spend a significant amount of their work days reading/writing reports [2, 3], but engineering graduates often struggle due to the disconnect between the classroom and industry. This research project collaborates with university partners and research facilities to integrate technical writing more effectively through the engineering laboratories. It aims to enhance technical writing skills while also demonstrating a proper context for where technical writing will be used in their careers.

The authors conducted a pilot study in a previous academic year with an upper-level mechanical engineering laboratory course [4], and will be referred to as the "pilot study" or "first study" throughout this paper. They presented their findings at an earlier engineering education conference. The goals of the pilot study were to develop themes to guide data analysis in the second study and to collect initial data. This paper builds on previously published work by providing the second study dataset, which offers insights into student experiences and feedback. The authors conducted the second study with a different upper-level mechanical engineering laboratory course and will share the student experiences, themes, and feedback.

## Literature Review

The literature review covers these topics: a technical writing overview, an engineering laboratory overview, examples of industrial collaboration, and pilot study discussions.

### Technical Writing

Technical writing is the logical and sequential style of thinking. W.E Britton argues that proper technical writing clearly guides the reader to derive one meaning from the paper, and Brooks and Warren note that technical writing relies on "specialization of language for the purpose of precision" within the context of science, engineering, and business [4, 5]. Guilford noted that "many undergraduate and graduate students understand neither the process of scientific writing nor the significance of peer review", commonly attributed to high school educators focusing on associative writing styles [2]. High school educators focus on associative writing, leaving undergraduate students underprepared for technical writing in undergraduate programs and in the industry.

Universities have integrated technical writing into the curriculum through different methods. Some engineering departments require students to take a technical writing course at the freshman to senior level [6-8]. Other departments send students to the English department collaborators during their senior design course [10]. Other faculty, such as Winsor, implemented technical writing and peer review directly in their course objectives. Winsor collected data from senior students (see table below) regarding common methods of learning technical writing and discovered that “Students indicate that a typical learning pattern is to use a model and seek advice from coworkers when preparing drafts, submit the draft to a supervisor, and use the supervisor's feedback to revise.” [11]. While some may say that using models produces poor quality work and hinders the desired learning outcomes [12], others explain that the industry already uses “cookie-cutter” models, thus demonstrating the reality of industrial technical writing [13].

| Method of Learning | Percentage Cited |
|---|---|
| Use of Models | 53% |
| Editing from supervisors | 38% |
| Editing from co-workers | 24% |
| Freshman college technical writing course | 14% |
| High school courses | 7% |
| Professional development at work | 5% |
| Work evaluations | 5% |

Table 1, Cited methods of learning among senior-level engineering students.
Statistics extracted from [11]

Engineering Laboratories

Engineering laboratories serve as a bridge between theoretical knowledge and hands-on practice, and are staple parts of most engineering curricula [13, 14]. Since their introduction in the 19$^{th}$ century, computer development has changed the laboratory experience most because it revolutionized how students collect, analyze, and present data [16], [17], [18], [19]. Along with data processing, synchronous and asynchronous lab activities allow for distance learning [19], [20]. Most engineering curricula include laboratory courses for students, but these courses are not centers for educational research. For example, only 5% of all articles published in the Journal of Engineering Education used “laboratory” as a keyword between 1993 and 2002 [21].

Industrial Collaboration in the Engineering Curricula

Academic and Industrial partnerships are crucial to developing academia and society. These partnerships prepare students to contribute upon graduation and build on the existing field. Industrial collaborations spur cross-continental economic development and innovation, advancing research and education for engineering departments. These studies highlight advancements in industrial engineering, engineering design, and renewable energy developments [22], [23], [24], [25], [26], [27]. Industrial partners also help develop curriculum, take part in career fairs, co-advise graduate students, and more [28], [29].

Pilot Study Overview

The pilot study was conducted in a senior-level mechanical engineering course covering fluid mechanics concepts. This course is historically offered once per year, with a maximum course size of 20 students, and covers Reynolds number, laminar and turbulent flows, and venturi meters. [4]**.** Our pilot study answered the following question:

1. What are the nuances captured in the industry, research, and graduate school writing styles that faculty need to implement into their lab reports?

After collecting and analyzing technical writing templates from industrial partners and university research facilities, we identified the following key features that should be included in a new lab report template:

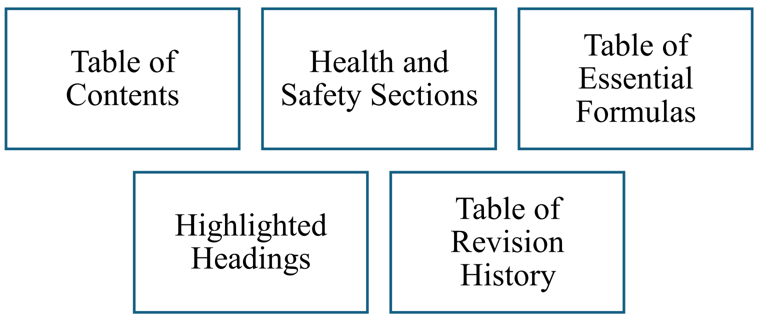


Figure 1, Key features found from analyzing technical writing templates. Elaborations found in [4]

We created a lab template shown in Appendix C. After completing the pilot study, we identified common errors and themes across groups (using the control template & rubric vs. the experimental template and rubric), which are shown in Figure 2. An important note from this study is that while students showed difficulty with generating a proper table of contents, the rubric did not have a penalty for incorrect generation. Because of this, the theme was not compared across the two studies.

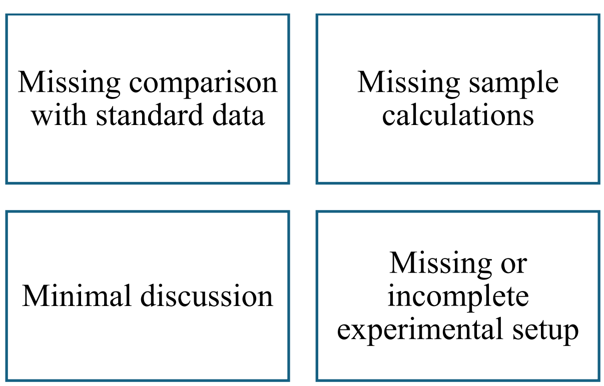


Figure 2, Themes and common errors found from the pilot study

## Research Questions

Our pilot study, as referenced previously, answered the following question:

1. What are the nuances captured in the industry, research, and graduate school writing styles that faculty need to implement into their lab reports?

This second study sought to answer the following research questions:

2. What were student' experiences and struggles with incorporating technical writing into their laboratory assignments?
3. Can this updated lab template be implemented without becoming a distraction to the overall course objectives?

## Classroom Design and Procedure

The second study was conducted in a senior-level mechanical engineering course that covered material science concepts. The materials lab is historically offered once per year, which covers tensile, fatigue, bending, and hardness testing. The experimental template and rubric were unchanged from the first study.

Students complete their labs once a week, write a lab report, and submit the reports for evaluation. This semester, students peer-reviewed each other's draft reports and were given another week to submit their final reports. Students in the first half of the semester followed the template in Appendix A and were graded according to the rubric in Appendix B. This template was used, with very little modification, for approximately five (5) academic years.

Third-party faculty obtained informed consent from students during the 8th week of class, and the updated writing template and rubric were implemented during the 9th week. The class adhered to the experimental writing template and rubric shown in Appendices C & D for the remainder of the 15-week semester. Students conducted peer reviews in both halves of the semester, and the instructor provided final-draft feedback.

The students were then asked to fill out a survey at the end of the semester. The survey included 10 questions to assess instructional clarity and template implementation, utilizing a 10-point Likert scale. There was a final open-ended question for students to share feedback on topics not covered in the Likert-scale questions. This survey can be seen in Appendix E.

The authors received the assignments, rubrics, and feedback from the instructional team at the end of the semester and highlighted common feedback themes by assignment and throughout the semester. These common feedback themes will be organized for future use as the authors refine the number of themes in subsequent work.

## Results and Discussion

Three (3) students consented to participate in the research study, some of whom were also participants in the pilot study due to lab sequencing in the degree plan. Comments, scores, and labs are listed in Table 2; the asterisk denotes the labs conducted after the template change. The average scores on the post-lab survey are also shown in Table 3. Two (2) students completed the post-lab survey.

| Lab | Lab Title | Avg. Draft Score (%) | Avg. Final Score (%) | Comments |
|---|---|---|---|---|
| 1 | Bending and Deflection of Beams | 80.7 | 96.3 | • Unclear photographs of the experiment and materials<br>• Incorrect formatting of headers and file naming<br>• Graphing errors (missing units)<br>• Lack of equation discussion and missing calculated data |
| 2 | Torsion Testing | 76.7 | 98.3 | • Missing Excel Workbook (calculations)<br>• Required graphs not created<br>• Missing Reference tables and discussion comparing data. |
| 3 | Charpy Impact Testing of Metals | 87.3 | 91.2 | • Title Page not updated from last experiment<br>• Mixed Unit system: The material temperature was submitted in (°F), and the impact energy was in (J).<br>• Missing specimen CAD drawing and Excel workbook |
| 4 | Charpy Testing of Plastic Specimens | 96.3 | 96.3 | • Title page not updated<br>• Formatting errors |
| 5* | Fatigue Testing | 78.8 | 95.2 | • The draft was incomplete<br>• Heading not on the same page as the body text<br>• Graph layout errors |
| 6* | Tensile Testing | 57.0 | 88.7 | • Title Page not updated<br>• One draft was not submitted<br>• Revision History table incomplete<br>• Introductions could be expanded<br>• Excel Workbook not attached |
| 7* | Hardness Testing | 67.6 | 65.0 | • Material specifications not listed<br>• Lab protocol not followed<br>• Draft incomplete<br>• One final draft not submitted |

Table 2, Lab experiments, scores, and common instructor comments from the participating students. The asterisk (*) denotes the labs where participating students used the experimental lab template.

| Question | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Average Response | 10 | 7.5 | 6.0 | 8.5 | 9.0 | 8.5 | 7.0 | 7.0 | 8.5 | 8.5 |

Table 3, Average response scores to the post-lab survey.

From Table 2, the most common errors included: failure to attach sample calculations or their Excel workbooks (calculations), incomplete/unsubmitted drafts, graphing errors (missing titles, missing axis labels), and minimal data comparison. These errors persisted across both halves of the semester. According to Table 3, the students perceived that the instructions were well presented, that the experiment was relevant to mechanical engineering concepts, and that they would be able to apply the skills gained from the experiment (questions 1, 5, 6, and 4, respectively). The students were satisfied with participating in the experiment and believed it should be expanded to other lab courses (questions 9 and 10, respectively). Students did not respond favorably to whether the experimental lab template was useful for completing an acceptable lab report or for enhancing their overall technical writing and knowledge of experimental techniques (questions 3, 7, and 8, respectively). An inquiry with interviews and surveys about past experience with technical writing would help understand students' responses.

An interesting situation arose near the end of the semester, in which students' grades decreased sharply despite peer-reviewed feedback from classmates. This occurred because the instructor used the additive grading method (also known as “reverse-grading” or “zero-based grading”) for the course. By the end of the semester, many students were approaching the threshold for their desired final grade and thus put in less effort to complete or revise their assignments. Because of this course structure, the common theme of “incomplete draft sections” was not considered in the conclusions. On top of this, the peer-reviewing process-more specifically, the initial draft’s weight- also affected the submission quality. Initial drafts counted for 10% of the final lab report grade in each module, so students would submit subpar work and then make it up before the final submission. To achieve higher-quality data analysis, the course should either eliminate the peer-review process or place greater weight on the initial draft in the final grade.

One student provided feedback on question 11 of the survey. They highlighted a positive experience with the experimental template but noted the difficulties of transitioning to a new template mid-semester.

## Recommendations, Limitations, and Future Work

The authors observe that students were given clear instructions for the assignments, yet participants often did not submit their calculations in their final reports, and the submissions included very limited discussion of the data or of how their results compared with data from the literature. Figure 3 depicts the differences across the studies. Based on this, the authors should revise the template and rubric to emphasize the importance of including all work in sample calculations and provide additional guiding questions to spur discussion in the lab reports. The discussion/post-lab questions should be rescoped to spur discussion and reflection, rather than simply repeating information. The authors believe that technical writing remains an integral part of the engineering education experience, even with the advent of AI, but recognize that AI integrity training should be taught alongside technical writing to produce well-written lab documents.

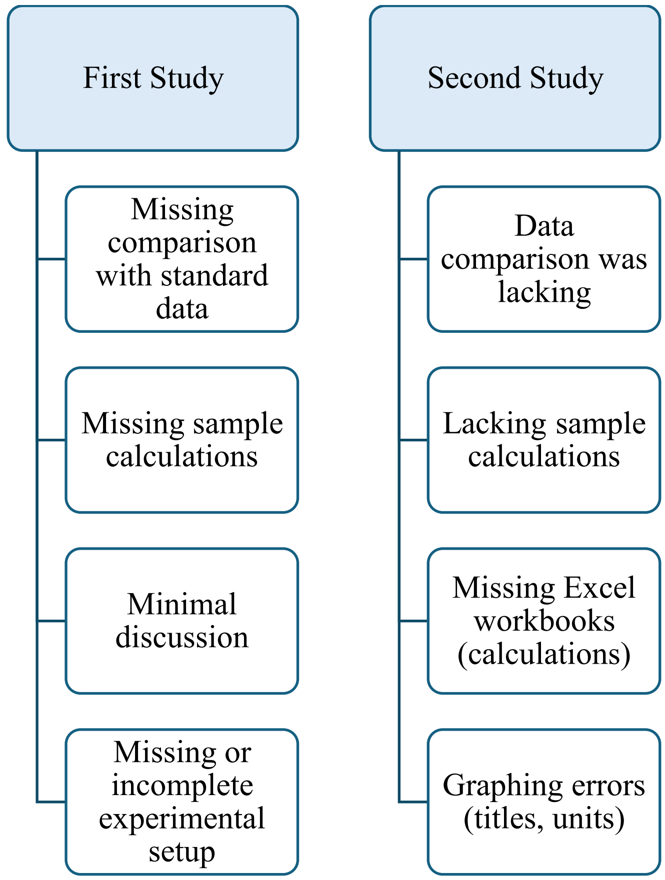

Figure 3, Themes and common errors found in the first and second studies.

The authors note limitations to the research project. The first limitation is participation in the research study. With one course section offered each academic year and a maximum course size of 20, recruiting participants to expand datasets will be difficult. This also affected the study because the instructor could give individual feedback to students. If the class sizes were larger, the research would depend more on peer review and instructor teams to compile the data. Another limitation of the qualitative analysis was that only one student completed the open-ended survey question across both studies; very little could be gleaned for thematic analysis. The authors will further refine and scope their qualitative analysis procedures on the laboratory documents and the post-experience survey.

Future work would include partnering with other engineering programs on campus, expanding and diversifying the dataset across multiple disciplines and laboratory levels. Another avenue for future work would be to revise recruitment methods and include incentives for participation in the research study, for which the authors would apply for grant funding to sponsor the research. Other future work options include partnering with a larger engineering program outside the home institution to provide greater depth for the investigation; we would ask larger engineering programs with multiple course sessions to implement this intervention into one course section and compare it to a control course section's technical writing.

## Acknowledgments

The authors would like to recognize the industrial partners on the UA Little Rock DCSTEM Leadership Council and Dr. Alexandru Biris from the UA Little Rock Center for Integrative Nanotechnology Sciences for their assistance with the research, including providing technical writing and standard operating procedure templates. The authors would also like to thank Dr. Anindya Ghosh for obtaining informed consent from the study participants. Lastly, the authors would like to recognize the UA Little Rock Institutional Review Board for their guidance and clearance for the research conducted.

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Appendix A- Spring 2023 - 2024 Lab Report Template and Spring 2025 Control Template

# **<u>Course Name</u>**

## **<u>(Course Number)</u>**

Lab V- Name of Lab

Semester Year

Submitted by:

Date:

# 1. Introduction

This experiment aims to…

# 2. CAD Model or Pictures of Experiment

# 3. ANSYS Workbench Project Schematic (if used)

# 4. ANSYS Mechanical Setup (if used)

# 5. Results

Graphs, Charts, Tables, and Pictures of Broken Specimen go here.

# 6. Conclusion

Answer Lab Questions and comparisons. Commentary on the Lab (what did you expect? Not expect? Any future studies with this that interest you?)

# References (if needed)

Appendix B- Spring 2023-2024 Rubric and Spring 2025 Control Lab Report Rubric

Rubric Detail

Levels of Achievement

| Criteria | Incomplete | Below Average | Average | Above Average | Full Points |
| --- | --- | --- | --- | --- | --- |
| **Introduction** Weight 20.00% | **0.00 %** No Title Page or Introduction | **50.00 %** Missing either Title Page or Introduction | **75.00 %** Some work completed, errors are evident | **90.00 %** All tasks were completed with a few minor errors or missed discussions or equations. | **100.00 %** Title Page, filled out completely. Introduction shows a clear and concise summary of the concepts, equations used, and aim of experiment |
| **CAD Model / Set up photos** Weight 20.00% | **0.00 %** No Pictures | **50.00 %** Very little Pictures of set up or design can be seen in the report / submission | **75.00 %** Missing Pictures but overall concept can be seen | **90.00 %** Pictures were given, but unclear, mislabeled, or missing some necessary details | **100.00 %** Necessary pictures were provided as to detail the set up for a future student to repeat this experiment. |
| **Data/Results** Weight 20.00% | **0.00 %** No Data or Graphs | **50.00 %** Graphs and data tables are missing, incomplete, or not reported. | **75.00 %** Data Tables and Graphs are missing figure numbers and axis labels. | **90.00 %** All Data tables are provided in but are not clear, or missing axis labels and units. | **100.00 %** All Data tables are provided in their document, filled out, along with graphs to analyze the data. |
| **Conclusions** Weight 20.00% | **0.00 %** No Concluding discussion or post lab questions. | **50.00 %** Very Little Conclusion, Discussion, or attempt at answering questions | **75.00 %** Some discussion and answers to post lab questions, some, however were not answered | **90.00 %** Discussion about the expectations, potential errors, conclusions, and post lab questions are attempted, with some details missing or some incorrect answers | **100.00 %** Discussion about the expectations, potential errors, conclusions, and post lab questions are clearly answered. |
| **Submission** Weight 20.00% | **0.00 %** No supporting files were attached. | **50.00 %** Files are Mislabeled and missing multiple files. | **75.00 %** Files are mislabeled or a file is missing. | **90.00 %** All Reports, Excel Sheets, CAD Models, Scripts, etc. are attached but some are missing name convention. | **100.00 %** All Reports, Excel Sheets, CAD Models, Scripts, etc. are labelled properly and attached in the submission. |

# **(Course Name)**

# **(Course Number)**

(Lab Number): (Name of Experiment)

## **Submitted by:**

(Name)

(School Email)

## **Submitted to:**

(Instructor’s Name, Instructor's Email)

**Date Performed:** (MM/DD/YYYY)

**Due Date:** (MM/DD/YYYY)

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## 1. INTRODUCTION

(Explain the lab/experiment in 100-200 words. Include relevant and brief backgrounds on the lab experiment topic. Give an abstract of the experiment, what it entails, and a summary of the data measured with the experiment.

## 2. OBJECTIVE (OF EXPERIMENT)

(The objective of the process is to measure x and y to determine the mechanical properties a, b, and c. This should also be around 100-200 words)

## 3. PURPOSE (OF REPORT)

The purpose of this document is to report the experiment's findings on (date), along with the processes and details necessary for sufficient repeatability (This should be around 100 words)

### A. RESEARCH QUESTIONS

1. Write Post Lab Questions Here (If applicable)

# 4. HEALTH AND SAFETY

## A. PERSONAL PROTECTIVE EQUIPMENT (PPE)

- List all necessary or advised PPE here. Includes (but not limited to): safety glasses, hearing protection, closed-toed shoes, gloves, long pants (not shorts), lab coat
- If this experiment is numerical (using ANSYS Fluent, ANSYS Mechanical, etc.), state it here.

## B. EMERGENCY CONTACTS:

- University Health Services:
  - Phone:
  - Location:
- University Department of Safety:
  - Phone:

# 5. MATERIALS

## A. APPARATUS (MACHINE OR SOFTWARE USED)

- Brand (or Software Name):
- Model Number (or edition):
- Picture of the Machine (or pictures of your ANSYS mesh):

## B. TESTING MATERIAL INFORMATION

- Material List and Uses
  - Provide applicable properties to the experiment
    - Ex. Thermal Conductivity, Density, Viscosity, Young's Modulus, etc.

## C. FLUIDS USED

- Lists Chemicals or Fluids used. If no fluids are used, type "No Fluids are used in this experiment."
- If used, provide pictures of the fluids
- If this is a numerical experiment, list the properties of the fluids from ANSYS (provide screenshots).

## 6. EXPERIMENTAL PROCEDURE

Reference the lab manual steps to complete this report portion, writing in past tense and 3rd person. Provide adequate details (one or two paragraphs) on the experimental procedure used to perform the lab experiment.

## 7. IMPORTANT FORMULAE & SAMPLE CALCULATIONS

| Name | Formula |
|---|---|
| | |
| | |
| | |
| | |
| | |
| | |

- Sample Calculations go here:
  - Include unit conversions, calculation steps, etc.

## 8. RESULTS

### A. SPECIMEN

- Show a picture of a specimen during and after testing (if applicable)
- Show pictures of the machine while running the experiment (if applicable)
- If this is a numerical experiment, provide screenshots of the mesh after running the experiment

### B. DATA COLLECTED

- Show data tables with numbers collected before/after the experiment as instructed in the lab manual
- Then show graphs/charts/plots of the data as instructed in the lab manual

### C. DISCUSSION

- Explain main data (results) from the data table (one or two paragraphs)
- Compare experimental data with the standard data (from textbook/internet source) and added appropriate justification if any error(s)

## 9. CONCLUSIONS

Write your conclusions from the lab, answer post-lab questions, and give commentary, expectations, and future studies. Add clear conclusion(s) or summary based on the experimental results

## REFERENCES


1. List References Here


## REVISION HISTORY

| REV # | RELEASE DATE | REVISED BY | REVISION DESCRIPTION |
|---|---|---|---|
| 0 | (Submission Date) | (Your Name)<br>(School Email) | N/A |
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |

Appendix D- Experimental Lab Report Rubric

| Lab report details | Points |
|---|---|
| **Cover (Title) Page (All in Times New Roman, 24 pt font)** | **5** |
| × Title of the lab | 1 |
| × Lab Number | 1 |
| × Student name, email & Instructor name, email | 1 |
| × Course number and name | 1 |
| × Date performed (lab experiment) | 0.5 |
| × Due date (lab report) | 0.5 |
| **Objective(s) and Purpose** | **5** |
| × Brief and clear aim(s) of the lab experiment | 5 |
| **Background (Introduction) - citations required** | **10** |
| × Relevant and brief background on lab experiment topic (one or two paragraphs based on the information from your textbook or online resources).<br>**Note**: *Add appropriate citation(s) in background. Do not plagiarize.* | 10 |
| **Health and Safety** | **5** |
| × List all necessary or advised PPE here. Includes (but not limited to): safety glasses, hearing protection, closed-toed shoes, gloves, long pants (not shorts), lab coat<br>If this experiment is numerical (using ANSYS Fluent, ANSYS Mechanical, etc.), state it here. Also, state which PPE would need to be used if the experiment were done analytically (in the laboratory). | 5 |
| **Materials and Methods** | **40** |
| **Materials:** | |
| × Adequate details on various materials, equipment, and instruments used to perform the lab experiment | 10 |
| × Added figure(s) (*images/pictures*) on various materials used | 5 |
| **Methods:** | |
| × Details on measuring parameters (independent and dependent variables) | 5 |
| × Adequate details (one or two paragraphs) on experimental procedure used to perform the lab experiment | 10 |
| **Important Formula & Sample Calculation:** | |
| × Added detailed calculations (sample calculation) including formulas, unit conversions, calculation steps, etc. | 10 |
| **Results (and Discussion)** | **20** |
| × Data table | 10 |
| × Explained main data (results) from the data table (one or two paragraphs) | 5 |
| × Compared experimental data with the standard data (*from textbook/internet source*) and added appropriate justification if any error(s) | 5 |
| **Conclusion(s)/ Summary** | **5** |
| × Added clear conclusion(s) or summary based on the experimental results | 5 |
| **References Page (and Appendix, if any)** | **5** |
| × Added "Reference page" | 5 |
| **Overall report** | **5** |
| × Grammar: Appropriate use of "**Third person and past tense**", spelling, report format<br>× Font type and size: **Times New Roman** and **12 font size** | 5 |
| **Total Points** | **100** |

Appendix E- Post Experiment Survey

1. How clear were the instructions for the laboratory experiment?
    a. (1 being very unclear, 10 being very clear) ________
2. To what extent did you feel prepared to conduct the experiment?
    a. (1 being very unprepared, 10 being very prepared) ________
3. Rate the usefulness of the technical writing templates provided for completing your laboratory report.
    a. (1 being not useful at all, 10 being extremely useful) ________
4. How confident are you in applying technical writing skills learned from this experiment to future assignments?
    a. (1 being not confident at all, 10 being extremely confident) ________
5. How satisfied are you with the instructor's communication of expectations?
    a. (1 being very unsatisfied, 10 being very satisfied) ________
6. Rate the relevance of the experiment to your overall understanding of mechanical engineering concepts.
    a. (1 being not relevant at all, 10 being extremely relevant) ________
7. How effective was the incorporation of industry-standard templates in improving your technical writing skills?
    a. (1 being not effective at all, 10 being extremely effective) ________
8. To what degree did this experiment enhance your understanding of proper experimentation techniques?
    a. (1 being not enhanced at all, 10 being greatly enhanced) ________
9. Rate your overall satisfaction with the laboratory experiment.
    a. (1 being very unsatisfied, 10 being very satisfied) ________
10. How likely will you recommend incorporating similar industry collaborations into future laboratory courses?
    a. (1 being very unlikely, 10 being very likely) ________
11. Please share any additional comments or suggestions for improving future laboratory experiences.