Increasing and Assessing Technical Argument Integration into Mechanical Engineering ME395: Laboratory 1

Pre-Assessment Results

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I. Background

ME395: Laboratory 1 is the Mechanical Engineering Department’s core laboratory course for juniors (100-150 students). It combines laboratory experiments drawn from across the department’s technical curriculum with writing on laboratory analysis and technical communication. During a typical semester, students perform eight or nine experiments in teams of three or four. The goals of each experiment are introduced through a take-home letter from a fictitious company. These technical letters provide scenarios in which a group of consultants (the student teams) are asked to perform a set of experiments and report back their findings and conclusions. Subject matter and engineering theory are drawn from courses on dynamics and vibrations, mechanics of materials, thermodynamics, and fluid dynamics.

Strengthening across laboratories and subject areas, overarching instruction focuses on two primary topics:

- Error analysis and interpretation: Students are instructed on identifying sources of error in experimental measurements (precision, resolution, and accuracy errors) and evaluating their impact on calculated results. Conclusions drawn from experimental outcomes are expected to be compatible with uncertainty of final results.

- Technical report writing: Students are instructed on the elements of an effective written technical report. While report format is standardized to an executive summary followed by procedure, findings, and conclusions, with accompanying instruction, additional lectures are dedicated to topics such as task letter interpretation, organization, effective use of figures, readability, and communication best practices.

II. Project Goals

The goal of ongoing curriculum development in ME395 is to improve the teaching of technical arguments through discrete changes to course structure, and to assess the impact of these changes by reviewing laboratory reports before and after curriculum development.

Traditionally, ME395 instruction is lecture-based and forward-looking.

- Technical communication topics introduced through a series of largely self-contained lectures.
- Engineering topics introduced as required by upcoming labs, with minimal review of past labs.

Support from a University of Michigan Whitaker Fund teaching grant is being used to perform course assessment and resulting curriculum development.

(Primary) Convert a portion of technical communications instruction to a writing workshop format, in which students actively apply the theory discussed to real-world writing tasks.

(Secondary) Provide students with opportunities to review/literature on students’ prior experiment integration to discuss effective approaches to technical argumentation.

III. Project Status

Results presented in this paper are drawn primarily from pre-assessment of technical argumentation in several aspects of technical argument, drawing from three semesters in which the authors co-taught the course.

1. Fall 2010: Traditional format
2. Fall 2011: Traditional format
3. Fall 2013: Writing workshops first introduced

Full incorporation of proposed curriculum changes will be implemented in Fall 2015, with review of additional student reports to be completed for comparison to older reports.

For the purposes of pre-assessment, laboratory reports are drawn from the course’s two individual labs, Lab 4 and Lab 7. Although task letters vary between semesters, the scenarios are in similar context and permit head-to-head comparison between reports from the same cohort of students. In particular, Lab 7 reports require similar logical progressions relating engineering theory to experimental results, from which proper conclusions are highly subject to experimental uncertainty. Lab 4, on feature of aluminum, requires assessment of whether fracture specimens have entered a regime of plane strain, while Lab 7, on fluid dynamics of a blower, requires assessment of whether self-similar behavior is present.

IV. Pre-Assessment Methods

A total of 42 laboratory reports have been reviewed, with 7 reports for each of ME395 Lab 4 and Lab 7 drawn from each of the three prior years of instruction. Reports were drawn from students evenly distributed in grade rank between years, representing A to D grades in the course. Students belonging to the same team in either Lab 4 or Lab 7 were also excluded to avoid overlap in laboratory results.

Traditional report grades combine evaluation of these technical and communication activities (i.e., proper use of equations, informative figure preparation) with more advanced technical argument content (i.e., interpretation of results in context of uncertainty, justifying conclusions or recommendations). An excerpt of a typical grading rubric is shown below.

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V. Results

Review of reports based on the criteria in Section IV enabled us to compare effective versus ineffective communication strategies employed by students.

2. Significant improvement in argument details between the first and second individual labs was not observed, despite an overall improvement in most grades over the duration of the course.

VI. Conclusions

Some possible interpretations:

- Students’ basic organization skills improved, and greater attention was given to the mechanics of report writing, but higher-level critical thinking was little influenced by current teaching practices.

- Large number of topics encountered within class obscures overarching themes across labs and across reports.

- Pre-assessment methods based on limited differentiation (3-level) of proficiency lead to relative error margins in pre-assessment results.

- Similarly, we did not observe significant changes in student performance following the first use of the writing workshops (Fall 2013)

VII. Future Work

Based on our analysis thus far, further curriculum development will focus on opportunities to:

1. Expand discussion of error analysis steps related to specific lab questions, to increase the number of examples of error analysis procedures seen by students.
2. Review key points and elements of argument after report completion, drawing on examples of well-argued and poorly-argued reports.
3. Investigate student performance at placing arguments in context of students’ problems, which was not addressed in review of reports across courses using different tools.

Acknowledgments

The investigators gratefully acknowledge financial support from the Center for Learning and Teaching and UM Whitaker Fund for support of ongoing curriculum development opportunities.