The Impact of Non-Traditional Laboratory Report Formats on Student Performance of Course Objectives

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Abstract – Numerous engineering courses include a laboratory component to augment comprehension of a given topic, with a lab report serving as a typical measure of student learning for these activities. This paper investigates the theory that a complete lab report may not be necessary to achieve the desired course outcomes, but rather a series of non-traditional laboratory report formats may serve the same purpose, while keeping students engaged and appealing to a wider range of learning styles. Results over three semesters suggest that student performance on course objectives is independent of the type of report submission, suggesting that extended reports are not necessary for topic comprehension. Details on the various report formats, student performance on associated assessment measures, and instructor perspective on benefits and limitations associated with non-traditional report formats will be presented.

Keywords: lab reports, Geotechnical Engineering, student assessment

BACKGROUND

The junior level Geotechnical Engineering I course at Florida Gulf Coast University (FGCU) is laden with laboratory activities throughout the semester. Offered in the spring, the course is not the first Engineering lab class students encounter, having completed sophomore level course such as Mechanics of Materials and junior courses of Civil Engineering Materials and Fluid Mechanics. Add to this the science lab courses, such as Physics and Chemistry, and it becomes even clearer that lab reports are not a new concept to the students in Geotechnical Engineering. Often these reports are standardized across a course, or possibly even across a series of courses or curriculum and provide students with an established format and clear set of expected deliverables [1]. Additionally, the reports can serve as assessment of not only knowledge gained, but also the ability to communicate; albeit more often than not on a group basis. The inclusion of laboratory activities is common in an engineering curriculum, and past research has considered the relative importance of the lab activities as they contribute to the undergraduate educational experience [2 – 4]. In addition, research has looked at the benefits and limitations associated with report writing linked to laboratory activities [5].

In the instructor's experience, many of the students approach laboratory report writing as an arduous chore and believe that greater quantity in the report equates to higher quality of the report. In an effort to dispel this notion, one of the primary goals of the revised lab reports in the course is to foster recognition for clear, concise and professional writing. Regardless of the topic, most lab reports are typically assigned to address one or more of the following broad learning objectives:

1. Improve students' written communication skills
2. Facilitate enhanced comprehension of select course material

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3. Validate results or justify causes of unexpected values based on standardized testing procedures

These objectives supplement skills and experiences gained from the actual performance of the lab. The focus of the revised reports was not on changing the in class lab experience, but rather to optimize the out of class post lab experience. Keeping these three objectives in mind, several potential revision options were considered. The first overarching conclusion drawn was that no single structure for the report would be utilized. This decision was made for a number of reasons. First, it is quite rare for individuals entering the workforce to be expected to adhere to a single delivery mechanism. In today's world each state, local or national agency or company may have established formats, but rarely are these universal. Second, requiring a variety of formats emphasizes attention to detail and highlights the fact that several different methods can be effective means of presenting information. Third, with the removal of the "cookbook" type approach, students may be more engaged with the process as more attention is required to deliverable expectations. Lepek and Stock [6] revised laboratory report submissions in a similar manner – including posters, memorandums, and oral presentations in addition to the more traditional reports and considered the impact of these revised reports on students' ability to communicate (objective 1) but did not present in detail the impact on student topic comprehension (objectives 2 and 3).

A second focus was a greater emphasis on what was being said, over how much was being presented. Hoffa and Freeman [7] conducted a rigorous study comparing the traditional report to that of a "synopsis" report (limited to a single page) in which the results and conclusion, rather than the background and process, were the emphasized topics. Their results found no significant difference in topic comprehension between the two submission types. Many student experiences with labs are often extensive reports in which critical points are identified by the "shotgun approach" (i.e. if enough information is given, hopefully some of it will be what the instructor wants). Including reports that drastically limit the overall length force students to more critically evaluate what they are saying and how it links back to the key concepts of the lab. The focus on clear and concise statements encourages intentional wording and the thoughtful integration of ideas.

APPROACH

The approach was undertaken in a Junior level soil mechanics class, which includes approximately ten different laboratories over the course of the semester. These lab activities are standardized not only from semester to semester, but also compared to established testing methods, such as ASTM, typical of a traditional lab experience. Lab activities remain essentially the same from year to year, while the report formats are adjusted or rotated on an annual basis. In addition, a new report method has been introduced every year for the past three course offerings. These lab reports range from a complete standard report or select sections (such as an abstract and appendices only) of a standard report to less established methods of submission such as a poster presentation or pecha kucha, each of which will be discussed in more detail in the following subsections. Reports are submitted either individually, in teams of 2 – 3 or in groups of 5 – 6. The variation balances more individualized assessment, team writing experiences, and ever increasing class size constraints. While the format may change for each report, certain standards are expected of all submissions: proper spelling and grammar, table and figure referencing and captioning, and the use of appropriate terminology and formality in the writing style. In addition, each report assignment clearly delineates what is expected in the deliverables.

Complete Standard Report

The Department of Environmental and Civil Engineering at FGCU has un-officially adopted a set of standards for technical reports, a copy of which is presented in several courses throughout the curriculum. This standard provides students with an established set of guidelines for both laboratory and design project reports and includes recommended report sections as well as formatting suggestions. Recommended sections for a laboratory report include the abstract, introduction, theory, experimental procedures, results and discussion, conclusions, references, and appendices. This more robust format is still required of one report within the Geotechnical Engineering I course. Unlike some of the other formats, this format has, in the past, been permanently linked to the final individual report submission of the semester. The justification for this link is to evaluate individual performance on a complete report, based on students having received feedback on several reports throughout the semester. Report length for this format (not including appendices) is typically 8 – 10 pages in length.

Short Report

One format developed with only minor modifications to the complete standard report is that of the short report format. The expectations for this format include a brief introduction, an abbreviated experimental procedure, results and discussion, and conclusions sections as well as the references and appendices. Unlike the complete report, where the experimental procedures must be fully developed, in this short report format this section can simply reference established laboratory standards that were followed, with a mention of any variations. Additionally this format has only a brief introduction, described as a single paragraph establishing the objective of the lab, rather than a more extensive objective and relevance section in the complete report. The other included sections of the report are identical to that of the complete report format. Excluded and condensed sections reduce the report length for this format (not including appendices) to 3 – 5 pages for a typical submission.

Select Section Report

Two layouts were developed that focus on distinct sub-sections within the complete report format. The first is what is termed the "abstract & appendices" report. As the name implies, this format requires only the single page abstract as well as the information typically found in the appendices (most often raw data sheet, hand calculations, and summary tables or graph). This format emphasizes the fact that abstracts should contain details from all sections of a typical report and thus should be able to provide a sufficient overview of key points. The second format is a "results and discussion" report which concentrates on laboratory output and an interpretation of results / justification of potential errors. While reliable and replicable lab data is desired, the ability to recognize and correlate erroneous data to variations in laboratory procedures is of utmost importance. For this format, key tables and graphs are typically expected in the results section rather than being relegated to appendices in other format layouts.

Excel Submission

A laboratory report submission that consists of an Excel file only was the new report format added three years ago. This submission underscores the importance of organization not only in documents, but also in electronic format, requiring submissions to document where values in each cell (or column) were obtained and adding features to graphs that may not have been emphasized in previous courses. This format proves especially beneficial in the subsequent Geotechnical Engineering II course, as students are required to submit an organized compilation of data analysis from a more complex design problem.

Poster

As implied by the title, this submission is similar in scope to that of a poster presentation; however it is limited in size to an 8.5″x11″ sheet of paper. This format contains the same set of sections as a short report, but utilizes a layout that requires a balance between writing and data presentation in tables or figures. Other considerations include the use of color and/or background patterns incorporated to enhance interest, but still allow for clarity in the presentation.

Lab Tweet

Adopted as the new lab format two years ago, a lab "tweet" is another single page report that imposes a word limit of no more than 140 words on the discussion section of the report. The framework is a hybrid of the "results and discussion" and poster formats in that it focuses on including tables and figures appropriate to the lab results with the limited lab discussion and presents this information on a single page. A high level of organization and clarity of discussion are critical in this approach to achieve a successful submission.

Pecha Kucha

Started in Tokyo in 2003, pecha kucha is a presentation style based on 20 slides and 20 seconds per slide [8]. While the standard combines the spoken word with illustrations only for a presentation lasting approximately 7 minutes, the lab submission format incorporated last year allows for the same 20 slides at 20 seconds per slide, but allows for words on the slides, as no spoken word is linked to the submission. Students are required to implement automatic timing in their submissions and are encouraged to recognize limitations associated with how much information can be gained from slides within the specified time frame.

Index Card Report

Historically used in the course as the first individual lab report, the format limits responses to a single side of a 4″x6″ lined index card. The initial report is feedback on a soil sample collected by the student, with the written portion addressing the collection location and any general information known about the sample. Index cards were initially used to provide a more durable submission better able to resist moisture present in the sample bag, but also serve as a clear indicator of how serious the instructor is regarding concise reports. Use of this format will be expanded in coming semesters to summarize discussions on lab results that occur during the class.

ASSESSMENT

Assessment of the impact of the non-traditional laboratory report formats is linked to the three broad learning objectives presented earlier in the background section. Results from the assessment of students' written communication skills are utilized as an assessment point for Outcome g of the Civil Engineering Program which is the "ability to communicate effectively." Geotechnical Engineering I is a course in which this outcome has been assessed since Spring of 2010. Table 1 presents the results for the past three years on student attainment of outcome g based on performance on laboratory reports.

Table 1: Student Assessment for Program Outcome g "an ability to communicate effectively" for Spring 2010 – 2012 in Geotechnical Engineering I

Assessment / Tool / Outcome	**Average of Total Points Earned as a Percent of Total Lab Points Available**	Results		
		Spring 2010	Spring 2011	Spring 2012
Program Outcome g "an ability to communicate effectively"	Goal: 40% of the students score 85 or above	56%	29%	28%
	Goal: 70% score 70 or above	98%	98%	96%
	Goal: 80% score 65 or above	98%	100%	96%

The goals presented in the central column of the table were established collectively by the faculty and reflect expectations for junior level courses. Results are based on individual student overall averages of total laboratory points earned as a percent of the total laboratory points available. This is a combination of approximately an equal distribution of individual, team, and group work interspersed throughout the semester. Results of the minimally competent and competent (score of 65 or above and 70 or above, respectively) are reasonably consistent across the three year period. Results for the highly competent (score of 85 or above) are similar in the last two years, but experienced a notable drop from the first year presented. As non-traditional reports were incorporated into all three semesters, correlating this difference to the introduction of these report formats is not reasonable. Anecdotal evidence from faculty retreats has noted the written communication skills of more recent students have declined, and the program is placing an emphasis on improving technical writing. A point to consider is that the course is junior level, and assessment is conducted at both the junior and senior level with regards to program outcomes, thus non-attainment at this point is a concern, but not a significant problem.

The second and third learning objectives for lab reports include enhanced comprehension of course material and validation of tests performed. Assessment of three learning objectives linked to three separate lab reports will be presented for the same semesters as the written communication assessment previously. The labs under consideration are Grain Size Distribution, Permeability, and Compaction. These labs map to the following course learning objectives:

- Classify soil according to the Unified Soil Classification System [requires identification of relative percent of soil types, calculation of coefficients of uniformity and curvature]

- Develop field specifications based on laboratory results for compacted soil [requires the construction and interpretation of proctor compaction curves]
- Calculate soil permeability based on lab and field data

Table 2 summarizes the type of lab report associated with each of the lab activities performed as a function of semester as well as the average score on the associated exam question. Overall exam averages fell into a range of approximately 7% (low to high) for the three semesters presented. Averages on each objective were within this overall range. Performance varied from objective to objective, but these variations were fairly consistent across semesters. Exam questions from semester to semester are quite comparable, with the overall format remaining consistent and the major variations in the raw data presented (e.g. different grain size distribution curve, variations in compaction data). One interesting note from the results presented, although it could be completely coincidental, is the greatest spread is within the grain size distribution data for the same type of report.

Table 2: Lab Report Type and Average Exam Score for Related Course Learning Objective as a Function of Semester for Grain Size Distribution, Permeability, and Compaction Labs

Topic	Spring 2010	Spring 2011	Spring 2012
Grain Size Distribution	Excel (88.7%)	Poster (80.7%)	Excel (81.3%)
Permeability	Results & Discussion (74.4%)	Abstract & Appendices (73.3%)	Lab Tweet (70.0%)
Compaction	Short (79.8%)	Lab Tweet (76.0%)	Abstract & Appendices (75.0%)

INSTRUCTOR PERSPECTIVE

From an instructor perspective the revised approach has both strengths and weaknesses compared to the more standardized approach. More concise reports optimize the time spent in evaluation and assessment – even more important when class size grows at a rapid pace, as is the case over the past few years at FGCU. Additionally the instructor has the ability to switch the type of report expected for a particular lab every semester. This provides another preventative measure from receiving plagiarized work from previous semesters as the report format is often completely different. The different formats also provide an increased interest both from a student and instructor perspective. One of the most significant weaknesses is the fact that since the number of formats is fairly large; care must be taken on the instructor level to clearly express deliverable expectations for each report. Connected with this is the greater difficulty students appear to experience translating feedback from one format into improvement on a different format, an issue that is minimized with a standard format approach. These concerns can become frustrating from both an instructor and student perspective. One way to try and minimize this weakness is to present examples of strong submissions from previous semesters. This approach has been undertaken for some formats, although currently is not incorporated for all format types. Future offerings of the course will continue to incorporate new report formats and will begin to cycle through the formats presented – including some, but not all, each semester. Formats that are under consideration are videos, blogs, or approaches that utilize various Web 2.0 technologies.

CONCLUSIONS

Providing opportunities for students to complete lab reports in formats other than the standard expected form has been shown to have a comparable effect on student topic comprehension and ability to communicate effectively through writing. The varied formats emphasize clear and concise writing and an increased focus on critical points

from laboratory results. Future studies will consider the impact these reports have on critical thinking skills, student perception of knowledge gained, and student interest in laboratory report activities.

REFERENCES

[1] Beams, D. and Niilar, L. (2004). "Improving Technical Writing Through Published Standards: The University of Texas at Tyler Electrical Engineering Laboratory Style Guide," *Proceedings of the ASEE Annual Conference and Exposition,* Salt Lake City, Utah.

[2] Feisel, L. and Rosa, A. (2005). "The Role of the Laboratory in Undergraduate Engineering Education," *Journal of Engineering Education*, 94, 1, 121 – 130.

[3] Felder, R. M., and Peretti, S. (1998). "A learning theory-based approach to the undergraduate laboratory," *Proceedings of the ASEE Annual Conference and Exposition*, Seattle, Washington.

[4] Gillet, D., Latchman, H. A., Salzmann, C., and Crisalle, O.D. (2001). "Hands-on Laboratory Experiments in Flexible and Distance Learning," *Journal of Engineering Education*, 90, 2, 187 – 191.

[5] Shull, P. (2000). "Formal Laboratory Reports Pros and Cons: An Interim Report," *Proceedings of the ASEE Annual Conference and Exposition*, St. Louis, Missouri.

[6] Lepek, D. and Stock, R. (2011). "Alternative Lab Reports – Engineering Effective Communication," *Proceedings of the ASEE Annual Conference and Exposition*, Vancouver, British Columbia, Canada.

[7] Hoffa, D. and Freeman, S. (2008). "Synopsis Laboratory Reports: Effects on Student Learning and Curricular Benefits," *Proceedings of the ASEE Annual Conference and Exposition*, Pittsburgh, Pennslyvania.

[8] Pecha Kucha. "Pecha Kucha 20 x 20," http://www.pechakucha.org, (25 January 2013).

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