2023 Annual Conference & Exposition
Baltimore Convention Center, MD | June 25 - 28, 2023
The Harbor of Engineering Education for 130 Years
ASEE
Paper ID #39150

Client-Focused Technical Writing through Laboratory Report Preparations in Geotechnical Engineering: A Case Study

Dr. Nirmala Gnanapragasam, Seattle University

Dr. Nirmala Gnanapragasam is an Associate Professor in the Department of Civil and Environmental Engineering at Seattle University. She also serves as the Design Coordinator for the department's capstone design program. She is a licensed professional engineer in the State of Washington.

Client-Focused Technical Writing through Laboratory Report Preparations in Geotechnical Engineering - A Case Study

Abstract

ABET 2019-20 Criterion 3 requires that engineering students at the time of graduation possess the "ability to communicate effectively with a range of audience". This paper presents a case study of the author's approach to achieve this outcome in a junior level soil mechanics course. In the laboratory portion of the soil mechanics course, students were presented with a real-life problem faced by a fictious client. Students performed standard laboratory experiments, analyzed the data, and compared their experimental results against applicable guidelines or codes to arrive at recommendations to the client. Students prepared technical reports with clients as potential audience and learned the fundamentals of technical writing along the way. In addition to meeting the ABET criterion, this approach also prepared the students to enter the work force with the necessary tools. This paper presents the details of the course approach and the assessment results for the past seven years. Student learning was assessed through report grades and student surveys. The student scores improved over the quarter; student surveys showed consistent increase in the ratio of preparation to importance starting from the beginning of the quarter through the end of the quarter up to the time of graduation. Written comments by students at the end of the course, at the time of graduation and after years of professional practice indicate an appreciation for the approach of client-focused laboratory report writing.

Introduction

Engineers need to have strong communication skills to carry out their day-to-day work and to advance in their careers. Engineers spend almost two thirds of their overall work time on some form of written or oral communication [1]. Of that, half the time is spent on written communication – preparing proposals, reports, memos, feasibility studies, white papers, operating manuals, engineering specifications, business letters and responding to emails. Rhodes [2] summarizes it well in his paper that "Long after most professional engineers have ceased to integrate a differential equation, they are still required to write technical reports".

Despite the importance and the amount of time engineers spend in written communication, engineers are considered to be poor writers [3]. To overcome this deficiency and to meet industry demand, the Accreditation Board of Engineering Technology (ABET) in its 2000 Criterion 3 required that all engineering graduates demonstrate an ability to communicate effectively at the time of graduation (criterion g of a-k program outcomes). In the ABET 2019-20 accreditation cycle, student outcomes 3 of criterion 3 was modified to graduates demonstrate an ability to communicate effectively with a range of audience [4].

Engineers write to a broad range of audience at work - engineering and non-engineering clients, the public, people in upper management, funding agencies, contractors, fellow engineers, potential employers, and graduate schools, to name a few. In addition, engineers must cater to three types of readers when preparing their technical documents: those who only read the text, visual readers who only look at graphs, figures and tables and the rest who read the text and the visuals [5]. Engineering programs planning for ABET accreditation visits need to identify how to

incorporate technical writing into their curriculum and develop a plan to assess the "ability to communicate effectively with a range of audience".

This paper presents a case study where students learn the basics of and practice client-focused technical writing in a junior level soil mechanics laboratory course in the department of civil and environmental engineering at Seattle University. The course organization, selected assignments, student evaluation, benefits and outcome assessment results are presented.

Literature Review

There is plenty of literature available on the importance of technical writing [1], [6-9], compilation of survey results of engineering students, graduates and employers [1], [3], [6] and variety of ways in which engineering programs around the country incorporate and improve the technical writing skills of their students [1], [10-19].

In most engineering programs, students write proposals, reports and technical memos to an external sponsoring agency in their senior year as part of the capstone experience. Although there is much written on senior design programs around the country, literature that solely focuses on technical writing within the capstone experience is somewhat limited [20-26]. Furthermore, the author has come across only very limited studies on engineering undergraduates writing to a range of audience prior to their capstone experience. In this paper the author focuses on literature where engineering students write to an audience other than the course instructor outside of a senior capstone course.

To meet the demands of the Silicon Valley employers, San Jose University College of Engineering redesigned its technical communication course with the goal of developing writing and speaking skills that students could use in their future careers. The course is taken by all engineering students in their junior or senior year. As part of the course, students write proposals, memos, and executive summaries in the areas of environment and sustainability. Although the course is taught by in-house faculty, several Silicon Valley entrepreneurs serve as guest speakers. Students were given a range of assignments involving writing to a variety of audience. Students were assigned to write a persuasive letter to the Undersecretary of Commerce for Oceans and Atmosphere on ocean acidification, a memorandum to the engineering dean requesting a feasibility study on implementing electronic waste recycling program on campus, a business letter to a client proposing an energy efficiency project with cost analysis showing that the project pays for itself and a set of instructions for an object or process. Students also put together a resume and an accompanying cover letter and a letter to a faculty member requesting a recommendation for a scholarship or to graduate school [27]. The authors found that the students were engaged in the writing process when they believed it helped their career. It was also beneficial for the students to hear frequently from the practitioners that technical writing was their most valuable course or regret that practitioners did not take a course on it while in college.

In the Electrical Engineering department at the University of San Diego, sophomores through seniors practiced "writing to communicate" as part of homework, laboratory section and coursework with their peers as audience. In a sophomore level circuits course, as part of a homework assignment students had to write a user's manual for PSpice, a circuit simulation

software. Writing a User's Manual is a common task for those entering industry involving product design. In a junior level electronics course lab section, students were required to write a memo to their classmates explaining the behavior of their circuit. This assignment provided an opportunity for the students to explain their circuit to their peers while learning how their peers' circuits worked without having to analyze multiple circuits. In a senior level optoelectronics elective course, every week a student had to select an interesting article from a trade journal, write a summary of the article and come up with at least two discussion questions. These were shared with the rest of the class and the student led a 15-minute discussion session the following week. This helped the students to learn materials outside the regular curriculum and improve their written and oral communication skills [28].

In junior level dynamics and introductory structural analysis courses at Texas A&M University, students were tasked with analyzing open-ended, design-oriented projects and thereafter asked to pretend to be engineering consultants and report their findings and make recommendations through a written report. In this project-based learning exercise, one of the five goals was to improve the written communication of the students; the other four goals being, 1) applying the knowledge of math, science and engineering, 2) functioning in a multi-disciplinary team, 3) formulating and solving engineering problems, 4) using computers to solve engineering problems. The paper includes examples of the assignments and a rubric developed to grade the reports. Following the introductory structural analysis course, the students took a senior level reinforced concrete design where they had to complete a design project involving a multi-story office building. Student project scores were compared between those who had the introductory structural analysis with and without the project component. On the average the former scored five points higher than the latter [29].

In a communication elective course at Rochester Institute of Technology, one of the assignments required students to prepare a trouble shooting documentation for a technological system or an equipment. Trouble shooting documents could take multiple forms: tables, step-by-step instructions, flow charts or narrative. Students learned that they needed a thorough understanding of the process or equipment, had to gather all necessary information, and consider various visual aids to clearly come up with a document that could meet the skills and knowledge of the audience to quickly and accurately diagnose the problem [30].

In a technical writing and experimental design course aimed at sophomores at Southern Indiana University, one of the assignments consisted of performing a laboratory experiment, synthesizing the results in graphical form and thereafter preparing a two-paragraph engineering memorandum summarizing the findings. In the same course in a different module, students were required to prepare a business proposal as if responding to a Request for Proposal (RFP) for a protype product based on given parameters and performance specifications. First the students designed, built and tested the prototype. Following this they prepared the business proposal documenting their design, including the associated cost, and the results of the testing as if presenting it to an external client [31]. Results presented from the above study showed that though students recognized the importance of technical communication, their performance did not improve much during the semester. Because this study was done only for one semester during the pandemic, the authors conclude further research is needed.

In Texas A&M University Qatar campus, the Engineering Enrichment Program partnered with a writing professor to introduce entrepreneurial and improve communication skills of students in a sophomore level English course. In 2017, the students were assigned the task of developing a prototype of a healthcare related product. Students had to first write a proposal to their supervisor describing the problem they are trying to solve with the necessary background. Following this, students presented their project to the peers to get feedback on their product idea. Thereafter students collected data from literature, synthesized it in a graphical form and prepared a memorandum explaining how this data pertains to their product development. The end of semester project deliverables consisted of the prototype, a poster describing the product and a brief video inviting the viewer to invest in the product. Student surveys showed that the entrepreneurial aspect of the project inspired students to be better communicators [32].

Overview of Course Organization

The author's institution, Seattle University, has an ABET accredited Civil Engineering program. The average class size in a civil engineering discipline specific course is around 25. One of the missions of the department is for graduates to possess strong written and oral communication skills. Communication skills of the students are developed throughout the civil engineering curriculum starting with laboratory reports in the sophomore year through a year-long, industrially sponsored capstone design experience where students prepare written proposals, design reports, memos, reflection papers, and posters for an external project sponsor.

CEEGR 3530 - Soil Mechanics is a 5 (quarter) credit junior level course required of all civil engineering majors for graduation. The course involves three 85-minute lecture periods and one three-hour weekly laboratory session. The concepts covered in the lectures are reinforced through traditional undergraduate soil mechanics laboratory experiments, namely, grain size distribution, Atterberg Limits, Proctor compaction, constant head permeability, direct shear testing and unconfined compression testing.

At the end of each laboratory experiment, students write a laboratory report individually as required in other science/engineering courses presenting the experimental data, reducing the data, and analyzing the results. What makes CEEGR 3530 stand apart from other courses is that three of the lab reports are written with external clients as the audience.

Logistics of Experimental process and Report Preparation

For three of the experiments (grain size distribution, compaction and permeability testing), students are given a real-life scenario encountered by a client (a county, a city, a private developer or a homeowner). Table 1 presents some examples of the assignments for each of the three experiments. Students perform the experiment in small groups according to standard ASTM procedures to reinforce the concepts they are learning in the course; they collect the experimental data and then use it to find a solution to the client's problem. For the rest of the experiments (Atterberg Limits, direct shear testing and unconfined compression testing) students collect and analyze the laboratory data but do not prepare a detailed report. This is planned intentionally to make the report writing and grading manageable for the students and faculty, respectively.

The instructor spends the first laboratory session discussing the basics of professional report preparations, engineers' responsibility to a client, details of the various parts within a report and the scoring rubric and expectations. From past observations, engineering students greatly dislike receiving negative criticism on their writing which is supported in the literature [8], [20]. To emphasize the importance of reviews and to prepare the students to receive critical feedback on their reports, the instructor shares examples of faculty members' drafts of technical manuscripts criticized by colleagues within the department.

Reports are required to be single spaced, word processed with a minimum 11point font, and 1" all around margin. Repetitive calculations are to be done using a spread sheet. All pages, figures, tables and equations should be appropriately and sequentially numbered. In accordance with engineering convention, figures captions should appear below the figures and table captions should appear above the tables.

Following the completion of each experiment, students prepare a professional report addressed to the client that resembles the ones seen in engineering practice. They present the results in conventional form as either figures or tables as accepted by the industry. Thereafter they analyze the experimental results, compare them against accepted design guidelines, and attempt to solve the client's dilemma and/or make recommendations.

Scoring Rubric and Grading of Reports

Figure 1 shows the scoring rubric used to grade the reports. This rubric was developed specifically with the user (ie. the client) in mind with regards to the following:

- letter of transmittal to client with emphasis on proper placement of sender and recipients' addresses, purpose of letter and professional ending.
- report title that succinctly describes a client's dilemma. *For example, the title "Sieve Analysis" does not convey the problem encountered. However, "Suitability of a Soil for Infiltration Pond Usage" gives the reader the context of the report.*
- introductory paragraph that clearly defines the engineer's understanding of the project, client's need and the scope of the project.
- figures and tables of professional quality with descriptive captions appropriately placed; figures and tables are self-contained, sequentially numbered and referred to in the text.
- professional appearance of reports: pages numbered with Roman numerals prior to the beginning of main report and Arabic numerals beyond; compilation and presentation of appendices.

Table 1. Real Life Scenarios Posed to the Students for the Various Laboratory Experiments

Topic (Lab Experiment performed)	Example of Scenarios
Grain Size Distribution (Sieve Analysis)	• Inadequate infiltration of storm water is causing flooding of residences and other property damage in a residential development in King County. You are provided with a grab sample from this infiltration pond. Your task is to explain the poor performance of the infiltration pond using sieve analysis results and come up with recommendations to overcome this problem. • Homeowner, Mr. T Rubble, is interested in constructing a rain garden on his property in the north Seattle area. He has approached you to test if the soil is suitable as a bio-retention soil media. Your task is to perform a sieve analysis and report if the soil meets the guidelines specified by Low Impact Development – Technical Guidance Manual of Puget Sound, 2012.
Compaction (Standard Proctor)	• The given soil is to be used as embankment for a Washington State Department of Transportation (WSDOT) earth embankment. WSDOT wants you to run the Standard Proctor compaction test on the soil and provide the compaction curve, minimum dry unit weight and suitable water content range to meet the WSDOT Geotechnical Design Guidelines. • The given soil is to be used as a fill material for a residential development in Thurston County. The engineering firm wants you to run the Standard Proctor compaction test and provide them with compaction curve to write the specifications to the contractor.
Permeability (Constant head testing)	• Snohomish County is interested in designing a rain garden on one of their project sites. A grab sample from the site is sent to you for testing. You are required to run a permeability test on the native soil and recommend the site's suitability for the construction of rain garden. • City of Seattle is planning on using a biofiltration system as pollution control technique in the city projects. The city has sent a soil sample that it plans to use as a soil filter medium in the biofiltration system. Your task is to conduct a permeability test and determine the suitability of the soil for this application.

TITLE	3	2	1 0
• Has appropriately detailed but concise technical title. • Describes topic; identifies writer's problem or purpose. • Font stands out from rest of the report.	Meets all criteria	Meets some criteria	Meets few criteria
COVER LETTER	4	3 2	1 0
• Addresses/date appear correctly; client's name spelled correctly. • Has opening paragraph describing purpose of letter. • Has professional ending. • Letter signed. • Does NOT include details of results/recommendation. • No spelling/grammatical mistakes; gives positive first impression. • Creative and refreshing to read.	Meets all criteria and refreshing to read	Meets some criteria	Meets few criteria
INTRODUCTION	4	3 2	1 0
• PURPOSE: States purpose of experiment; identifies client and explains client needs clearly; done concisely.	Meets all criteria;	Meets some criteria;	unclear
METHODOLOGY	3	2	1 0
• Provides name of experiment; if standard equipment states relevant ASTM Standard(s). • If non-standardized equipment is used, includes ASTM Standards; clearly describes apparatus and procedure; in a narrative form, outlines procedure for another engineer to replicate experiment.	Meets all criteria	Meets some criteria;	Meets few criteria; unclear or undeveloped
CALCULATIONS	5 4	3 2	1 0
• Raw (ie. lab) data sheet is included. • Calculations complete; sample calculations included. • Calculations correct, logically arranged, easy to follow. • Relevant spread sheets attached and sample calculations presented in reader friendly manner. • All assumptions explicitly stated. • Approach briefly explained in words to guide reader.	Meets all criteria at high level; clear, easy to follow;	Meets some criteria; needs improvement	Meets few criteria; often unclear or undeveloped
FIGURES AND TABLES	5 4	3 2	1 0
Quality of content • On graphs, data points included as markers, appropriately sized and lines of best fit. • Figure/tables have units, appropriate significant digits. • Gridlines included as appropriate for type of experiment. **Quality of graphic(s)** • Graphics visually appealing and easy to read. • Penmanship neat if used on figures in main report. • Graphics have effective labels, legends. • Graphics have effective captions: o Table captions above/Figure captions below. o Stands-alone from text. o Refers to all pertinent dimensions of graphics (axes, legends). o Captions unique, brief but descriptive. • For tables: o Column headings separated from data. o Tables don't run into multiple pages. o Tables are not just list of values.	Meets all criteria at high level;	Meets some criteria; needs improvement	Meets few criteria; often unclear or undeveloped

Fig 1. Rubric used in Grading the Reports

RESULTS, DISCUSSION & RECOMMENDATIONS			
EXPERIMENTAL RESULTS AND DISCUSSION	4	3 2	1 0
• Presents results in table/figure before discussing it. • Describes results without interpretation. • Tables and figures referred to in text in numerical order. • Results presented as figure or table but not both. Main report does not contain raw data and calculations (these belong in appendix). • Uses table judiciously (ie. no unnecessary tables).	Meets all criteria at high level; clear, easy to follow	Meets some criteria; uneven or has some lapses in clarity or development	Meets few criteria; often unclear or undeveloped
APPLICABLE DESIGN GUIDELINES	4	3 2	1 0
• Presents appropriate standards, codes or guidelines. • Discusses relevant parts of guidelines pertaining to project.	Meets all criteria at high level; clear, easy to follow	Meets some criteria; uneven/lapses in clarity or development	Meets few criteria; often unclear or undeveloped
RECOMMENDATIONS	4	3 2	1 0
• Based on results and applicable design guidelines, makes justification leading to recommendation. • Clearly states recommendation to client. • Recommendations based on results obtained from experiment and valid scientific principles or established standards; recommendations backed by evidence.	Meets all criteria at high level; clear, easy to follow	Meets some criteria; uneven or lapses in clarity or development	Meets few criteria; often unclear or undeveloped
SUMMARY	4	3 2	1 0
• Restates purpose stated in introduction. • Summarizes main results obtained from experiment; recommendations backed by evidence and/or valid scientific principles, established standards or guidelines. • Self-contained with no extraneous references. • No new information introduced. • No repetition of information within summary.	Meets all criteria at high level; clear; well-developed; logical; easy to follow	Meets some criteria; uneven; less clear, developed or logical	Meets few criteria; unclear; not logical; undeveloped
CLARITY OF WRITING	4	3 2	1 0
• Uses proper grammar, spelling, punctuation, no missed words, logical transition between sentences/paragraphs. • Uses appropriate tenses; changing tenses in the middle of paragraph is kept to a minimum. • Is clear, concise and adequately developed. • Sentences don't begin with numbers or symbols; abbreviations written out fully first time. • Paragraphs have 2 or more sentences. • Avoids use of slang, colloquial forms, shop-talk. • Uses passive voice to a minimum.	Meets all criteria at high level	Meets some criteria	Meets few criteria
OVERALL QUALITY, PROFESSIONALISM, DOCUMENT DESIGN	4	3 2	1 0
• Pages numbered appropriately and appears at same location throughout report; no unnecessary font changes. • Has 1 inch all around margin. • Gives reader favorable impression technical knowledge, communication skills and professionalism. • Appendix has cover page and contains raw data; sample calculations included; calculations easy to follow. • Neat work and penmanship.	Meets all criteria at high level	Meets some criteria	Meets few criteria

Fig 1. Rubric used in Grading the Reports (cont.)

The scoring rubric clearly conveys to the student the expectation under each category. Once students submit the reports, the instructor completes the scoring rubric and also provides detailed written feedback in the body of the report on how it could be improved in the future. Students are generally given the opportunity to revise the first report to improve their grade. As stated in the literature, providing written feedback on reports is a time-consuming process. Therefore, the instructor limits the number of reports that could be resubmitted.

Student Assessment of Learning

Lab reports count 15% towards the final grade. At the end of the quarter the instructor administers a survey to assess students' perception of technical writing skills at the beginning and at the end of the quarter. In addition to this, the civil engineering department assesses student learning outcomes through annual senior exit surveys and alumni surveys every few years. The findings from these assessment tools are presented below.

a) Student Performance of Technical Writing

Figure 2 shows the average scores earned by the students in the three laboratory reports for the past seven years. In 2015, 2017 and 2019 students were given the opportunity to edit and resubmit the first lab report; both the initial and resubmittal scores of the first report are included in the figure; the final score of the first report was the average of the previous two submittals. Figure 2 shows that the average student performance increased from the first report to the third in all seven years as evidenced by an increase in the mean score.

.

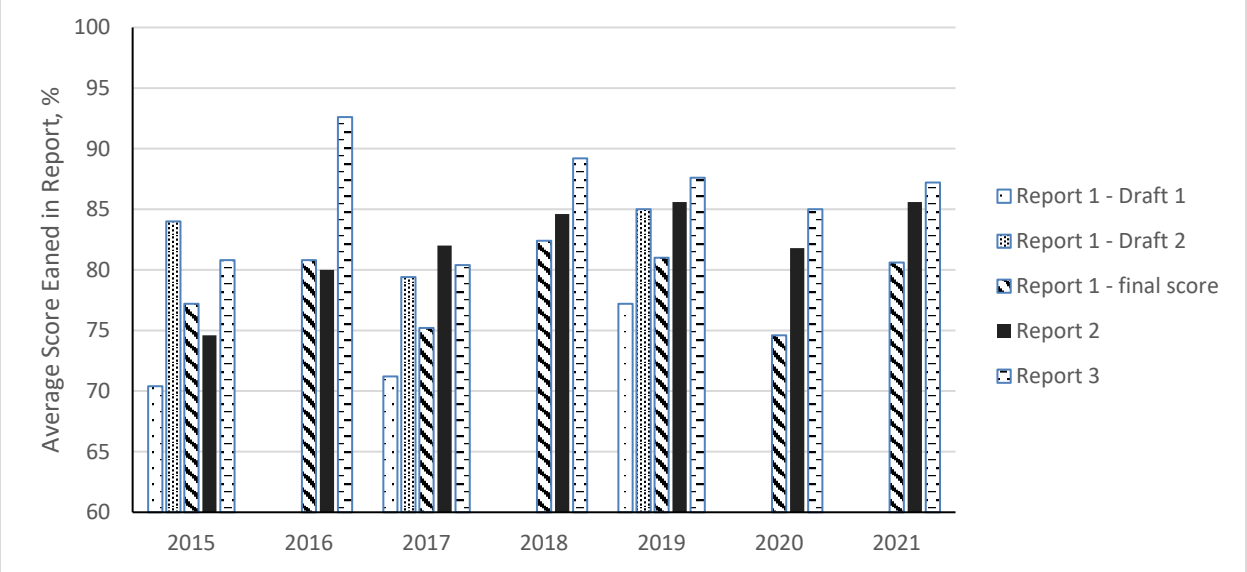

Fig. 2. Student Performance as Demonstrated by Scores Earned for the Past Seven Years

A paired t-test was performed to compare the means at the beginning (report #1) and at the end (report #3) of the quarter. These results are presented in Table 2 and indicate significance level of less than 0.05 for all seven years. Thus Figure 2 and Table 2 suggest that the student scores improved from the beginning of the quarter to the end of the quarter.

Table 2. Paired t-test Results between First and Last Report for the Past Seven Years

Year	N value	t value	p-value
2015	31	-4.80	<0.001
2016	19	-7.86	<0.001
2017	22	-2.36	0.014
2018	22	-4.46	<0.001
2019	24	-4.46	<0.001
2020	21	-5.74	<0.001
2021	22	-4.97	<0.001

Note: if p-value is < 0.05, there is significant difference between the two sets

b) Assessment through Surveys

i) *End of quarter course survey*

At the end of the quarter, students complete a survey of their learning experience in the course. The survey consists of a numerical portion where students rank their perception of learning on a 1 through 5 Likert scale (1 being strongly disagree and 5 being strongly agree) and a qualitative portion where students share the most and least valuable aspects of their learning experience.

Table 3 summarizes the numerical results of the student assessment survey over the past seven years. The survey clearly shows that students recognize the importance of technical writing in engineering practice. The ratio of student preparation (P) to importance (I) of technical writing, P/I, was computed at both, beginning and end of the quarter and are presented in Figure 3. The P/I ratio ranges from 0.61-0.73 when students begin the soil mechanics course; however, by the end of the course it increases to 0.83-0.92. This shows that the students believe that their technical writing skills improved by taking the course. Table 3 also shows that students believed that client-based writing prepares them better for the engineering workforce than traditional lab reports.

Table 3. Results of End of Quarter Student Surveys for the Past Seven Years

Statement	2015 n= 29	2016 n=20	2017 n=21	2018 n=24	2019 n=17	2020 n=18	2021 n=23
I believe that technical writing is very important in engineering practice	4.9	4.9	4.9	5.0	4.9	5.0	4.8
I was well prepared in technical writing prior to taking the course	3.0	3.6	3.3	3.1	3.4	3.1	3.5
My technical writing skills have improved as a result of report writing in this course	4.2	4.4	4.0	4.6	4.5	4.4	4.6
I believe that the traditional lab reports will prepare me well for the engineering work place	3.6	3.1	3.4	4.0	3.6	4.4	3.6
I believe the client-based writing will prepare me well for the engineering work place	4.6	4.8	4.5	5.0	4.8	4.9	4.7
I would like if other engineering courses adopt the model of client-focused reports	3.8	4.4	4.0	4.3	4.1	4.7	4.4

Note: Ranking on a scale of 1 to 5 (5 = strongly agree and 1 = strongly disagree)

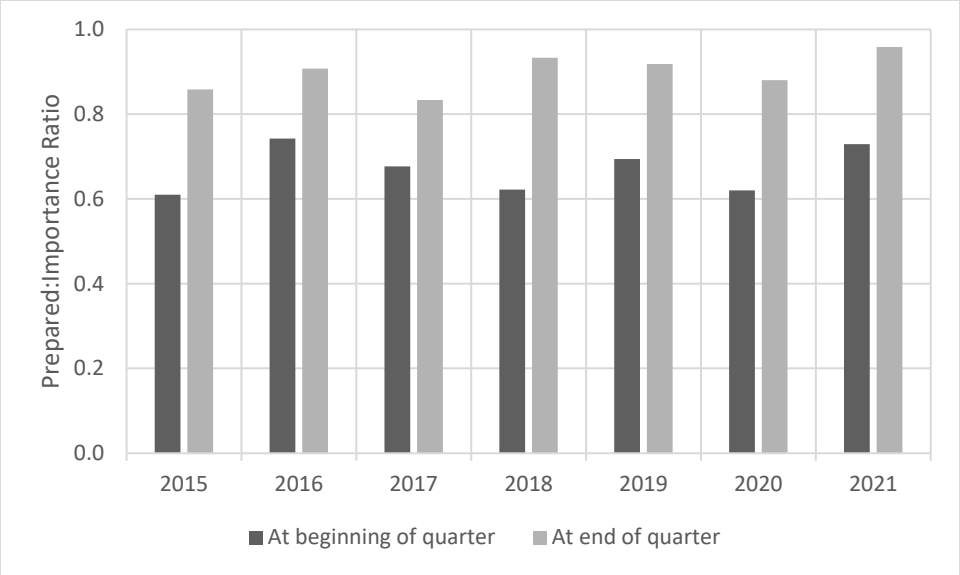

Fig. 3. Ratios of Preparedness is to Importance of Technical Writing at the Beginning and End of Quarter through End of Quarter Survey for the Past Seven Years

The written feedback portion of the survey showed that the students found the relevance to real life applications, ability to write to non-engineering clients, organization of report and formatting of figures and tables most valuable of the client-focused report writing. The students also considered writing letters of transmittal would be highly valuable when applying for engineering internships and jobs.

Some of the written comments from the students are as follows.
"It was helpful to put our lab results into a client focused context, to remind us where we are headed and why we will be performing lab tests."
"Writing client focused reports to better understand the engineer-client interactions. The basic structure of reports and how to organize them was also important."
"I found that writing these reports helped me get a glimpse into what I may be doing in the future. It is a more practical and applicable practice of our studies."
"It gives an opportunity to write reports in a real life setting and the information has a purpose. This allowed me to relate information and knowledge to scenarios that potentially could happen in the work field."

ii) *Senior exit surveys and alumni surveys*

The civil engineering department conducts two surveys: an annual senior exit survey prior to graduation and an alumni survey every three years of its 2-, 5- and 10-year graduates. Seniors and graduates are asked to rate their perception of the importance of technical writing and how well the department prepared them on a scale of 1 to 5 (1 being low and 5 being high). The senior exit surveys have nearly 100% participation as they are administered in class during the last week of the academic year. However, the alumni surveys typically have low response rates close to 10% of the survey recipients.

Figure 4 shows the average values of preparation to importance (P/I) ratio of technical writing from the senior exit and alumni surveys over the past 20 years. This senior exit survey results clearly indicate that there is a generally increasing trend of this ratio over the years. This increase cannot be solely attributed to CEEGR 3530 – Soil Mechanics because the students practice technical writing in multiple technical courses and in their year-long senior capstone project. In addition, the emphasis on technical writing has increased over the years in several courses, which is a reason for the increasing trend in the P/I ratio. However, when the P/I ratios of CEEGR 3530 at the beginning and end of quarter survey results from Table 3 are overlaid on Figure 4 an interesting trend emerges. Majority of the students take CEEGR 3530 in their junior year, there after complete the year-long capstone project in their senior year which involves extensive writing of proposals, final reports and technical memos to clients. For the past six years of graduates, if the P/I ratios are tracked from the beginning to the end of quarter of CEEGR 3530 and thereafter till the senior exit survey at the end of capstone experience, one can see a consistent increase. Although client-focused laboratory reports have been written in CEEGR 3530 since 2000, the assessment surveys, unfortunately, were not administered prior to 2015.

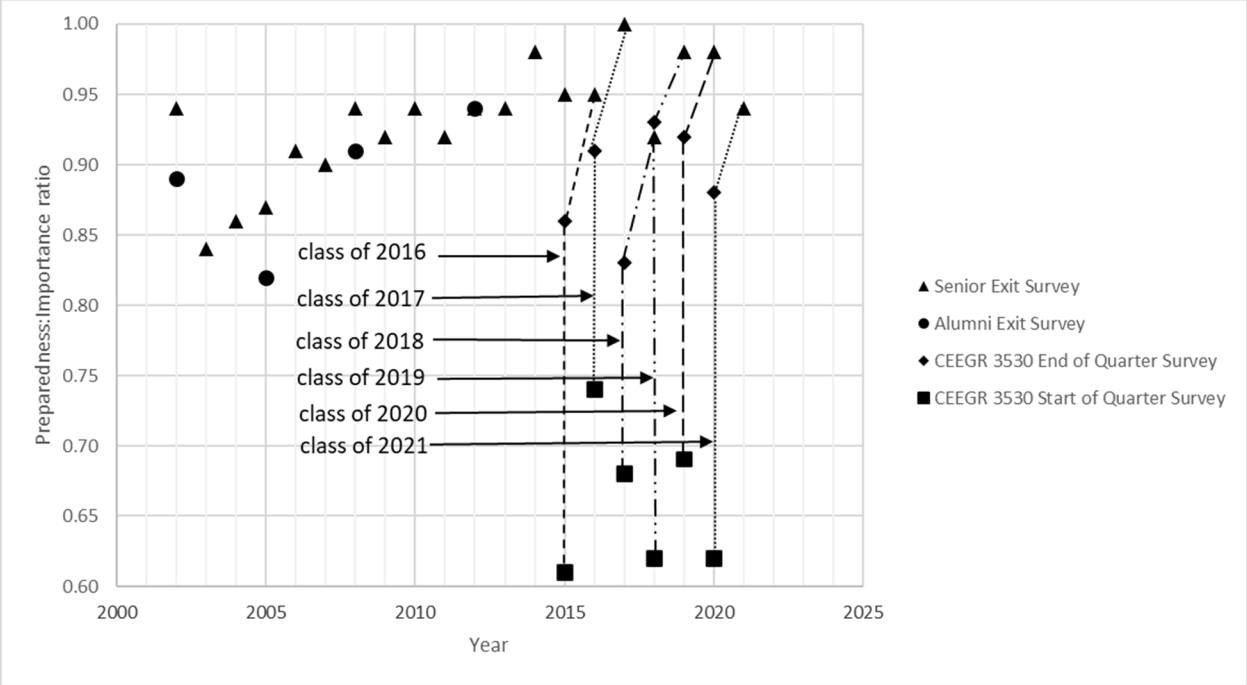

Fig. 4. Ratios of Preparedness is to Importance of Written Communication Compiled from Beginning and End of Quarter CEEGR 3530 Course, Senior Exit and Alumni Surveys

Student perceptions of the value of their education evolves beyond graduation. They may feel frustrated when going through a course but appreciate the benefits when they use the skills developed at a later date [29]. Therefore, some quotes from alumni are worth sharing.

"I often think of you when I am writing a technical document at work and I remember your advice to always write with my reader's (now client's!) expectations and preferences in mind." (class of '17)
"I wanted to thank you for the way you prepare students for working in the field. Specifically, the real-world oriented lab reports and technical writing portions of the senior design project. I started working as a forensic engineer several weeks ago and have been writing near constant reports since starting. Even on day one, technical writing didn't feel like anything new. I think that experience was invaluable, so thank you!" (class of '16)
"Your teaching on technical writing has single handedly launched my career as a transportation engineer." (class of '14)
"If I never mentioned it to you, I was in the year where you limited the soils report to be two pages. Having to explain issues with brevity and to the point – but emphasizing key concepts – is an EXTREMELY important skill in the working world. I usually run into engineers who write too little or are too verbose. Being concise while being informative is something I have tried to develop over the years!" (class of '96)

Benefits of Client Focused Writing

Client focused laboratory reports have several advantages. It prepares students to enter the work force with necessary communication skills. At job interviews when employers request a writing sample, students have typically taken their best report from this course to showcase their knowledge of technical writing. Preparing a writing piece for their portfolio motivates the students to get the most out of the writing experience in this course. This course has helped students to write cover letters for internships and entry level jobs upon graduation.

Our institution requires all civil engineering undergraduates to complete a year-long, industrially sponsored capstone project in their senior year. The capstone course requires several written deliverables to the client: a proposal in fall quarter, a final report at the end of the academic year and intermediate technical reports and memoranda during the year. CEEGR 3530 prepares them well and transitions them to write to a real client in their senior year.

Summary and Conclusions

Civil engineering undergraduates at Seattle University in their junior year learn client-focused-technical writing through CEEGR 3530 soil mechanics course. In the laboratory portion of the course, students are assigned a real-life problem encountered by a fictitious client. Students perform the laboratory experiment using standard ASTM procedures; they then use the experimental results to come up with solutions and/or recommendations to the client through a written report. This approach while providing an assessment tool for the ABET 2019-20 criterion 3 that engineering students by the time of graduation should possess the "ability to communicate effectively with a range of audiences" has several other benefits: engineering students are exposed to writing in their profession early in their academic life; it prepares them for their year-long, industrially sponsored capstone project where multiple deliverables are required by an external sponsoring agency throughout the year; it prepares them to enter the work force. Student, graduate and alumni assessment surveys and feedback show that this approach has had positive long-term impacts on graduates.

References

[1] L. Reave, "Technical Communication Instruction in Engineering School: A survey of top-ranked US and Canadian Programs", *Journal of Business and Technical Communication*, vol 18 (4), pp. 452-490, Oct 2004

[2] D. G. Rhodes, "Organization in Technical Writing", *Journal of Professional Issues in Engineering Practice*, Vol 131 (3), pp. 213-216, 2005.

[3] S. Katz. "The entry level engineer: problems in transition from student to professional", *Journal of Engineering Education, ASEE*, vol 82(3), pp. 171-174, 1993.

[4] Accreditation Board of Engineering and Technology (ABET) Engineering Accreditation Commission, Baltimore, Maryland, "Criteria for Accrediting Engineering Programs, 2019-2020", https://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2019-2020/#GC3 (accessed Jan. 31, 2023).

[5] P. Miller, J. Bausser, A. Fentimen, "Responding to Technical Writing in an Introductory Engineering Class: the Role of Genre and discipline", *Technical Communications Quarterly*, Vol 7 (4), pp 443-461, Fall 1998.

[6] M. Itani, I. Srour, "Engineering students' perceptions of soft skills, industry expectations, and career aspirations", *Journal of Professional Issues in Engineering Practice*, Vol 142 (1), 2016.

[7] J. Lang, S. Cruse, F. D. McVey, J. McMasters, "Industry expectations of new engineers: A survey to assist curriculum designers", *ASEE Journal of Engineering Education*, Vol 88(1), pp 43-51, Jan 1999.

[8] R. R. Essig, C. D. Troy, B. K. Jesiek, N.T Buswell, J. E. Boyd, "Assessment and Characterization of Writing Exercises in Core Engineering Textbooks", *Journal of Professional Issues in Engineering Education and Practice*, Vol 144(4), pp 04018007, June 2018.

[9] J. D. Ford, S. W. Teare, "The Right Answer is Communication When Capstone Engineering Drive the Questions", *Journal of STEM Education*, Vol 7(3&4), pp 5-12. July-December 2006.

[10] R. J. Bonk, P.T. Imhoff, and A. H. D. Cheng, "Integrating written communication within engineering curricula", *Journal of Professional Issues in Engineering Education and Practice,* vol 128 (4), pp. 152–159, Oct 2002.

[11] J. D. Ford, L. A. Riley, "Integrating Communication and Engineering Education: A Look at Curricula, Courses, and Support Systems", *Journal of Engineering Education*, Vol 92(4), pp 325-328, October 2003.

[12] D. C. Andrews, "An Interdisciplinary Course in Technical Communication", *Technical Communication*, Vol 50 (4), pp. 446-451, November 2003.

[13] S. Manuel-DuPont, "Writing-across-the-curriculum in an Engineering Program", *Journal of Engineering Education*, Vol 85(1), pp. 35-40, January 1996.

[14] J. D. Ford, L. A. Riley, 2003. "Integrating Communication and Engineering Education: A Look at Curricula, Courses, and Support Systems", *Journal of Engineering Education*, Vol 92(4), pp. 325-328, Oct. 2003.

[15] W. Jensen, B. Fischer. 2005. "Teaching Technical Writing through Student Peer-Evaluation", *Journal of Technical Writing and Communication*, Vol 35 (1), pp. 95-100, (2005).

[16] J. Mackiewicz, "The Effect of Tutor Expertise in Engineering Writing: A Linguistic Analysis of Writing Tutors' Comments", *IEEE Transactions on Professional Communication*, Vol 47(4), pp 316-328, Dec. 2004.

[17] L. G. Kryder, "Mentors, Models and Clients: Using the Professional Engineering Community to Identify and Teaching Engineering Genres", *IEEE Transactions on Professional Communication*, Vol 42(1), pp. 3-11, March 1999.

[18] J. E Mahan, A. Jayasumana, D. Lile, M. Palmquist, "Bringing an Emphasis on Technical Writing to a Freshman Course in Electrical Engineering", *IEEE Transactions on Professional Communication*, Vol 43 (1), pp. 36-42, Feb. 2000.

[19] N. Amare, C. Brammer, "Perceptions of Memo Quality: A Case Study of Engineering Practitioners, Professors, and Students", *Journal of Technical Writing and Communication*, Vol 35(2), pp. 179-190, 2005.

[20] N. Gnanapragasam, "Evolution of Technical Writing in Senior Design – A Case History", *Advances in Engineering Education*, vol 2(1), 2010.

[21] J. S. Norback, G. A Forehand, S. A Jernigan, A. B Quinn. "Teaching Workplace Communication in Senior Design", *Proceedings of the ASEE Annual Conference*, *Montreal, Canada,* 2002.

[22] G. W Brinkman, T. M van der Geest, "Assessment of Communication Competencies in Engineering Design Projects", *Technical Communication Quarterly*, Vol 12(1), pp. 67-81, Winter 2003.

[23] A. Kedrowicz, "Developing Communication Competence: Assessment of the Intensive Capstone Experience and Developmental Experience", *Proceedings of the ASEE Annual Conference, Honolulu HI, USA,* 2007.

[24] J. L Seagrave, "Communication IS Engineering – Responding Needs of Industry in a Capstone Course", *Proceedings of the ASEE Annual Conference, Chicago, IL, USA,* 2006.

[25] M. Lumsdaine, E. Lumsdaine. 2008. "Improving the Quality of Senior Design Reports", *Proceedings of the ASEE Annual Conference, Pittsburgh, PA, USA,* 2008.

[26] N. Amare, “Act Well thy Part: Performing Technical Writer and Engineer”, *IEEE Transactions of Professional Communications*, Vol 47 (3), pp. 211-215, Sep. 2004.

[27] J. Linsdell, T. Anagnos, “Motivating Technical Writing through Study of the Environment”, *Journal of Professional Issues in Engineering Practice*, Vol 137(1), pp. 20-27, Jan 2011.

[28] S. M Lord, “Integrating Effective ‘Writing to Communicate’ Experiences in Engineering Courses: Guideline and Examples”, *International Journal of Engineering Education*, Vol 25(1), pp. 196-204, Jan 2009.

[29] L. Barroso, J. Morgan, “Projects in Department-wide Junior Civil Engineering Courses”, *Proceedings of the ASEE Annual Conference, Pittsburgh, PA, USA, Chicago, IL, USA,* 2006.

[30] T. Moran, “Troubleshooting Procedures – Technical Writing Lessons That Challenge”, *Proceedings of the ASEE Annual Conference, Salt Lake City, UT, USA,* 2004.

[31] S. J. Ely, J. E. Chen, “Educational Opportunities for Technical Writing”, *Proceedings of the ASEE Annual Conference, Virtual Meeting,* 2021.

[32] A. Hodges, Y. M. Al Hamidi, “Improving Students’ Writing Skills by Integrating Prototyping Activities in their Writing Course”, *Proceedings of the ASEE Annual Conference, Salt Lake City, UT,* 2018.