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A Survey of Alternative Modes of Technical Communication in Engineering Laboratory Courses

Dr. Maryam Mirabolghasemi, Mississippi State University

Maryam Mirabolghasemi is an Assistant Professor in the Dave C. Swalm School of Chemical Engineering at Mississippi State University. She received her Ph.D. degree in Petroleum Engineering from The University of Texas at Austin in 2017. She is an active member of ASEE, SPE, SAGE, and AGU.

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Abstract

Today's engineers need diverse technical communication skills that are not limited to preparing detailed and long reports. However, classic engineering curricula lack courses that focus on these skills. Engineering laboratory courses offer a unique opportunity to fill this gap. In this paper, we review cases reported in science and engineering education literature that cover laboratory assignments other than traditional lab reports. We discuss the use of modified reports, oral presentation, poster presentations, and video reports as alternatives to conventional lab reports.

Results from multiple studies indicate that, in addition to gaining technical communication skills, preparing alternative forms of lab assignments helps students to improve their teamworking skills. Students may also benefit from immediate feedback from the instructor and their peers in case of oral and poster presentations. Other advantages include a lower grading workload for lab instructors, natural evolution of class discussions, and the potential for students to interact with diverse external audiences.

To ensure a successful learning experience, engineering educators recommend the early incorporation of alternative modes of technical communication into engineering curricula. Additionally, research shows that evaluation rubrics must be carefully designed and provided to the students fairly in advance.

Introduction

Technical communication of experimental procedures and results serve multiple pedagogical purposes. An important role of lab reports, as a mode of technical communication, is to provide an opportunity for students to think and act in a different capacity than just learners. Preparing a lab report allows the student to assume the role of a professional engineer, and practice elements such as systematically analyzing technical issues and providing different lines of reasoning. However, students' perception of lab report is rarely a hypothetical professional technical communication; rather, it is just another class assignment with the instructor as the audience (Herrington, 1985). This mindset often manifests itself as what is known as the "information dump". When a student practices information dump, they present their experimental findings in a disorganized manner and they often do not offer any persuasive arguments because their audience - the instructor – is already a subject matter expert (Goldsmith et al., 2019).

Diversifying the mode of technical communication allows for real time and direct interaction with a professional audience that, preferably, is not limited to the course instructor. This interaction might simulate a professional forum much better. For example, an oral presentation using slides or a poster can engage the whole class as the audience. Although other students may also be considered knowledgeable about the topic, my observation shows that they are curious about how other lab teams managed to overcome the same challenges that they experienced while running the experiment or analyzing the results. This form of peer interaction encourages the students to present a persuasive argument and engage in a technical discussion. An audience

of peers is less authoritative and less intimidating than the course instructor, and may serve as a learning resource for students (Hilgers et al., 1999).

In addition to the benefits presented above, by learning and practicing other modes of technical communication, engineering students develop a foundational skill that is key to their future success (Prausnitz and Bradley, 2000; Kmiec, 2004). Writing emails, preparing budgets and justifying them, and taking meeting minutes are examples of routine tasks for engineers (Tranquillo and Cavanagh, 2007; Lepek and Stock, 2011). Nonetheless, engineering curricula do not often specifically target these skills (Pinelli et al., 1996). While several studies have been dedicated to understanding how technical written communication skills of engineering students may be improved, especially through lab reports (Hilgers et al., 1999; Goldsmith et al., 2019; Goldsmith, 2018; Wallwey et al., 2021), a cursory review of the available literature reveals a limited number of studies that focus on alternatives to lab reports and their effectiveness. The objectives of this article are to provide a brief survey of these studies, and to serve as a quick reference for those lab instructors who wish to diversify the form of lab assignments in their courses. Alternatives to lab reports discussed in this article are poster and oral presentations, videos, and modified reports.

Poster presentation

Poster presentation is often assigned as one of the final deliverables of project-based engineering courses (Sweeney et al., 2004; Stagg-Williams et al., 2021). Poster presentations are usually assigned in addition to a final report in engineering design courses and are expected to enhance students' presentation skills (Davis and Wilcock, 2003; Sibley et al., 2012).

Tranquillo and Cavanagh (2007) argue that short assignments such as posters allow the students to think about the content instead of solely focusing on writing a long lab report, which they refer to as "busy work". They point out the time and space limitations that restrict technical communication in the real world and assert that lengthy reports or long oral presentations might not be appropriate tools to prepare students to handle those limitations. Whereas, the limited space on a poster persuades the students to design rich graphics to convey a message that may need several paragraphs to explain. Furthermore, students may use the poster to create a graphical story of their experiment.

A study published in 2009 (Dogan and Kaya, 2009) investigated poster presentation as an alternative to traditional lab reports. In this study, participants were enrolled in a chemistry lab over two semesters. The participants were assigned to prepare lab reports over the first semester and poster presentations over the second semester. At the end of the second semester the participants were interviewed about their experience with poster presentation vs. written lab reports. Most of the participants reported that communicating their experimental results through poster presentation was more interesting than written reports. They expressed that compared to lab reports, poster presentation increased their motivation and decreased their test anxiety. Some students stated that discussing the lab topic over the poster session helped them retain the knowledge and improved their technical communication skills.

Lepek and Stock (2011) reported on incorporating poster presentation as one of the alternatives to the lab report in their senior chemical engineering laboratory sequence. They collaborated with the communications program at their institution to provide professional support to the engineering faculty and students involved in this laboratory sequence. The facilitators from the communications program served as non-technical audience for the students' poster and gave them feedback on their design and the quality of technical exchange. Engineering faculty evaluated the technical content of the posters.

Another benefit of poster presentation as a lab course assignment is reducing the instructor's grading workload. Some instructors ask all class to grade every poster. The instructor may choose to use these peer evaluations for final grade determination (Seifert et al., 2009; Sibley et al., 2012). Nonetheless, the instructor should manage the students' perception of the grading of lab assignments by providing clear rubrics. Without a rubric, students are likely to think that the assessment is subjective (Tranquillo and Cavanagh, 2007).

Modified report

Engineers need diverse professional writing skills that is not limited to preparing detailed and long reports. For example, they may be asked to write meeting minutes or project memos (Tranquillo and Cavanagh, 2007). Tranquillo and Cavanagh (2007) propose short written assignments as a more efficient alternative to full lab reports. They back up their claim by a student survey conducted among the students of a biomedical engineering laboratory course where this alternative approach was implemented.

Memorandums are a popular alternative to full lab reports. Newell et al. (1997) tasked the students of a second-year engineering laboratory course with one-page memos for each experiment. This format made the students reduce a full lab report to a single page summary without missing any important component. Other benefits of this short submission format were increased frequency of the writing assignments and quick feedback from the instructor on each assignment. Aung (2006) allocated 30% of the final grade of their mechanical engineering "Measurements Laboratory" to lab memos. These memos do not include details on the theory or the apparatus. The final course evaluation survey showed that the majority of the students were satisfied with their learning experience of effective communication. Aung's study did not survey the students to evaluate the effectiveness of lab memos separately. Lepek and Stock (2011) assigned lab memos as one of the assignments of their chemical engineering laboratory sequence. They asked the students to prepare these memos to address the hypothetical laboratory director (the instructor). Similar to posters (discussed above), the facilitators taught the students the basics of preparing different types of memos and helped the engineering faculty develop evaluation rubrics.

Jenson and Jenson (2019) assigned different types of technical documents as alternatives to lab reports. These documents include validation report, product report, conference abstract, and quality report. They prompted students with scenarios in which students assumed different roles in the industry and prepared the technical document accordingly. Jensen and Jenson (2019) found an overall positive response from the students; however, they noticed that some students

may have difficulty adjusting to the changes in the scope and style of different types of technical documents. Nonetheless, students are required to understand these variations in order to learn how to communicate with a wide range of audiences.

In another lab, students were asked to prepare a journal article, which is similar in scope to an extended abstract, for each experiment they conducted. These articles were then peer-reviewed by other classmates, and these reviews were then graded as well. Students were required to revise their articles according to the feedback from their peers and the instructor, and resubmit them for final evaluation by the instructor. The peer review proved to significantly increase the quality of the articles submitted by the students (Newell, 1998).

After training their students about technical proposals, Lepek and stock (2011) tasked them to use the proposal format to present their experimental results. The students were instructed to propose additional experiments and/or equipment improvement based on the results they obtained. The proposals had to cover standard lab report contents such as methods and outcomes as well as additional sections on budget, schedule, and facilities.

Oral presentation

In almost all engineering settings data and results are orally communicated with management and other team members. Information exchange through oral presentation is faster than written communication, and instant feedback from the audience is an obvious advantage of oral presentations (Winsor, 1990). Efficient technical communication means optimal use of words and graphics in oral presentations (Linsky and Georgi, 2005; Tranquillo and Cavanagh, 2007). Usually engineering students practice their oral presentation skills only at the final presentation of their design projects. However, assigning multiple oral presentations as lab course assignments provides them with an opportunity to receive feedback and improve on their next oral presentation assignment (Linsky and Georgy, 2005).

Experts argue that outsourcing the necessary training on written and oral communication skills to the humanities courses or faculty is not beneficial for a future career in engineering (Newell et al., 1997; Kmiec, 2004). It may be for this reason that Vanderbilt's Chemical Engineering Department dedicated a technical communication co-instructor to their junior and senior level lab courses (Sharp, 2003). The technical communication element of Vanderbilt's chemical engineering senior course was presented by Sharp (2003). She counts alumni guest lectures as a valuable addition to this lab course. The alumni talked about the communication needs of their jobs during the dedicated technical communication lectures. The other positive experience that she cites is the peer feedback on student teams' presentations. After each oral presentation, the audience were given a form to evaluate the presentation and give feedback according to the instructions. Sharp (2003) mentions that the speakers enthusiastically welcomed the peer feedback.

Kmiec et al. (2003) reported on an NSF-funded project that aimed at improving students' written and oral technical communication skills from a teamwork perspective. They implemented the project in the chemical engineering's "Unit Operations Lab". The module on collaborative oral presentation targeted proficiencies such as planning, designing, and conducting the presentation

as a team. Their strategies for facilitating the development of these skills included multiple oral and communication consultation sessions with the teams and allowing a final rehearsal session where the teams received feedback from other students and the instructor before their final presentation to the invited external audience.

Oral presentation was one of the alternative assignments that Lepek and Stock (2011) incorporated in their chemical engineering laboratory sequence. Students were evaluated based on criteria such as time management, body language of the presenters, slides quality, technical content, and the ability to engage with the audience and answer their questions.

Video

It is a well-known fact that visualization is an effective tool for teaching engineering topics. Among visual teaching aids, training videos are most efficient as they can provide real-world examples and applications, and explain how processes work (Stefanova, 2014; Cutri et al., 2016; Caridade and Rasteiro, 2018). It is for this reason that videos are particularly helpful in a hands-on course such as the laboratory (Stefanova, 2014). Students can learn, not only by watching training videos, but also by making educational video content. When students are involved in creating training videos, they will study the content in depth to be able to teach it to the audience. This opportunity also allows them to practice their technical presentation skills and flex their creative muscle (Caridade and Rasteiro, 2018).

With the abundance of mobile phones and the ease of video recording with them, assigning video lab reports have become more popular in science and engineering courses. Lin et al. (2014) reported on an introductory physics course offered as a Massive Open Online Course (MOOC). Students of this course were tasked to create video lab reports and evaluate their peer's video reports. The evaluation rubric focused on whether the video contained clear information regarding problem definition and theory, models used, experimental and model results, and discussion of the results. The production quality of the video was also part of the grading scheme in the rubric. Evaluation of the submitted videos over two semesters showed that the main flaws of those video reports were insufficient explanations of the underlying theories, and superficial discussion of the results.

Luks and Ford (2015) proposed gamifying the senior chemical engineering lab. They offered "bragging points" for various activities such as attending class sessions on time and submitting complete draft presentations. One of the items that could garner significant bonus points for teams was creating interesting videos. Overall, Luks and Ford (2015) reported only a nominal increase in course average grades after implementing the bragging point system. Students did not obtain better grades in their video presentations over the semester where bragging points system was implemented.

In a study conducted by Hanson et al. (2010), students were assigned to videotape their assigned experiments in a geotechnical engineering lab and later use the footage to prepare a video lab report. Student feedback indicated that filming the experiments helped them analyze the experimental procedure in detail and find better explanations for potential sources of error. At the same time, students stated that they spent significantly more time on working on videotaped

labs compared to other labs. While some students were enthusiastic about video production, some other students believed that the added educational value was not proportional to the time spent on the additional tasks not directly related to the technical topic.

A unique advantage of producing video lab reports is the potential of reaching out to a diverse audience, beyond course instructors and peers. Communicating to audiences with various backgrounds is an important skill that is also emphasized in ABET student outcome #3. Students of a mechanical engineering course at The University of Texas at Tyler were tasked with filming their material failure experiments and using the footage in their video lab reports, which they had to upload onto a dedicated YouTube channel (McCaslin and Young, 2015). Similar to the geotechnical engineering lab discussed above, students of this lab expressed their concern about the video editing being too time-consuming, but they also stated that the high-quality footage of the experiment allowed them to observe more experimental details. Overall, McCaslin and Young (2015) reported that students self-assessed their level of acquired knowledge more positively compared to previous offerings when videotaping had not been part of the lab.

Summary

While lab reports comprise the majority of engineering lab assignments (e.g. more than 50% of biomedical engineering labs' grade on average according to Rathslag et al. (2020)), students may benefit from lab assignments that require different forms of technical communication. The survey of the studies on alternatives to lab reports provides evidence of the effectiveness of oral presentations, poster presentations, short reports and memos, technical proposals, and peer-reviewed extended abstracts in improving students' technical communication skills. Video reports are not as effective as the aforementioned alternatives because preparing video reports requires additional tedious non-technical tasks.

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