

Writing and Engineering – Perfect Together

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Lynn Mayo, PE is Co-Founder of RePicture. After working for over 30 years as an engineer, Lynn dreamed of a better way to help students and professionals discover careers shaping the future. So, she co-founded RePicture. RePicture is a public benefit corporation with a mission to increase interest and diversity in STEM. RePicture helps college and high school students make better career choices by helping them explore careers in science, technology, engineering and math (STEM), develop critical professional skills such as networking, and boost their STEM resume. Through our technology platform and community, RePicture.com, students tell the story of STEM all around us and discover diverse role models. The RePicture Program is helping students “breaking through” the artificial barriers that prevent many from pursuing and flourishing in STEM by building their STEM identity, moving beyond what they know, and showing them what is possible.

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Abstract

Good communication skills are essential for engineers. Approximately half of an engineer's workday is spent in communication-related tasks. Many job postings for entry-level engineers indicate they are looking for people with strong oral and written communication skills.

Communication learning objectives are typically taught in a university's general engineering coursework, as part of a stand-alone communication course. It is seldom integrated into the student's dedicated major. Faculty teaching a rigorous upper-level technical elective may consider communication learning objectives to be beyond the scope of what they can teach.

Good writing skills are developed over time and not over a single course. When instructors expect students to use written or oral communication in coursework, but do not provide formal instruction on the topic, students may fail to improve their communication skills beyond what they already know. Students who are strong at communicating stay strong, while less proficient students do not improve. For upper-class students who are about to enter the professional working world, their current proficiency in communication may be the difference between receiving a desirable job offer or not. Potential employers are well equipped to mentor young people on the nuances of technical proficiency. However, it is hard for companies to teach how to speak and write well. Universities can better support their students for future success by including communication skills learning objectives in all years of undergraduate coursework.

This paper discusses a writing assignment used in 2020 and 2021 in an upper-level Structural Engineering class at Case Western Reserve University. The assignment follows a lesson plan developed by RePicture and the American Institute of Steel Construction (AISC).

The assignment was designed to help students in several ways, including:

- Practice writing skills
- Engage with technical concepts and relate what they are learning to actual projects
- Better understand the breadth of their engineering career options
- Create online material that they can include on their resume

The structural engineering assignment was a modification of a lesson plan developed by RePicture that can be used for any science, technology, engineering, and math (STEM) course. For this assignment, students researched and wrote about a structural engineering project and then posted their article on the RePicture website. The RePicture platform includes an instructor dashboard which allowed the instructor to review and privately comment on the student's work. Once their work was completed, the student could then publish it on RePicture.com for the world to see. The online article the student created can be used as a sample of their writing abilities, to demonstrate their depth of knowledge about structural engineering projects to potential employers, and to enter contests sponsored by AISC. Students can refer to their published article

on their resume to stand out to employers, which is of particular benefit to those with no engineering-related work experience.

The majority of Case Western Reserve University students provided positive feedback about the assignment and recommended the assignment be used again. The students indicated that they enjoyed connecting a real project to what they learned in class, gained further direction in their career aspirations, and liked the freedom to focus on the aspects of the engineering project that most interested them.

Introduction

Good communication skills are essential for engineers. Approximately half of an engineer's workday is spent in communication-related tasks [1]. In addition, a survey of technical professionals indicated over 29% of their total work time is spent writing [2].

While educators may think our students are good writers, engineering employers have indicated otherwise. In a 2010 survey, 52% of university mechanical engineering department heads thought their graduates had strong written and oral communication skills. However, in a survey of over 1,000 engineering industry professionals, only 9% thought recent mechanical engineering graduates had strong communication skills and the majority (52%) thought the graduates' communication skills were weak [3]. Consequently, engineering students may benefit from additional writing assignments.

Communication learning objectives are typically taught in a university's general engineering coursework as part of a stand-alone technical communication course. It is seldom integrated into the student's dedicated major. However, good writing skills are developed over time and not over a single course [4]. Incorporating writing into technical courses can help engineering students improve their writing skills and help them understand the importance of writing in their future career.

Faculty teaching a rigorous upper-level technical elective may consider communication learning objectives to be beyond the scope of what they can teach without cutting technical content [5]. However, writing assignments can help students better understand class material. Studies show that having students write a summary about material increases their comprehension of it [4]. This helps all students, but especially students who are weaker readers. Having students write about a topic (including technical topics) is more effective than having them re-read the information [6]. Writing also increases students' class engagement more than any other course characteristic [4].

The project discussed in this paper involves upper-level structural engineering students identifying a project that interests them in a structural engineering professional magazine, specifically the American Institute of Steel Construction (AISC) Modern Steel Construction magazine. Students then research the project and are encouraged to reach out to the project stakeholders to learn more about the project. Based on their research, students write an article about the project and post it on the RePicture website. This assignment could be done in any STEM course using other professional magazines.

Having students research and then write about an actual engineering project helps students understand the relevance of what they are learning in class. According to psychology professor Dr. Christy Price, one of the principals to creating the “ideal learning environment” is to help students understand the relevance of what they are learning [7]. In addition, it helps students see the large variety of work they can do with their degree. A study by Matusovich, et al. concludes that showing students the breadth of engineering career options is important for retaining engineering students of both genders. However, Matusovich indicates it may be more important for helping female engineering students, since they often are less certain about engineering [8] [9]. It is possible that exposing engineering students to the variety of projects they could work on may also help retain students in engineering after they graduate. Approximately 15% of women who graduate with an engineering degree never work in engineering. For these female engineering graduates, the top reason they give as to why they didn’t take an engineering job was because they were “not interested in engineering” [10].

In addition to improving writing skills and exposing students to the breadth of career options, a unique aspect of this project is that students can publish their assignment on a designated STEM website, i.e., RePicture.com. They can then include this article on their resume. Many large companies scan applicants’ resumes and use computers to search for key words to find “qualified” candidates to further consider [11]. Students without these key words on their resume may never get past the initial screening. This can be especially challenging for students who have not had an internship in the area for which they are applying [12]. Engineering students from underrepresented groups, first-generation to college, and low-income students are significantly less likely to have internships compared to their counterparts. For example, 42% of first-generation, low-income engineering students had internships compared to 58% of high-income engineering students [13]. After completing this assignment, all students can discuss the work on their resume and include a link to their work.

How to Make Writing Assignments Effective

A large study by the Council of Writing Program Administrators and the National Survey of Student Engagement looked at the strategies that are most effective at increasing student learning in undergraduate education. The study found that writing assignments with the following three characteristics result in deeper learning. The study gives examples of how to implement the three characteristics. Provided below are the three characteristics and a subset of the examples they give [14]:

1. Interactive Writing Processes
 - Received feedback from your instructor about a draft before turning in your final assignment
 - Received feedback from a classmate, friend, or family member about a draft before turning in your final assignment
 - Asked you to give feedback to a classmate about a draft or outline the classmate had written

2. Meaning-Making Writing Tasks
 - Summarize something you read, such as articles, books, or online publications
 - Include drawings, tables, photos, screenshots, or other visual content in your written assignment
 - Asked you to address a real or imagined audience such as your classmates, a politician, nonexperts, etc.
3. Clear Writing Expectations
 - Provided clear instructions describing what he or she wanted you to do
 - Explained in advance what he or she wanted you to learn
 - Explained in advance the criteria he or she would use to grade your assignment
 - Provided a sample of a completed assignment written by the instructor or a student

Writing Assignment: Writing and Engineering – Perfect Together

The topic of this paper is a free lesson plan developed RePicture and AISC. The lesson plan is a modification of a lesson plan originally developed by RePicture for any STEM class under a grant from the American Geophysical Union (AGU) and uses the RePicture platform. The lesson plan can be found at repicture.com/lessonplans/AISC.pdf. The assignment documents will also be available on AISC's new educator collaboration site for any faculty to use (see aisc.org/aisc-membership/member-types/educator/).

In the fall of 2020 and fall of 2021, an upper-level Structural Engineering class at Case Western Reserve University used the lesson plan. In 2020, nine students published their assignment. In 2021, there were 11 students in the class and all completed and published the assignment.

The assignment generally followed the characteristics indicated above to make writing assignments engaging: interactive writing processes, meaning-making writing tasks, and clear writing expectations.

Students were given detailed assignment instructions, examples of past students' work, a "how-to guide" to publishing their work on RePicture.com, and information on what would make a good project write-up. Students were also told that others would be reading their published work to better understand what structural engineers do. Additionally, students were told that structural engineering industry professionals would be reviewing their work, if the student self-nominated their article for consideration of an AISC award.

The assignment started with students finding a structural engineering project that interested them in a current or past publication of the AISC Modern Steel magazine. Students then researched other sources of information about their selected project and were encouraged to contact the project stakeholders featured in the AISC article to interview them about the project. Based on their research, students synthesized key details of the project.

Students uploaded their writing (and citations) on the RePicture website, which provided prompts for the write-up, including an overview of the project, who benefits from the project, environmental considerations, what is unique about the project, funding, and the project team (including people, companies, and disciplines). All fields were optional, but one or more

pictures of the project was required. The typical write-up was about 10 paragraphs long and included multiple pictures of the project, citations, links to articles and videos, the names of some engineers that worked on the project, and a listing of several disciplines involved in the project.

Students were asked to write at the high school level, since the material they create will be used by high school students to learn about structural engineering. This requires the engineering students to explain technical information in a way that allows people without a technical background to understand it. This “teaching others” is part of the Feynman Technique for learning and considered by some as the “strongest learning method in history” [15].

Initially, only the student and the instructor could see the uploaded work. The teacher accessed the students’ article through an instructor dashboard and privately commented on it. Through the dashboard, the teacher tracked the status of the projects.

The students completed the assignment in three separate deliverables.

- Steps for Deliverable 1 (15% of total grade)
 - Students learned why this writing assignment is particularly useful to an upper-classman seeking employment in engineering.
 - Students chose an article from Modern Steel Construction featuring a design project using structural steel.
 - Students read a step-by-step guide outlining the workflow for assignment completion; this verbiage is provided by RePicture.
 - Students read clear instructions on topics such as finding reliable/relevant information, correct use of citations, avoiding plagiarism, how to proofread, and how to comply with picture copyright laws; this verbiage is provided by RePicture.
 - Students created an online account on RePicture.com. The student then had a personal profile page that was linked to the instructor’s online dashboard.
 - The instructor graded this deliverable as “Complete/Incomplete”.
- Steps for Deliverable 2 (35% of total grade)
 - Students read an additional reference with specific tips to avoid plagiarism while completing their first draft of the writing project.
 - Students were expected to have emailed at least one professional who worked on the project, requesting a short interview.
 - Students uploaded information about the project to their RePicture project page at 75% completion.
 - This deliverable was graded using four criteria: “pictures, contact of project professionals; references; 75% completion requirement.” The instructor used a rubric of “high, satisfactory, weak” categories with 5, 4, and 3 points respectively. Detailed feedback was then provided through the online dashboard on each student’s project page.

- Steps for Deliverable 3 (50% of total grade)
 - Students completed a “Final Review Checklist” that asks the student to confirm they adhered to the expectations of reliable sources, copyright laws, citations, etc.; this checklist is provided by RePicture.
 - Students submitted their project page at 100% completion.
 - Students submitted a short self-nomination form of their project for consideration of an AISC award, which was optional.
 - Students completed a “self-reflection”. They were asked to answer the following: What aspect of the project was most successful for you? What sparked curiosity and/or satisfaction when working on this project? What challenges did you encounter? Students were then asked what grade they think their project deserves.
 - This deliverable is graded by review of the student’s self-reflection and suggested final grade. Using the instructor dashboard, projects were marked as “ready to publish”.

Completion of the assignment in this manner had benefits for both the instructor and students. Three deliverables allowed the students to break up a large assignment over the course of a semester. They easily fit alongside traditional course homework as students had weeks of time to work on each deliverable. It also allowed the students to revisit important material more than once, such as tips to avoid plagiarism. And it provided ample time for project stakeholders to reply to interview requests. For purposes of grading, Deliverable 2 was the only one that took significant time. Deliverable 3 was intentionally structured to put the student in the role of “grader”. The purpose of this was two-fold. First, to encourage learning through reflection on the student’s process of completing the project. Second, to recognize that some students picked projects that had more creative license content, interesting resources, videos, or project professionals willing to give an interview. It was felt that the students should have a role in assessing their effort and justify why a certain grade was earned.

After addressing the teacher’s comments, the student could “publish” their article, which made it visible to the public and linked it to the student’s profile on RePicture.com. Projects submitted for consideration of the Best AISC Modern Steel Construction Article award were reviewed by industry professionals. The winning student received a copy of the AISC Steel Construction Manual (valued at \$400), or another AISC manual of their choice. You can see the winning project at repicture.com/project/northeastern-university-pedestrian-crossing-pedx.

Students have published articles on a variety of steel related topics, such as the Northeastern University Pedestrian Bridge, Raleigh Union Station, and Whitney Museum of American Art (see Figure 1).

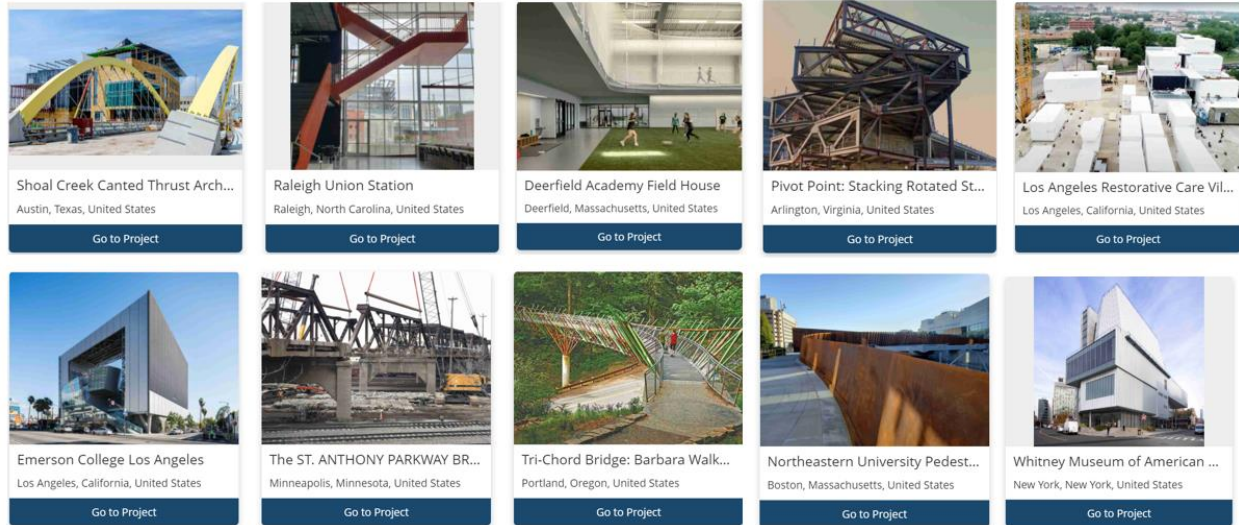


Figure 1: Examples of Structural Project Articles Written by Students on RePicture.com

Students were also given an example of how to include their article, and a link to it, on their resume. This allowed students to include key structural engineering words in their resume, show their interest in the technical area, and demonstrate their writing ability. Students have used this online article as a sample of their writing abilities and to demonstrate their interest in special or challenging structural engineering projects to potential employers. The students who won the Best AISC Modern Steel Construction Article contest each year can also add this recognition from a professional organization to their resume.

Evaluation of Assignment

Through this assignment, students practiced the art of writing for a large audience and reaching out to professionals to interview in a respectful way. They also followed a workflow which reinforces the importance of research, finding their voice, avoiding plagiarism, and copyright laws.

In addition to practicing writing, this assignment helped students learn about real-life applications of the structural concepts they were learning in class. Students wrote about parapets that are canted outwards, trapezoidal tub girders, and moment frames. It is expected that writing about these technical issues increased their understanding of the variety of structural component options. More research is needed to confirm this; however, the following feedback was provided by students in their reflection of the assignment:

“I found [structural project name] extremely interesting in regards to how forensically the existing structure was examined and how it was decided which structural components would remain and which components would be replaced.”

“I find the physical design and the choice of weathering steel to be very eye-catching, which is what led me to pick out the [project name] for my project.”

“While researching this project, I became interested in considering the construction process. Because the building is in a busy city area and was stripped down to its structural system to address the mold/vapor barrier issues, I imagine the construction logistics were quite complicated.”

“It was really interesting to hear from a professional engineer about why the project was chosen, how it was designed and why it was designed that way, and about the uniqueness of the project itself. Having that perspective on a really interesting and socially important project was really valuable.”

“What sparked my curiosity was the ability to write about a project that had an interesting construction method in Modular construction while also focusing on a project with really important social implications. For me, projects that are both innovative and socially important are ones that should be prioritized in our changing culture and market.”

After the fall 2021 assignment, students were asked to provide anonymous feedback regarding the assignment. In general, the students appeared to be engaged by the assignment and enjoyed it. Their feedback included:

“It was fun to connect a real project to what we're learning in class.”

“I felt that it was interesting to take a look at a real example of the application of what we have learned in class.”

“I enjoyed learning about projects in the world, knowing that someday maybe someone will care enough about one of my projects to write about it.”

“I enjoyed [the assignment]. It made me realize how much I have learned!”

Students were asked if the assignment helped them better relate what they were learning to the actual work of structural engineers. Seven students indicated it did, two were neutral, and two did not think that it helped them. The written comments from the students frequently mentioned their future careers in structural engineering, including:

“It was a good excuse to read about a more unique structural design challenge. After internships, it can be easy to have tunnel vision and panic about having to work on traditional/cookie-cutter projects for the rest of your career. So, it is refreshing to remember that "fun" and "challenging" projects do exist.”

“I recommend [you use this assignment again next year] it because it is rare that we get to look at real projects through the structural design curriculum.”

“I feel that it is a good study on a project that relates to what we will be doing in our careers.”

“I believe it exposed me to work being done in structural engineering in the real world. This has helped to gain further direction in my career aspirations.”

While most of the students recommended the assignment be continued next year, two of students did not. Both students thought the assignment was “busy work”. These two students’ feedback included:

“...felt like I was ... doing busy work for a Language Arts class.”

“it is busy work and students' time could be spent much better in an alternate way. Though, it was a nice change of pace to have an assignment which is nice, straightforward, and not stressful! I don't think it is a bad or harmful assignment, just maybe not the best use of time.”

A common theme for the other students was that they liked the flexibility of the assignment to pursue their interest or expand their horizon:

“I enjoyed the freedom and lack of restrictions about choosing my project as well as the aspects which were necessary to focus on. This allowed for freedom in focusing in the aspects of the project I was most interested in.”

“It's a neat way for each student to analyze something they find interesting through the lens of the engineering profession, without putting on a lot of pressure.”

“It was interesting to research a project that had some unique structural elements, something you don't see much in class.”

“It is a good way to extend students' horizon.”

Posting Work and Using on Resume

The majority of the students indicated they were motivated to do well on the assignment since their work would be posted on the internet (7 of 11) and since they had an opportunity to win an award from AISC (5 of 9).

Two of the students mentioned the benefit of putting the project on their resume:

“I thought [the assignment] was good, especially if students do not have other practical experience to show on resumes.”

“I think it is interesting and helpful since you can put it on your resume and potentially get an award.”

However, most students indicated they did not plan to include the article on their resume. For students that do include the article on their resume, this assignment may help them to pass the

initial job application screening based on key words and demonstrate their passion and writing abilities in areas of interest to companies. This may benefit students if they do not have an internship, or other experience, in the technical area for which they are applying. It is unknown how many of these students had a structural engineering internship experience at the time of the class.

It is also unknown how many of the 2020 or 2021 Case Western Reserve University structural engineering students actually included their article on their resume. However, we have received information from other students in other majors that they have included it on their resume and it has helped them obtain a job. For example, a recent biology graduate created articles on RePicture.com for eight projects and included the work and a link on their resume. Her new employer indicated this made her a good job candidate since the “RePicture STEM writing were qualities that they look for in candidates”.

In an informal review of about 50 job listings for entry-level structural engineers, about 75% of the job postings indicated they were looking for people with strong oral and written communication skills. At least one civil engineering student (from another university) used their RePicture article as a writing sample to obtain a job offer. The employer was impressed with the topic, format, and writing by the student.

Summary

Writing is an important skill for engineers. Writing assignments can engage students and help them connect the technical work they are learning in class to real-world applications. The RePicture-AISC assignment gives students freedom to choose a structure that piques their interest. It helps students understand that engineering projects are completed with the collaboration of many professionals and stakeholders. For this assignment, students posted their work on a public platform, which motivated most of the students to do well on the assignment. Students could also nominate their work for an AISC award which provided the winning student an opportunity to list an industry award on their resume. A similar assignment can be used for any STEM course.

The majority of students recommended the assignment be used again next year, showing that engineering and writing are perfect together!

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