2021 ASEE ANNUAL CONFERENCE
Virtual Meeting | July 26–29, 2021 | Pacific Daylight Time
Paper ID #34516

Switching Gears in Machine Design; A Focus Toward Technical Writing Skills in Lieu of a Hands-On Semester Design and Fabrication Project

Dr. Dennis O'Connor, California State University, Chico

Dr. Dennis O'Connor received his B.S. (2004) and M.S. (2007) in Mechanical Engineering from Southern Illinois University Edwardsville and Ph.D. (2014) in Engineering Science from Southern Illinois University Carbondale. His major research interests are dynamics and vibration including nonlinear systems and numerical methods. He joined the Department of Mechanical and Mechatronic Engineering and Sustainable Manufacturing (MMEM) at California State University Chico in 2015 as an Assistant Professor. Dr O'Connor teaches a myriad of courses including: Dynamics, Materials, Thermodynamics, Machine Design, and Vibrations. In addition, he is the faculty advisor to both Chico State Rocketry and SAE Mini Baja student clubs.

Switching Gears in Machine Design; A Focus Toward Technical Writing Skills in Lieu of a Hands-On Semester Design and Fabrication Project

Abstract

In light of the recent global pandemic, many universities have decidedly transitioned to fully online. The obvious consequence being that technical hands-on activities are essentially no longer possible. Mechanical Engineering Design (i.e., Machine Design) at California State University Chico normally facilitates a semester-long design and fabrication project to give students a real-world engineering experience. As an alternative, this paper considers the effectiveness and benefit of focusing on the documentation and presentation of engineering analysis and design work rather than hands-on projects. In a series of activity assignments, students are required to compose short technical reports which document their engineering analysis in professional form. Each subsequent assignment had an increased level of analysis complexity and documentation which related to the course material. A mid-semester survey was administered to help improve this learning modality, and a second survey near the end looked to quantify any said benefits of improved student outcomes. Student feedback and their measured performances on each technical writing assignment is presented herein.

I. Introduction

As the Covid-19 pandemic abruptly ended in-person classes, the transition to teaching fully online offered both new possibilities and challenges. On one hand, interactive software such as *Zoom* allowed for unique and dynamic lectures which could be recorded and later reviewed by students. On the other hand, engaging collaborative projects such as designing and fabricating an electric ceiling hoist [1] are no longer possible. At Chico State, *Mechanical Engineering Design*, or MECH 340, is a junior level design course in which students are expected to learn how to design complex engineering solutions. Notwithstanding its rigorous mathematics, students must learn the interplay and execution of system components such as motors, shafts, gears, bearings, etc. On top of this, there is a requirement for technical presentation of design work which usually takes the form of typed reports with mechanical drawings of said work. Prior to teaching this course online, a hands-on semester design project proved invaluable at both maintaining student engagement and improving student learning outcomes. For the fall 2020 online semester, a focus toward improving the technical documentation skills of students was chosen in lieu of the hands-on semester project. With an incremental increase in requirements and grade percentage, a series of five writing intensive design assignments were facilitated within the course's weekly two-hour activity time.

While examples abound for a positive impact on student outcomes through hands-on projects [1], [2], [3], there is also evidence of a positive correlation between student success in engineering design and their writing skills. Engineering students completing their two semester senior Capstone Project experience have substantial writing and technical documentation requirements in addition to designing and fabricating a complex engineering solution. Interestingly, in one study teams demonstrating good writing skills throughout their capstone program ultimately proved to be more successful at project completion [4]. Whether in undergraduate studies or in future careers, there are obvious advantages to possessing good writing skills as they may actually improve design skills [5]. Given the profound importance and requirement for demonstrated technical communication, ironically there is not a specific course in the mechanical engineering curriculum dedicated to teaching technical writing. As a result, students may find themselves in their Capstone Program suddenly expected to write professional engineering design reports and test procedures with only the experience of lower division laboratory reports and English essays. To better prepare students for the workforce and facilitate a more cohesive writing experience, one department took a more system-level approach, [6]. By requiring technical writing exercises throughout their curriculum instead of just a few courses, students would gain substantially more writing practice. Having different courses and different styles of writing assignments indeed presents additional value to a student's overall abilities, [7]. That being said, there is a profound difference between assigning writing exercises and actually teaching writing. Crucially, there are proven pedagogies such as feedback and iterations to ensure a more successful outcome in teaching writing, [8], [9].

Specific to the work herein, implementing a focus on technical writing in MECH 340 aims to both improve student learning outcomes as well as bridge the gap between writing simple laboratory reports and senior-level capstone design reports. With its rigorous mathematics and complex design theories, there is terrific opportunity for students to learn and practice writing professional technical communications. For the fall 2020 semester, the online weekly two hour activity time was perfectly suited to teaching writing skills. The goal of this work is to showcase the writing focus strategy and assess the experience through student outcomes and feedback.

II. Writing Assignments

For the fall 2020 semester of Mechanical Engineering Design, a total of five writing assignments were administered during the weekly two-hour activity time. Each assignment grew incrementally in both requirement and grade contribution. In total, these five assignments represented fifty percent of students' overall grade while exams and homework made up the other half. The aforementioned point scheme is given in the Table 1 below.

Table 1. Activity assignment chart with point contribution.

Activity	I	II	III	IV	V
Points	20	40	60	80	100

The first four assignments were individual, and the last activity was a group effort. The class met synchronously through *Zoom* with each session being recorded and made available for later review. To begin, a thoroughly detailed overview of formatting guidelines and how-tos was given in the first week. Utilizing the share-screen option in Zoom, students were explicitly shown the steps to create the required formatting and arrangement of their work. From typing equations within *Word* to adjusting figures in *Excel*, every aspect of technical documentation was covered in exceptional detail. Additionally, sentence formulation in support of design work was addressed at great length. Examples were provided to help guide students in developing their unique communication of work. Specifically, students were instructed to utilize a 3rd person passive voice in writing their reports. Activity reports were submitted electronically and graded with detailed comments to provide feedback for improvement as shown in Figure 1 below.

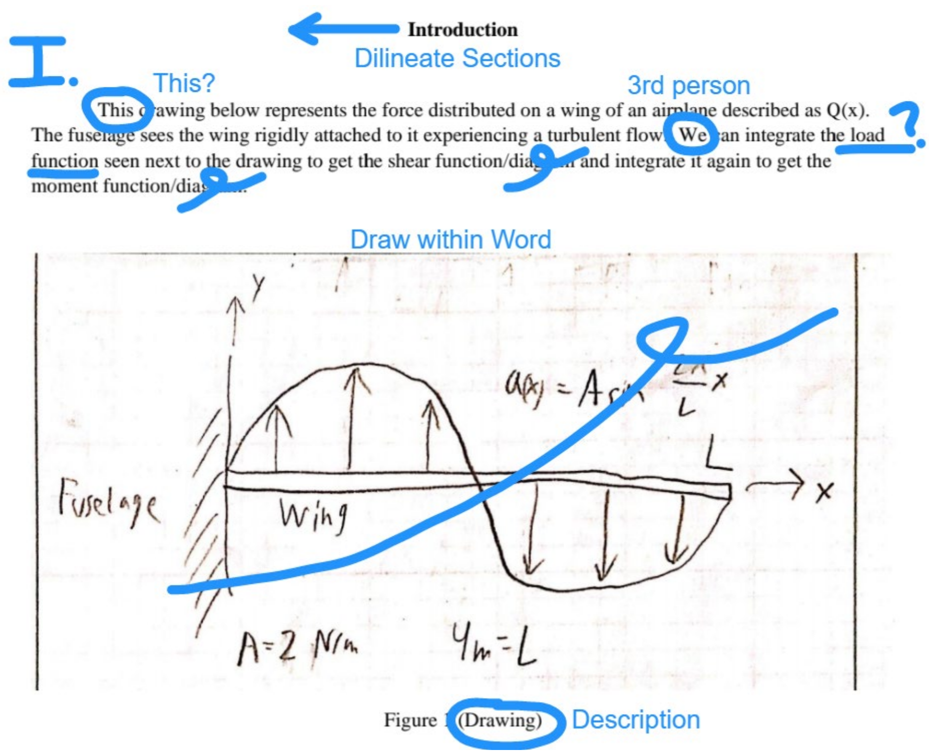


Figure 1. Example of student work with provided feedback.

In this first iteration, a rough draft requirement was not implemented. However, generous due dates and interactive breakout rooms enabled students to share their work and get direct correctional feedback before submitting their final draft. In fact, the Zoom screen-share allowed students who shared their work during activity time to make real-time corrections under the instructor's guidance. Other students watching on Zoom also benefited from the live feedback. After submission of the first activity, the grading and feedback was completed before the due date of the second activity. That being said, the average performance on the first activity assignment was far from great. While there was obvious room for improvement in actual writing (e.g., voice, grammar, run-ons, etc.), there was an acute, and profound deficiency in preparedness for the technical aspects of engineering documentation (e.g., equations, tables, figures, etc.). As seen in Figure 1 on the preceding page, some students on the first activity opted to pencil sketch equations and figures rather than utilize *Microsoft Word*. Through class discussion, it was made abundantly clear that the majority of students had little-to-no experience with technical documentation of this sort. For many, this was the first time that they had ever attempted to type equations or follow a specific format for plotting. Even with explicit formatting instructions, most students failed to earn a passing grade on this first assignment. Writing aside, this was a recognizable opportunity to make a profound difference on improving the technical aspects of their writing.

Regarding their performance assessment and grading feedback, Table 2 below illustrates the grading rubric consisting of five main categories with the percentage of grade contribution divided evenly. A simple description categorizes their performance for each said category. Additionally, comments were provided for more explicit feedback in each category. Finally, a generalized description was provided as shown by Table 3.

Table 2. Grading Rubric.

	Solid	Almost	Somehow	Maybe	Nope	Zero
Organization (20%)						
Writing (20%)						
Loading (20%)						
Analysis (20%)						
Figures (20%)						

Table 3. Scoring rubric with descriptions to support judgment.

Scoring	Description
Solid (100%)	Complete, accurate, consistently professional with perhaps minor infractions
Almost (80%)	Complete, mostly accurate, somewhat professional, with some mistakes
Somehow (60%)	Attempted completion, unprofessional, with major mistakes
Maybe (40%)	Incomplete, confusing, unprofessional, trouble
Nope (20%)	Incomplete, sloppy, terribly wrong
Zero (0%)	Self-explanatory

A. Activity I

The first writing assignment activity emphasized the fundamental aspects of technical documentation. In addition to obvious professional formatting guidelines, an engineering report should address a problem's loading conditions, Free-Body diagrams, analysis, equations, calculations, tables, and plots to sufficiently represent the technical nature of said work. For this first activity, students were given a cantilever beam under a sinusoidal distributed load as shown below in Figure 2.

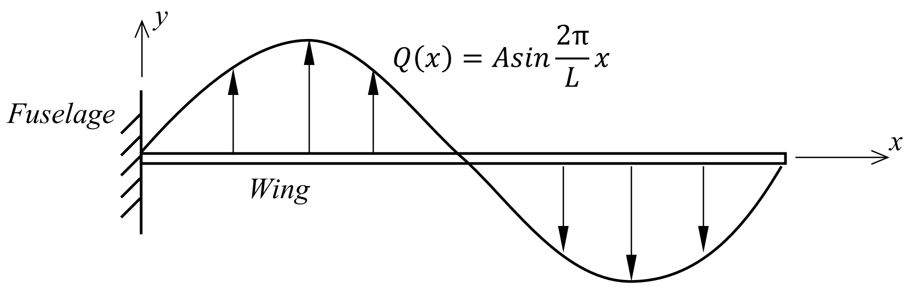


Figure 2. Loading conditions for a wing in turbulent flow.

The specific requirements for them to consider in their reports were: a title page, introduction, FBD, engineering analysis, typed equations, shear and bending moment diagrams, conclusions, and references. Clearly for many, this was their first experience at sketching FBDs in *Word* or typing equations with its equation editor. Perhaps even more challenging for them was navigating *Excel's* intricate formatting menus to produce a substantially more professional looking figure than with default settings. As an example of poor versus professional, Figure 3 below is a side-by-side comparison of student work from this first activity. Please note, feedback corrections were removed for clarity. From the location and endpoint of the *x*-axis to units and tick-marks, the figure in (a) is typical of students not following instruction and relying heavily on default settings for plotting. In the more professional example (b), notice that all font is Times New Roman, inside minor and major ticks, proper axis titles with units, and the intersection of the *x*-axis at bottom. This student paid careful attention to the required formatting guidelines.

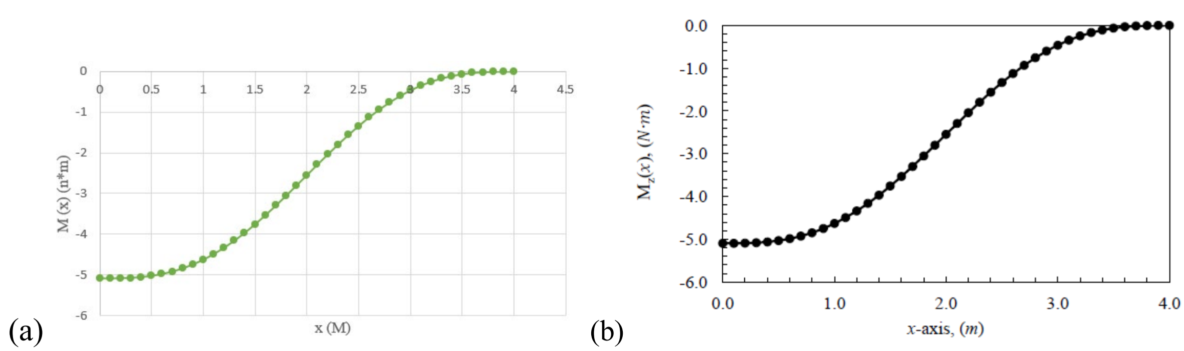


Figure 3. Samples of student work from Activity I; (a) poor and (b) professional.

B. Activity II

For the second assignment, students were given an idealized loading condition for a cold-rolled steel process as shown below in Figure 4. With a slight increase in level of difficulty, students had to determine the relationship for torsional loading, bearing reactions, two-plane bending, and principal stresses.

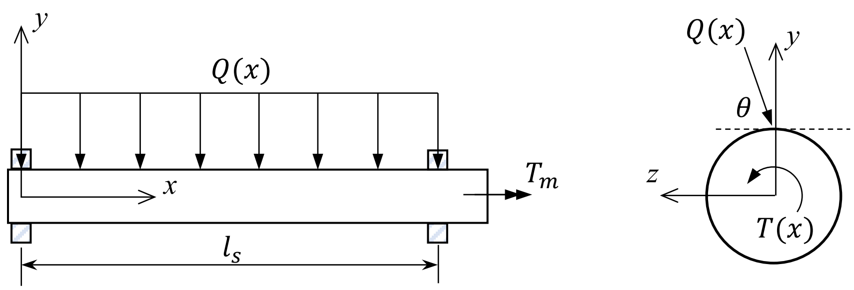


Figure 4. Loading conditions for cold-roll steel process; (a) y-x plane and (b) y-z plane.

Although there was substantial improvement in following guidelines, many students still did not succeed in less practiced areas such as drawing Free-Body diagrams. Here, many students struggled to achieve a consistent level of detail and accuracy as described during instruction. Although not a pencil sketch on paper as in Activity I, some students opted to draw their FBD in *Paint* rather than *Word.* The comparison below in Figure 5 illustrates the difference between those following the instruction guidance (a) and those who did not as shown in (b). Again, correction feedback markings are removed for clarity. Formatting aside, the FBD drawn in Paint is both incomplete and inaccurate.

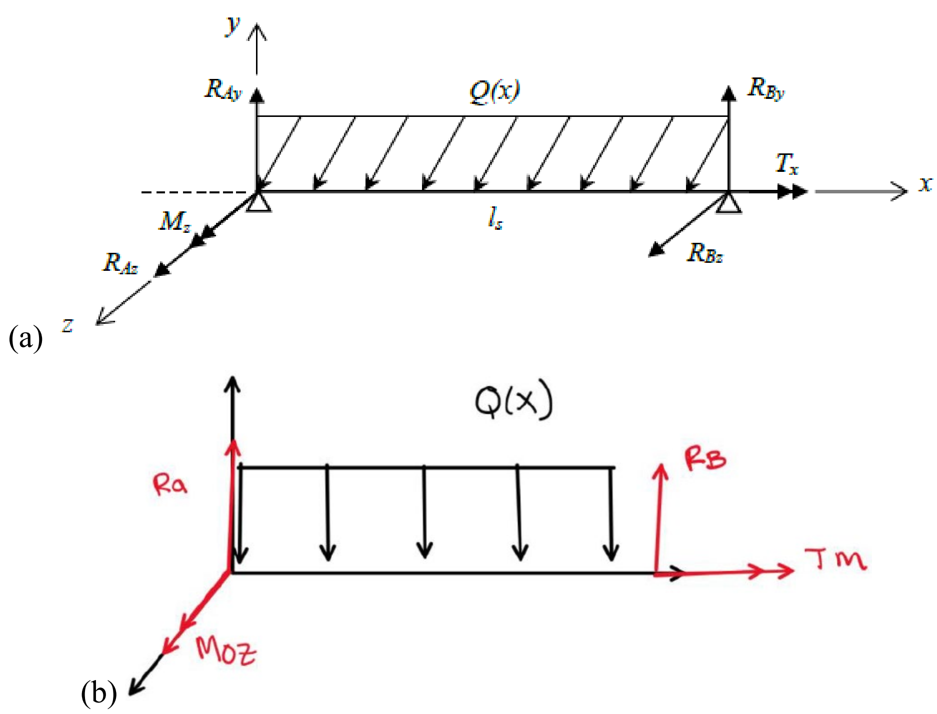


Figure 5. Samples of student work from Activity II; (a) professional and (b) poor.

C. Activity III

The third activity marked the transition from simple component analysis to a more system-level design problem. Pictured below in Figure 6 is an idealized loading condition for a benchtop grinding machine. With the consideration of maximum power and coefficient of kinetic friction, students had to design the shaft diameter to minimize its slope through the bearings. In addition, students were required to include calculations of stalling force, maximum principal stresses, and plots of shaft deflection and slope.

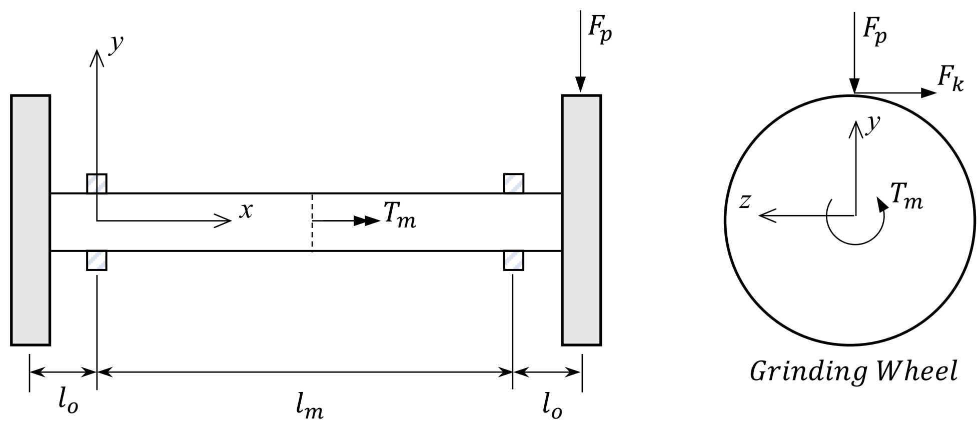


Figure 6. Loading conditions for benchtop grinder; (a) y-x plane and (b) y-z plane.

Although there was noticeable improvement across the board in terms of writing and formatting by the third activity, describing the technical design process still proved a challenge to many students. For comparison, Figure 7 below shows an example of (a) a well described process and equation to calculate the shaft diameter while (b) showing a somewhat confusing and incomplete process. Nevertheless, most students were composing sentences reasonably well but struggling with typing up appropriate and finalized equations. Even with clear guidelines and explicit demonstrations, simple formatting errors were pervasive such as the use of asterisks as seen in the equation below.

To determine the size of the diameter needed, the maximum slope of 0.001 is used and the diameter portion of the moment of inertia is isolated. Doing this and applying the terminology used in the introduction gives the following equation.

$$D_s = \left| \frac{-64(F_{total})(l_o)(l_m)}{3\pi E\xi} \right|^{1/4} \quad (7)$$

(a)

This will result in an equation that, when solved for I, looks like equation 10.

$$I = \frac{-6*E*\frac{dy}{dx}}{F_p*l_o*(3x^2-l_m^2)} \quad (10)$$

Combining equation 10 and equation 2, solving for d_s and plugging in tan(0.001) for dy/dx gives the minimum diameter for the shaft that results in the maximum allowed slope in the shaft at the bearing.

(b)

Figure 7. Samples of student work from Activity III; (a) professional and (b) poor.

D. Activity IV

For the fourth individual writing assignment, Activity IV required students to design a powered water well and its connected support structure. The simple sketch below in Figure 8 was provided as a concept guideline, and the only given parameters were the mass of water to be lifted and the height and width of the support.

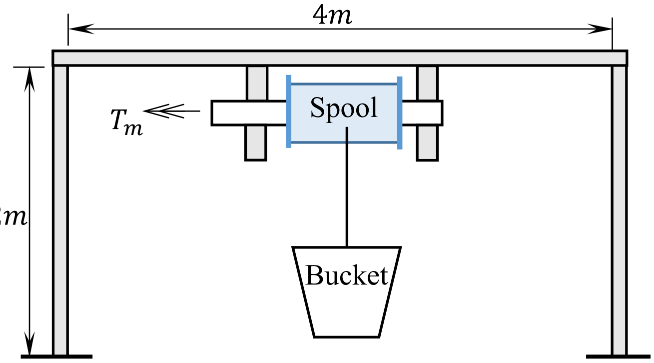
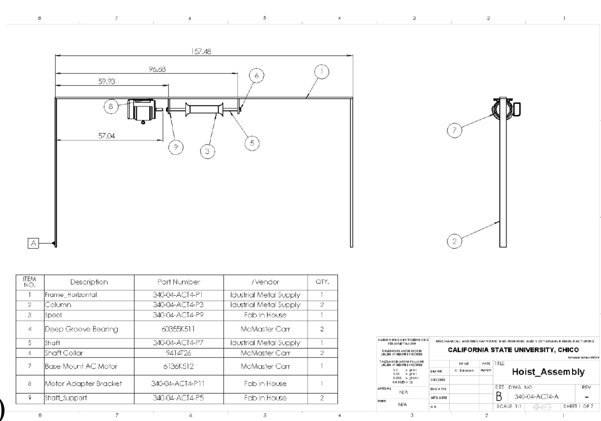


Figure 8. Simple model of a powered water well.

From motor sizing and shaft design to bearing supports and dynamic loading, this problem presented a rather extensive requirement of complex engineering analysis. In addition to the standard technical documentation of engineering analysis, the students were required to draw their design in *SolidWorks* using a provided standard template. The results varied tremendously as seen below in Figure 9. The drawing in (a) shows a full assembly with a parts table while (b) is incomplete with exaggerated thickness. To be fair, this was their first system level design activity for the class. Up to this point all focus and practice was on a single part design. Indeed, many students struggled with the integration of power and design. The motor added a new element and as such many students missed key connections or components.

(a)


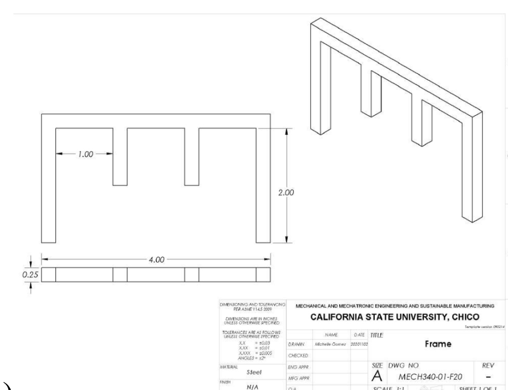
(b)


Figure 9. Samples of student work from Activity IV; (a) professional and (b) poor.

E. Activity V

The final technical writing assignment, Activity V, was a group project to design a powered ice-cream maker. The concept sketch provided to the students is shown below in Figure 10. The only fixed parameter given was the two paddle configuration with each measuring five inches square. The required levels of engineering analysis and technical documentation were substantial. Firstly, the students had to research ice-cream making to develop a model of torsional loading as the ice-cream thickened. Then, specifically size and source a motor with gearing sufficient to power through the worse-case scenario. Secondly, students were required to address the Thermodynamics and heat transfer to achieve proper mixture temperature. As well, they designed the shaft diameter, paddle thickness, container, motor support, bearings, motor control, and bill of materials. Figure 11 is an exploded view for one such group's final design.

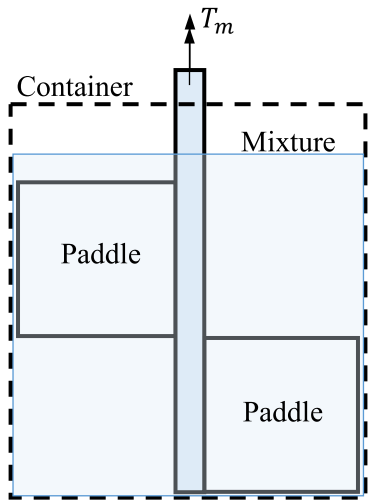
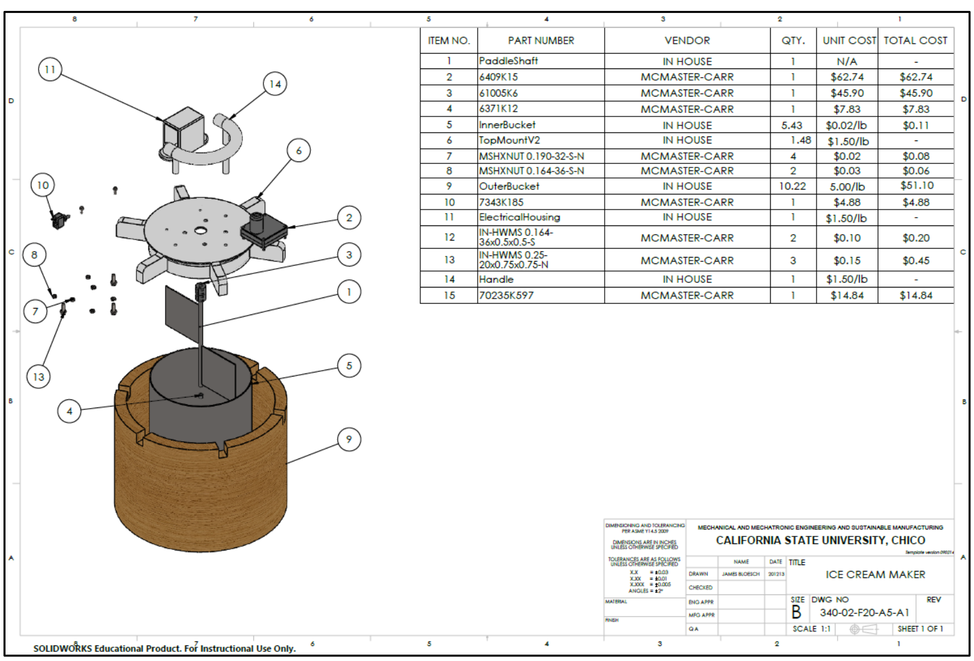


Figure 10. Ice-cream maker with paddle concept sketch.



ITEM NO.	PART NUMBER	VENDOR	QTY.	UNIT COST	TOTAL COST
1	PaddleShaft	IN HOUSE	1	N/A	-
2	6409K15	MCMASTER-CARR	1	$62.74	$62.74
3	61005K6	MCMASTER-CARR	1	$45.90	$45.90
4	6371K12	MCMASTER-CARR	1	$7.83	$7.83
5	InnerBucket	IN HOUSE	5.43	$0.02/lb	$0.11
6	TopMountV2	IN HOUSE	1.48	$1.50/lb	-
7	MSHXNUT 0.190-32-S-N	MCMASTER-CARR	4	$0.02	$0.08
8	MSHXNUT 0.164-36-S-N	MCMASTER-CARR	2	$0.03	$0.06
9	OuterBucket	IN HOUSE	10.22	5.00/lb	$51.10
10	7343K185	MCMASTER-CARR	1	$4.88	$4.88
11	ElectricalHousing	IN HOUSE	1	$1.50/lb	-
12	IN-HWMS 0.164-36x0.5x0.5-S	MCMASTER-CARR	2	$0.10	$0.20
13	IN-HWMS 0.25-20x0.75x0.75-N	MCMASTER-CARR	3	$0.15	$0.45
14	Handle	IN HOUSE	1	$1.50/lb	-
15	70235K597	MCMASTER-CARR	1	$14.84	$14.84

Figure 11. Example of student work from Activity V.

Regarding the writing element, composing sentences which concisely articulate the technical analysis of engineering design did not come easy for many students. Although there was marked improvement as compared to early activities, issues still persisted into the final assignment. Even the best of students would occasionally slip from third-person passive voice into first-person as seen below in Figure 12. In fact, the narration of engineering analysis was superb, but there were occasional uses of "we". In more problematic examples, students listed numerous equations one after the other without supporting sentences intermixed. Also, figures might look professional but sentences which described the results within them were scarce or non-existent. As understood anecdotally, their experience with technical writing up to that point was limited to laboratory reports. Clearly, rewriting experimental procedures and tabulating results had ill-prepared them for the more rigorous requirements of engineering design documentation.

To determine the diameter of the shaft, the bending is analyzed to find the minimum diameter based on the forces seen on the paddles by turning the ice cream. Since the container is not very deep, we are assuming pressure does not increase based on the depth of the paddle.

$$F_D = \alpha\,\eta\,v$$

Where α = size factor, η = viscosity ($Pa \cdot s$), and ν = velocity. Velocity can be further equated to equal ν = ω·x to obtain the following equation:

$$F_D = \alpha\,\eta\,\omega\,x \qquad \text{Eq. (1)}$$

The distributed load acting on each paddle can be equated using Eq. (1) above:

$$Q(x) = \alpha\,\eta\,\omega\,x \qquad \text{Eq. (2)}$$

After the distributed load has been found for each paddle, the individual paddle force F_p is found by taking the integral over paddle with as follows:

$$F_p = \int_0^b Q(x) = \int_0^b \alpha\,\eta\,\omega\,x\,dx$$

$$F_p = \frac{\alpha\,\eta\,\omega\,b^2}{2} \qquad \text{Eq. (3)}$$

The applied moment from each paddle is then found by taking the following integral of the distributed load:

$$M_p = \int_0^b x\,Q(x) = \int_0^b \alpha\,\eta\,\omega\,x^2 dx$$

$$M_p = \frac{\alpha\,\eta\,\omega\,b^3}{3} \qquad \text{Eq. (4)}$$

Figure 12. Example of student work from Activity V.

III. Student Outcomes

Under a single instructor having a full teaching load, a total of 60 students enrolled in the fall 2020 semester of MECH 340. While lecture consisted of the entire class, activity time was divided into two sections. Prior to this semester, DFW rates for this course varied in the single digits for the same instructor. Unfortunately, the DFW rate for this first online semester was 38%. Notwithstanding the effectiveness of online teaching, assessing student outcomes under such an extreme difference in teaching modality is no less than problematic. That is, was the aforementioned implementation of technical writing exercises a success given the high DFW rate? As for as technical writing skills, profound levels of improvement were observed over the course of the semester. Regarding their curriculum, students must take four courses which are classified as writing intensive (WI). The first three are from non-technical general education classes and the fourth being their Capstone class. Upon taking MECH 340, students have taken at least two of these courses.

For MECH 340, the formatting guidelines and rigorous standards were made explicitly and abundantly clear. That being said, the majority of students on the first assignment did not follow even the most basic formatting guidelines such as margins and font type. Even after being shown explicitly over Zoom "share-screen" how to adjust word formatting and *Excel* plots, many turned in results with default settings. In fact, the Zoom sessions were recorded, so all one needed to do was re-watch the video specific to Activity I. Anecdotally, there was considerable surprise at the strict requirement for attention-to-detail and adherence to formatting guidelines. The average grade with standard deviation for all five activity assignments is given below in Figure 13. As compared to the first, there was significant improvement in Activity II. Moving on however, the standard deviation widened substantially as more and more students struggled with the online teaching modality. By the end of the semester, a significant percentage had either dropped the class or were struggling to maintain a passing grade. Switching to groups for Activity V, the students rallied for their final project and did remarkably well.

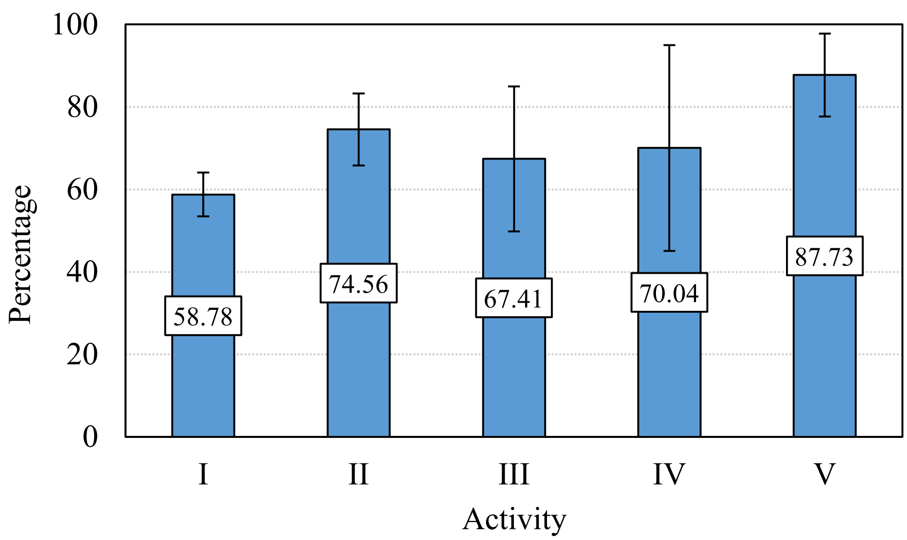


Figure 13. Average grade percentage for writing activities.

After the first activity assignment was returned, a survey was administered to recognize student experience with technical writing and assess the execution of writing focused activities for Machine Design. This first survey consisted of four questions:

- *To what extent have you practiced writing professional technical reports prior to this course?*
- *To what extent have the pace, expectations, and feedback for the writing assignments been agreeable?*
- *To what extent have the technical writing assignments enhanced your level of understanding of course material?*
- *To what extent has your ability to write professional technical reports improved in this class?*

The point system shown below in Table 4 was adopted to characterize their response.

Table 4. Summary of Survey 1 response scheme and questions.

None	Little	Some	Lots	Substantial
1	2	3	4	5

The average response with standard deviation is given in Figure 14. As seen by the response to question one, the students overwhelmingly lacked experience with technical writing. This was somewhat surprising given that laboratory courses such as with physics and material science typically require typed reports for experiements. The second question targeted the pace and execution of said writing assignments. From their response and general classroom discussion, due dates were extended and more specific feedback was provided to help improve subsequent assignments. Always looking for enhanced learning benefit, the fourth question sought to appreciate added benefit to the course material. Their response and anecdotal feedback suggested positive value. Finally, the last question was an early check on their reflection of improved writing skills. Although they had only one assignment, their reponse indicated substantial improvement. This makes sense given that they apperently had little experience in technical writing prior to this course.

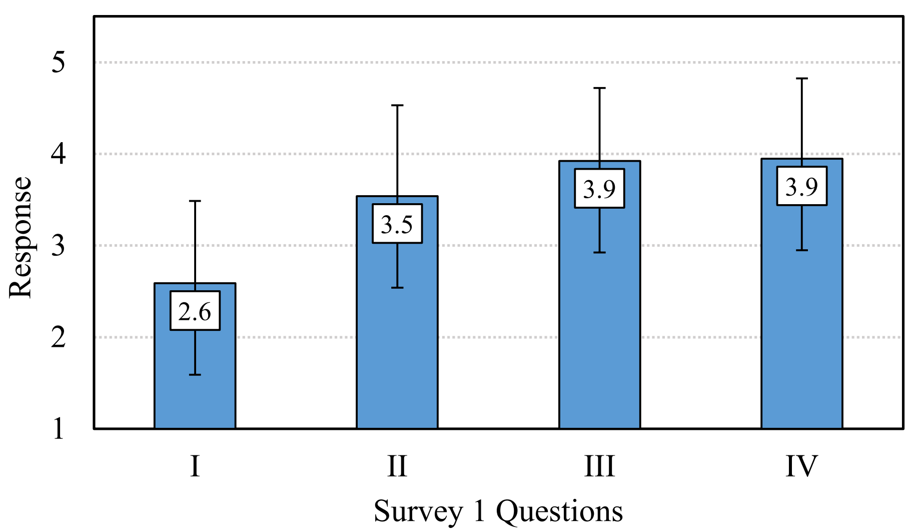


Figure 14. Survey 1 responses averaged with standard deviation.

A second survey was administered at the end of the semester. The four questions are listed below:

- *To what extent have your professional writing skills improved in this course?*
- *To what extent did the activity assignments help improve your level of understanding of course material?*
- *To what extent could the series of activity assignments be improved to better support your educational experience?*
- *To what extent would you prefer a hands-on semester project over written activity assignments?*

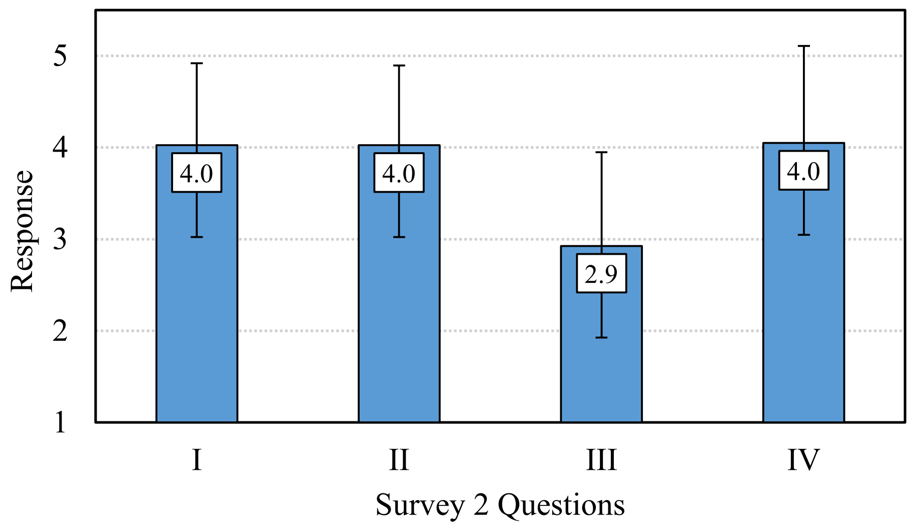


Figure 15. Survey 2 responses averaged with standard deviation.

The average response with standard deviation is given in Figure 15 for all four questions on the second survey. To evaluate successes with the writing focus effort, the first three questions were the same as in the first survey. In an almost identical response, a majority students again reported significant recognition of improved writing skills. As well, the students again reported that the writing assignments enhanced their level of understanding of course material. Interestingly, for the third question regarding ways to improve the activity assignments, the response was more favorable indicating that early adjustments to feedback and timing had helped. Finally, the last question targeted their preference towards hands-on projects versus the writing activity assignments. Although there was clear indication of hands-on preference from the survey response, the high standard deviation and anecdotal feedback indicated that the students recognized significant value in their improved technical writing skills.

IV. Conclusion

Although teaching MECH 340 fully online meant no possibility for an exciting and engaging hands-on project, there was a silver-lining in being forced to redesign the weekly two-hour activity time. The focus on developing technical writing skills presented an opportunity to help students drastically improve their preparedness for all aspects of technical writing. Learning to compose sentences which describe the engineering design process certainly takes practice and many clearly improved their writing over the course of the semester. On the other hand, most students had never typed an equation nor learned to properly sketch Free-Body diagrams, for instance. Ironically, it was the basic formatting requirements that seemed to be some of the greatest challenges for students. Even with explicit guidelines and feedback, many early works and even some later ones were shockingly terrible. How much of this was a result of being fully online? Impossible to say, but certainly many students struggled overall as can be seen in the DFW rate.

Instituting a new focus on technical documentation is no less than difficult in the best of times, but such a focus during a pandemic may have not been the best timing. Overall, the semester experience with writing focused design activities was a success given the overwhelming feedback from students appreciating their substantially improved skills in technical documentation. Another important factor to consider is that the activity assignments actually helped students better understand the course material. On the other hand, the shear logistics of giving so many students detailed and timely critical feedback was overwhelming at times. Given the starting point of most students, many needed significant help with even the most basic formatting issues. As well, many struggled with basic sentence composition. Consequently, some class-time was devoted directly to formatting demonstrations and examples of sentence formulation. This was particularly surprising because students must pass at least two, if not three, writing intensive (WI) classes prior to MECH 340. All of which begs the question, would students be better served if MECH 340 itself were to be qualified as a WI course? Such a classification would mean that they would satisfy curriculum requirements directly in line with their field of study. Another benefit is that enrollment would be capped at thirty students per section which would mean that the teaching load of the instructor would be far more conducive to handling the writing assignments and feedback.

In the end, there was profound acknowledgement of value appreciated by the students. With this experience in mind, the instructor is currently working on the approval process of making MECH 340 a WI course. An integration of writing practice specific to the engineering curriculum should better prepare students for their Capstone experience and beyond. That being said, there is also undeniable value in implementations of semester hands-on design projects. Furthermore, as seen in the survey results, students clearly prefer hands-on projects but at the same time understand the importance of improving their writing skills. Upon returning to in-person instruction, is there a way to conduct both? The key will be in finding balance between writing assignment activities and time devoted to an actual design and fabrication of a hands-on project. Indeed, it is the goal of this instructor to develop the course in such a way as to get the best of both worlds for students.

V. References

[1] O'Connor, D. (2020, June), *Electric Ceiling Hoist: A Semester Project with Competing Forces to Enhance Student Learning in Machine Design* Paper presented at 2020 ASEE Virtual Annual Conference Content Access, Virtual On line. 10.18260/1-2-34512

[2] Henderson, H., & Dillon, J. (2010, June), *Water Turbine: Improving A Project For Reinforcing Machine Component Design* Paper presented at 2010 Annual Conference & Exposition, Louisville, Kentucky. https://peer.asee.org/16462

[3] Mikhail, M., & Engle, C. D. (2017, June), *Enhancing Machine Design Course with an Integrated Vending Machine System* Paper presented at 2017 ASEE Annual Conference & Exposition, Columbus, Ohio. https://peer.asee.org/28277

[4] Jaeger-Helton, K., & Smyser, B. M. (2018, June), *The Write Background Makes a Difference: What Research and Writing Skills can Predict about Capstone Project Success* Paper presented at 2018 ASEE Annual Conference & Exposition , Salt Lake City, Utah. 10.18260/1-2--31137

[5] Hutto, D., & Hollar, K., & Constans, E., & Marchese, A., & Harvey, R., & Pietrucha, B. (2002, June), *Writing As A Design Practice: A Preliminary Assessment* Paper presented at 2002 Annual Conference, Montreal, Canada. 10.18260/1-2-10690

[6] Reynolds, M., & Untener, J. (2001, June), *A Systemic Approach To Integrating Technical Writing In The Curriculum* Paper presented at 2001 Annual Conference, Albuquerque, New Mexico. 10.18260/1-2-9841

[7] Simson, A., & Randi, J., & Becker, A. L. (2017, June), *Assessing the Value of Different Techniques for Teaching Technical Communication Skills* Paper presented at 2017 ASEE Annual Conference & Exposition, Columbus, Ohio. 10.18260/1-2—27628

[8] Figliola, R., & Daniell, B., & Young, A., & Moline, D. (2003, June), *Learning To Write: Experiences With Technical Writing Pedagogy Within A Mechanical Engineering Curriculum* Paper presented at 2003 Annual Conference, Nashville, Tennessee. 10.18260/1-2-11457

[9] Smith, S., & Watt, A., & Carvill, C., & Williams, J. (2002, June), *Integrating Writing Into Technical Courses* Paper presented at 2002 Annual Conference, Montreal, Canada. 10.18260/1-2-10296