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Implementation of Blogging as an Alternative to the Lab Report*

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Undergraduate engineering laboratory courses are designed to increase students' hands-on capabilities through application of theoretical knowledge. However, a laboratory manual may lack any connection to prior content, and expectations for thoughtful, developed writing are minimal. In this article, an instructor's implementation of a collaborative project to build Rube Goldberg machines combined with the course laboratory reports presented via blogs has been evaluated. An end-of-semester survey was conducted with the 18 students in the course and results are discussed along with the analysis of blog comments and student products. Overall, the intervention was deemed successful as a means to improve students' engagement, learning, and collaborations, despite some students' concern that blogging may not have improved their learning.

Keywords: circuits lab; writing; blogging; blog; digital writing; Rube Goldberg; engagement; collaboration, interdisciplinary skills; laboratory report

1. Introduction

Engineering educators must promote students' content knowledge mastery and—as a recent survey of employers demonstrates [1]—cross-disciplinary skills such as teamwork, problem solving, and communication. Writing, in particular, is critically important, yet research in engineering education dating back three decades notes that "the structure of most engineering courses fails to conform to this pattern [of using writing] found in the work setting" [2]. Additionally, newer literacies and technologies influence the ways in which writing circulates in the world and, subsequently, is taught in our classrooms [3] and this communication problem/skills gap is exacerbated in STEM fields where a large shortage of qualified applicants exists, especially among female and minority graduates [4].

This manuscript documents one professor's attempt to improve writing, problem solving, and collaboration in an electrical engineering course by requiring students to create blog posts documenting their work instead of writing traditional lab reports. The intervention was designed to promote students' higher-order thinking, to build collaborative skills, and to increase engagement through peer response. In traditional lab reports, students follow step-by-step instructions and record what they see, usually in rote format; students can get the machine to work, but struggle to adapt what they are doing to new situations or explain to one another what happened. By employing blogs for collaborative writing, the instructor believed that it would avoid problems with traditional lab reports and promote high-order thinking.

This shift in writing practice required two changes in teaching. First, the instructor revised the format of the lab questions in the manual and, second, required students to use blogs; this, in turn, requires students to thoughtfully explain the phenomena they are reporting. Blogging, it was speculated, could also allow students to explore their classmates' ideas and question their process of problem solving, much the same way as one would be expected to collaborate in a post-university job.

Against this backdrop, this study explores the following research questions: How did the implementation of blogging:

(1) impact student's experience of collaboration?
(2) change student's learning of the material?
(3) influence student's overall engagement in the course?

To further these questions and to make our work more applicable to other STEM scholars, we take seriously the call from Reynolds et. al. who have

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argued that we need to examine writing-to-learn (WTL) practices in a coherent manner across studies [5]. Thus, we borrow their conceptual framework to articulate our own study. Reynolds et. al. offers the following template for framing inquiry around a writing-to-learn practice:

> "What is the role of [specific WTL practice] in improving [disciplinary-specific learning objective] through impacting [specific cognitive, metacognitive, motivational, and/or emotional process], as a function of [context variables, such as course level and class size; discipline; level, background, and goals of students; and subdiscipline, local, and institutional factors]?"

Our questions, through this framework, become:

> What is the role of implementing blogging as a teaching strategy to attempt to transfer applied engineering theory into practice as a function of student-reported (1) engagement, (2) learning, and (3) collaboration by replacing the traditional lab report with an inquiry-based approach to writing?

This article documents the work of an Electrical Engineering Professor (Kaya) who collaborated with a Professor of English and Education (Hicks) as well as a Teaching and Learning Consultant (Bruner) while analyzing the effect that this intervention had on students enrolled in his course, EGR 393: Circuit Lab.

1.1 Rationale for writing in engineering courses

In the past three decades, hundreds of colleges and universities, and thousands of programs and individual courses have made a shift toward writing across the curriculum (WAC) or writing in the disciplines (WID) programs. While there is no comprehensive list of WAC/WID programs, the National Census of Writing is the most recent survey of writing programs across the United States. Results from the 2013/14 administration of the survey suggest that nearly two-thirds (62%) of four-year institutions require students to take writing or writing-intensive courses after their initial experience in freshman composition [5].

At the course level, we must consider a variety of factors related to the integration of writing including: faculty members' own experiences and dispositions as writers, professional development opportunities at the institution, department and college culture, and, perhaps most importantly, student perceptions of writing in the disciplines. We agree with Reynolds et. al. who suggest that "Since higher-order thinking involves restructuring knowledge, we need to determine what types of writing activities evoke this process of knowledge transformation" [6]. To that end, we considered how blogging about the laboratory experience could be one such option.

Moreover, for a school of engineering to be considered a high-quality, accredited program, it must be certified by the Accreditation Board for Engineering and Technology (ABET). Our institution's electrical and mechanical programs are accredited and, in turn, must meet a variety of student outcomes. In particular, the instructor of this course aimed to meet the following ABET goals through enhanced use of writing:

(a) an ability to apply knowledge of mathematics, science, and engineering;
(b) an ability to design and conduct experiments, as well as to analyze and interpret data;
(e) an ability to identify, formulate, and solve engineering problems;
(g) an ability to communicate effectively;
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice [7].

1.1.1 Writing in engineering

Engineering undergraduate students take, on average, five to six laboratory courses, starting with fundamental chemistry and physics labs and continuing in engineering-specific courses such as circuits, microprocessors, vibrations, fluids, and computer simulations. Lab courses are based on hands-on experimentation, computer simulation, or even online experiences [8]. The biggest component of lab courses—besides executing procedures according to the manual—is composing the lab report [8, 9] Depending on the content and the instructor, requirements for a lab report can be as little as filling out a few tables during the experiment all the way up to 20-page formal reports. Regardless of the report requirements, a written document is submitted by the student or a team of 2–3 students. Engineering lab reporting, on the other hand, is relatively different than writing in social sciences, the humanities, or other general education courses as it heavily deals with data, figures, and schemes [10]. Regardless, developing technical communication skills is important as it helps students "*learn to learn by teaching them to transfer knowledge through metacognition, analogical reasoning, and cognitive flexibility*" [11].

Yet, the lab report serves more functions than just a summary of the tasks completed. Specifically, in considering the ways that writing can be taught in engineering courses, the instructor's goal must move beyond reporting and into higher levels of analysis, application, and synthesis. Vazquez et. al. note that "[u]nlike writing summaries, generating explanations requires students to reconstruct information and integrate this information with prior knowledge" [12]. Similarly, with the engineering circuit lab, students must be able to communicate

effectively both in writing and orally, and they must compare predicted results with actual experimental findings. By providing feedback to their peers, students would engage in deeper thinking than a traditional question and answer session [13].

Beyond the write-up of explanations, deeper benefits can be found in using writing-to-learn assignments. For instance, when discussing the use of writing in biology, Dirrigl and Noe point out that

> "As students take a more active role in their learning, the role of the biological writing instruction shifts from teacher to mentor, assisting students in their own attempts to improve their writing and providing a learning environment that allows them to become self-aware of, engaged in and proud of their progress" [14].

Similarly, writing in the electrical engineering lab becomes an opportunity for thinking, for demonstrating understanding of the concepts. Moreover, opportunities for digital writing—such as a blog post including photos and videos taken with smart phones—would provide students additional ways to express their understanding of the engineering concepts. Videos, in particular, help students explain the results in a concise, 20-30 second segments. This "writing-by-the-way" can, over time, become a method for students to generate more substantive, formal writing [14].

1.2 Blogging

As the instructor redesigned this course for the spring of 2016, he relied upon his experience having taught the same course three times before, as well as multiple other lab sections. In particular, he revised the lab report requirement by asking students to compose a blog entry about the week's experiments. This instructional move was also an innovation because the blog could include photos, drawings, tables, and videos. Given the instructor's interest in having students' make their work public, open for review and response by classmates, blogging seemed appropriate. Halica et. al.'s previous success with blogging discusses a similar approach:

> "The majority of the participants in this study reported that their blog experience was positive and enhanced their overall learning, in particular helping them think about concepts outside of the classroom. They also acknowledged that the blogging task facilitated the sharing of knowledge among peers" [16].

Additionally, Ebner and Maurer examined the ways in which students who participated in a process of blogging and micro-blogging described their experience as writers compared to their peers who chose to write a more traditional scientific paper:

> "The most positive effect of weblogs usage was that the students wrote about a topic over a longer period of time. This led to a more in depth cognitive process: each blogger discussed his topic much more in detail than a comparable Scientific Writer" [17].

Thus, while blogging is still a relatively new phenomenon in higher education, the instructor felt that it could offer his students a chance to explore lab topics in more detail and generate substantive conversation about engineering concepts. Further elaboration on the ways in which blogging was implemented in the course is shared in section 2.1.2 below.

2. Presentation

The integration of blogging coincided with two additional innovations in the EGR 393 class. Whereas previous sections of the course had students completing individual lab reports and designing a final project of their own, the instructor worked in two other collaborative activities: the use of a "Rube Goldberg Machine" project and the introduction of peer response to the blogs.

2.1 Teaching methods

2.1.1 The "Rube Goldberg machine" as basis for course design

Although lab courses are hands-on experiences, single outcome experiments have limitations and project-based laboratory experiments are more effective [15]. One such approach that has become popular at universities such as Rochester Institute of Technology, Carnegie Mellon University, and Robert Morris University is the creation of a Rube Goldberg Machine [16]. Based on the famous cartoonist and his overly-engineered contraptions, according to Merriam-Webster, "Rube Goldberg" is defined as "doing something simple in a very complicated way that is not necessary" [17].

The EGR 393 began with a few weeks of relatively structured Rube Goldberg (RG) construction and circuit building; then students were asked to make their own RG machine using the material they mastered in the past few weeks. Students were given full autonomy on the complexity of their individual components of the machine that the class would create together. Students spent more time than the instructor had anticipated and a majority of groups came up with quite complex RG setups including both course material and advanced topics that would be covered in the later weeks (with the instructor's help). Lab experiments were set up in a way that, in every step, students would face a structured failure. Students needed to develop persistence. However, it is very important for the instructor to create those structured failures in a certain way that students can build on their recently acquired skills or knowledge

Table 1. Examples of Course Changes

Traditional question	Critical thinking/open ended question
• Comment on the level of percent difference in Table 3.3. • Are the percent differences sufficiently small to establish firmly the fact that the current determined by Ohm's law will be very close (if not equal) to that measured directly? • Answer the question in sentence form (Experiment DC 3, Laboratory Manual to Accompany Introductory Circuit Analysis, 12th ed., Robert L. Boylestad and Gabriel Kousourou, Pearson Prentice Hall, Upper Saddle River, NJ (2010).) [18]	Student instructions for blog post: • How do you experimentally prove Ohm's Law? • Provide measurement results. • Compare calculated and measured voltage, current, and resistance values. • Also, include an experimental setup photo
Traditional Lab Instructions	**Open-Ended Lab Instructions**
There are two types of LED 7-segment displays: common cathode (CC) and common anode (CA). The difference between them is that the common cathode has all the cathodes of the 7-segments connected directly together, while the common anode has all the anodes of the 7-segments connected together. The figure below shows a common anode seven segment. As shown above, all the anode segments are connected together. When you work with a (CA) seven segment displays, power must be applied externally to the anode connection that is common to all segments. By applying a ground to a particular segment connection (a–g), the appropriate segment will light up. An additional resistor must be added to the circuit to limit the amount of current flowing thru each LED segment. We will use this type of seven segment display in our experiment. In a common cathode (CC) seven segment display, the cathodes of all LEDs are connected together. To use this seven segment display, the common cathode connection must be grounded and power should be applied to appropriate segment in order to illuminate that segment. Each segment of the seven-segment display is a small light-emitting diode (LED) or liquid-crystal display (LCD). A decimal number is indicated by lighting a particular combination of the LED's or LCD's elements. Connect the seven segment display, seven segment driver, and resistors as shown below.	Check the manual of 7 segment display. Pdf document's page 5 (or in the document page 4) circuit B is the one we have. Connect pin 3 or pin 14 to 5 V. Connect a 330 Ω resistor to pin 1. Other end of the resistor goes to ground. Which line lit up? Using package dimensions and function for B (page 4 in pdf), explain the operation of the 7 segment display by lighting up different segments. (**EXPLAIN with VIDEO**).

as well as develop the confidence to ask for help from peers. Surprisingly, even without providing extra credit for RG setups, students exceeded the expectations of what was required of them. In short, their RG setups were completely unique.

Ultimately, the goal for students was to create unique solutions to particular electrical engineering problems. Students would understand and apply course concepts by collecting and analyzing the data, checking their understanding through probing questions. In the traditional lab style, students were not involved in deeper thinking to explain engineering concepts such as current requirements, alternative circuit implementations, and practical uses of fundamental circuits. In previous semesters, the instructor had also noticed that students' performance on quizzes and the final exam were superficial. This year, the instructor prepared his own manual. Students were still required to look at the manual and prepare for the pre-quiz each week. What differed from previous years, however, was that questions were more open-ended and required explanations. Furthermore, most of the quizzes were even posted online to give students enough time (mostly over the weekends) to grapple with the questions and come up with ideas.

Some examples from the traditional lab classroom from previous years (same instructor) and the current classroom are provided in Table 1 and Fig. 1. The first example is the way how Ohm's Law was introduced experimentally. Ohm's Law is the fundamental electrical engineering concept about current and voltage. Students know the concept theoretically from previous engineering circuits and physics classes. In the traditional setting, the lab manual (from a lab manual textbook) goes step-by-step with a particular approach to the problem. Once students fill out tables and answer mostly "yes/no" type questions, they are prompted to make a conclusion statement, which usually results in sentences like "Ohm's Law is true," or "Ohm's Law was proven." In the current lab course, students were given the opportunity to choose their method of proving the Ohm's Law. Students were provided the original datasheet of the circuit and were loosely led to the direction so they could figure out the connections by themselves. Students got to choose their own circuit parameters and values. They

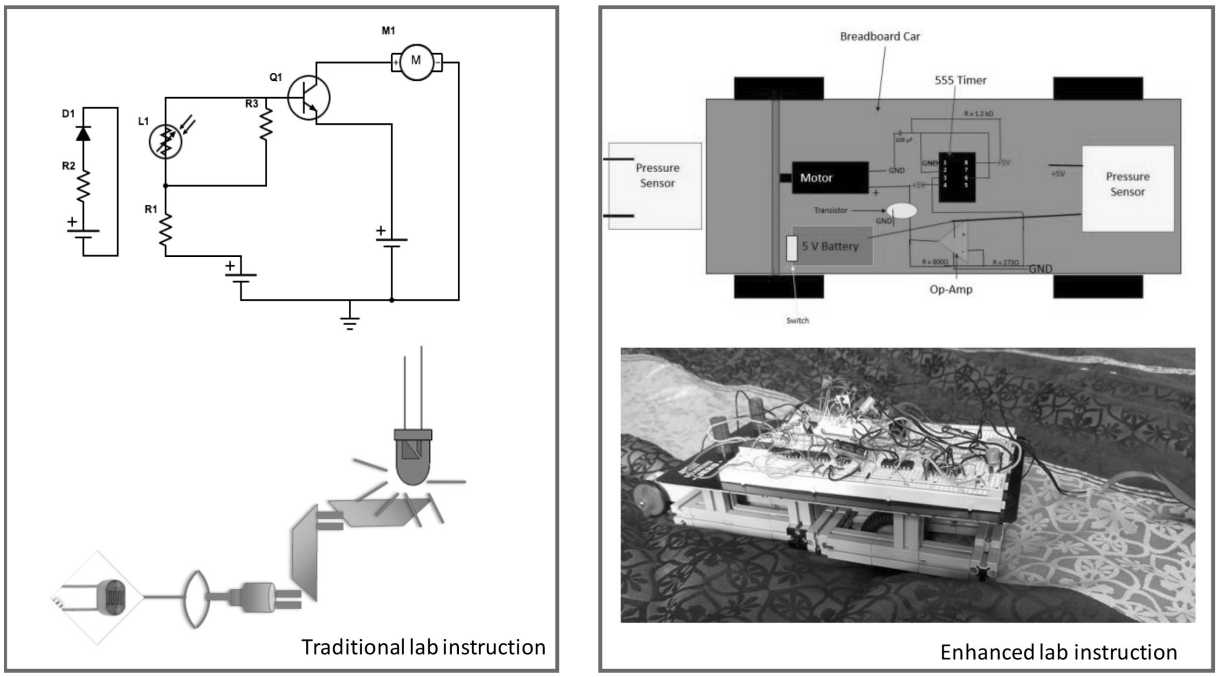

Fig. 1. Comparison of a student final project samples. Revised format yielded more complex project outcomes with deeper understanding.

needed to explain their methodology and provide measurement results to check if the Ohm's Law was confirmed. Furthermore, students were asked to create a short video of their findings where they were required to explain the circuit operation with their own words.

The RG project was the final project for both this year and in previous years. Two examples were provided by choosing one of the best projects of those different years. It can be seen that the previous years' best project was quite unsophisticated compared to the one that was designed this year. Although the instructor's knowledge about the RG project has improved—and that likely had an effect on students' projects—it is quite apparent that circuit complexity was significantly better this year.

2.1.2 From lab reports to blogging

Because the main goal was to work towards a class-wide RG machine where each contraption is connected to another contraption, the entire class was structured around accountability and collaboration. Students were given advanced lab set ups with detailed instructions. Once they succeeded in creating the lab experiment, the following weeks were spent trying to understand how the mechanism works. Students were not given direct instructions during those exploration phases. Rather, they were provided questions or clues about how they should be approaching the problem. Once students built an innovative, working contraption, they were then steered towards understanding how it worked.

In this context, blogging then provided students a way to deliver their findings publicly, creating a positive type of peer pressure. For engineering students, writing technical documents often leads to a kind of "fake writing," whereby they create artificially-long sentences with complex vocabulary that do not add any value to the topic. Asking them to blog helped filter that kind of extraneous information, for many of the reasons noted above. If they were to submit the lab report only to the instructor, their thinking process would end there. In addition to making students think more deeply, the instructor also believed that the public nature of blogging would raise the overall quality of writing. It was very powerful for students to see and respond to other blogs, which might provide a different solution or, at the very least, the same solution presented in a different way.

3. Data collection

To evaluate the effectiveness of the blogging intervention, the three researchers designed a survey, which was administered by the professor of English and Education immediately after one of the course meetings near the end of the semester. The instructor left the room and the survey was explained to the students: participation was voluntary, their responses were blinded, their instructor would not know who participated, and that if they did complete the survey they would be given a $10 gift card for their time. At this point, students who remained were given a secure link to a survey created in

Google forms where they entered their responses and the administrator verified their completion.

The full survey is available in Appendix A, and was specifically structured into different parts and built on the questioning of Top [19]. Basic demographic and background information was collected such as gender, race, grade, major, and GPA. These were intended to underpin the responses for any differences by grouping. The next sections focused on blogging specifically: how blogging impacted their learning, how blogging supported their engagement in the course, and how blogging impacted their collaboration with other students. Finally, some university-specific questions related to initiatives were asked, and they are not reported in this paper. Except for the demographics and background, all questions in the sections about blogging used a six-point Likert scale where a '1' represents "Strongly Disagree" and a '6 represents "Strongly Agree." A six-point scale was selected because the authors were interested in which way the students were leaning with respect to more positive or negative and did not want to provide the option for a neutral response.

3.1 Sample information and limitations

The final sample contained 18 students of which 89% were male and 89% were white. This aligns with the large body of literature showing how females and minority students are disproportionately underrepresented in university STEM courses. As expected, over 90% of the participants were engineering majors. Given the lack of heterogeneity in these groups, we elected not to study our responses by these characteristics. Diversity was present in GPA and grade level. Half of the participants were junior status with about a quarter of the students each at sophomore or senior status. GPA for both overall and major GPA was almost equally distributed across the five GPA ranges (from about 17 to 28 percent in for each range) which offers the opportunity for insight into how blogging may differ by class rank or GPA.

The major limitation of this study, quantitatively, is that the sample size is too small to make any meaningful statistical inferences. Due to these limitations, we simply present summary statistics and make no attempt to aggregate our findings through further statistical analysis. Students were also selected based on convenience, and there is comparison group; however, we intend to pursue additional surveys in future semesters to allow for more robust analysis. Based on these limitations, our results should in no way be interpreted as causal or be considered representative of a larger population.

4. Results

Unfortunately, despite having good variation by GPA and class, no clear patterns emerge in the data by these filters; thus, it is difficult to conclude whether using blogs was better or worse for a particular group of students. On the other hand, blogging seemed to benefit students regardless of GPA or class standing, so that can be seen as an overall advantage. This initial finding is something that may merit additional future research.

As a block, the collaboration scores were extremely high with the exception of students reporting that blogging was not better than the in-class experience; however, the remainder of their responses would appear to indicate otherwise; students strongly agreed with the fact that blogging increased their collaboration. Student engagement, as a block, was neutral with respect to students agreeing or disagreeing that blogging increased their engagement in the course. Finally, students reported that they agreed that their overall learning in the course increased moderately as a result of blogging.

What was extremely surprising was how these characteristics distributed across the different sections of the survey. Figs. 2a–2c below show the distribution of the Likert averages for learning, engagement, and collaboration sections of the survey by student GPA. As can be seen, in no case was a certain group of students advantaged or disadvantaged in any of these aspects as it related to implementing blogging. If anything, the students in the lowest group of GPA had the most favorable responses to blogging. More research would be needed over various groups and semesters, but we can make a modest claim that implementing blogging did not have the distributional effects of advantaging some groups of students over others (as is common in many educational interventions).

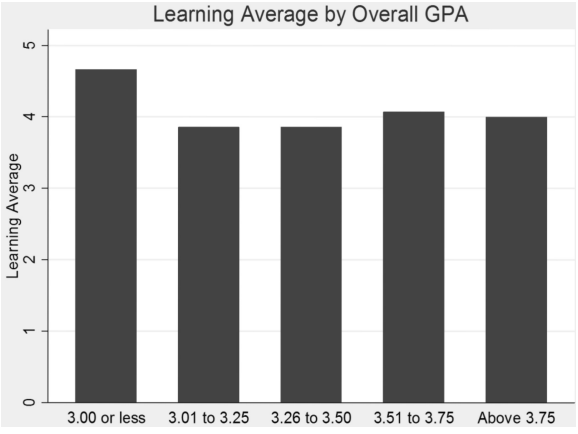

Fig. 2a. Student reported agreement that blogging increased their *learning* by GPA.

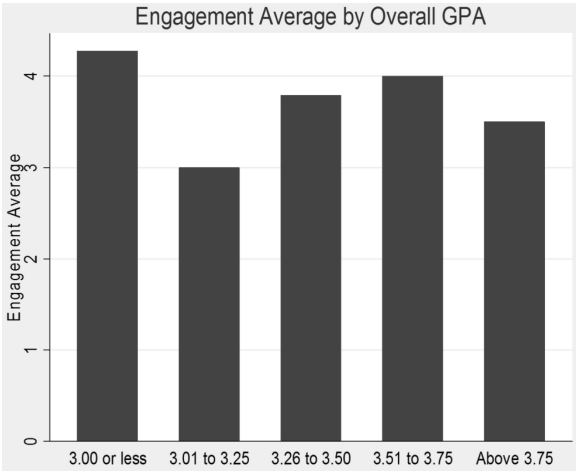

Fig. 2b. Student Reported Agreement that Blogging Increased their *Engagement* by GPA.

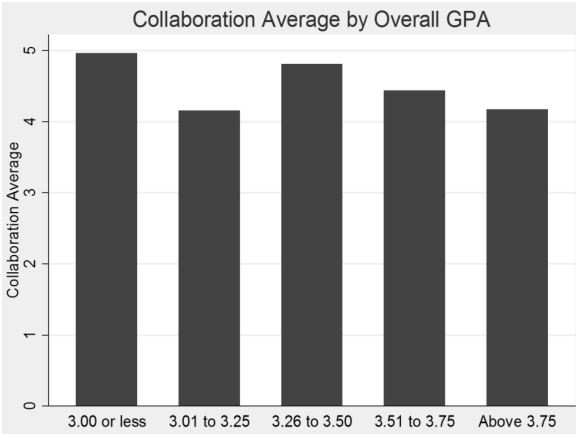

Fig. 2c. Student reported agreement that blogging increased their *collaboration* by GPA.

4.1 Student reported impact of blogging on engagement

As a block, the impact of blogging on student engagement had the lowest overall average at 3.64. This was perhaps due to the fact that the blogging was just one aspect of the course and the RG contraptions were a major focus as well. The highest scored item in this section was that students felt that blogging increased their interaction with their peers compared to other courses. The lowest rated item in this section was that blogging did not inspire students to do additional research. Table 2 below details the averages for each item.

4.2 Student reported impact of blogging on learning

One positive outcome was that the participants felt that blogging helped improve their learning, yielding a 4.11 average rating to this question. As table 3 shows below, with one exception, all the item averages hovered around a 4.0 or above, suggesting that students felt blogging moderately contributed to their learning. Students felt most positive about how the blog discussions allowed them to share their learning but did not feel that other students' comments about their blog were important which seems to be contradictory.

4.3 Blogging and collaboration

As seen in table 4, by far this section was the most highly rated by the students. All of the averages were at 4.5 or higher—with two exceptions (though one was still a 4.39)—suggesting that students felt the blogs were a useful medium for improving collaboration. What is interesting is the somewhat contradictory responses by the students in this section. The lowest rated item showed that students felt that collaboration through blogging was not as good as face-to-face collaboration. However, when asked specific questions about their collaboration, the students rated all the items very highly. This may suggest that there was some initial student resistance to working in an alternative space such as blogs, but that they were able to recognize the benefits with respect to collaboration.

Table 2. Student Reported Likert Scale Averages for Engagement Question Block

Question	Mean	SD
I visit our group blog more than required by my instructor.	3.50	1.86
The blog helps me feel connected to other students in this course.	3.39	1.69
Due to the class blog, I feel that I am an important part of our classroom community.	3.50	1.38
I have been stimulated to do additional readings or research on topics discussed on the blog.	3.33	1.91
In comparison to my other classes, the amount of interaction with other students in this class has increased due to the blog.	4.17	1.54
In comparison to my other classes, the quality of the interaction with other students in this class has increased due to the blog.	3.94	1.51
Engagement Average	**3.64**	**1.39**

Notes: N = 18; Six-point Likert Scale where 1 = strongly disagree and 6 = strongly agree. Data is averaged by all students for each question within the block.

Table 3. Student Reported Likert Scale Averages for Learning Question Block

Question	Mean	SD
The blog discussions help me to share my knowledge and experiences with my peers.	4.72	0.96
I believe that incorporating blogs with teaching can enhance my learning experience in general.	4.17	1.10
Other students' comments on my blog posts are important.	2.61	1.46
Blog discussions help me understand other points of view.	4.39	1.04
Blog discussions have made me think about project development concepts outside of this class.	3.94	1.55
My point of view has been acknowledged by my peers and/or the course instructor in this course.	4.44	1.20
Overall, using the blog has helped me learn.	4.11	1.53
Learning Average	**4.06**	**1.01**

Notes: N = 18; Six-point Likert Scale where 1 = strongly disagree and 6 = strongly agree. Data is averaged by all students for each question within the block.

Table 4. Student Reported Likert Scale Averages for Collaboration Question Block

Question	Mean	SD
The collaborative learning experience in the blog supported environment is better than in a face to face learning environment.	2.94	1.47
I felt part of a learning community in my group.	4.39	1.14
I actively exchanged my ideas with group members.	4.83	1.38
I was able to develop new skills and knowledge from other members in my group.	4.72	1.27
I was able to develop problem solving skills through peer collaboration.	4.56	1.20
Collaborative learning in my group was effective.	4.89	1.23
Collaborative learning in my group was time consuming.	4.89	1.23
Overall, I am satisfied with my collaborative learning experience in this course.	4.56	1.04
Collaboration Average	**4.47**	**0.86**

Notes: N=18; Six-point Likert Scale where 1=strongly disagree and 6=strongly agree. Data is averaged by all students for each question within the block.

5. Discussion of implementation of blogging

This study was designed to better understand the role of implementing blogging as a course adjustment to attempt to transfer *applied engineering theory into practice* as a function of student reported (1) engagement, (2) learning, and (3) collaboration by replacing the traditional lab report with an inquiry-based approach to writing. Since it is difficult to work with only numbers in interpreting our findings, we have pulled responses from the student blogs that participated in the survey. In the comments below, when students are identified based on responses we gathered from their blogs, we have taken out names and only used first initials.

5.1 Impact of blogging on student engagement

Student engagement is a very broad term there is an important difference between engagement with the course content and engagement with the blogs. Students did report that they felt more interaction with other students both in frequency and quality as a result of the blog, so we are left to conclude that the blog itself was a good tool for increasing these aspects of student interaction. Yet, students reported negatives, too, creating an overall lower level of engagement. This is echoed by some of the student comments from the survey:

- The blogging increased my engagement by encouraging me to write down information during the labs and paying attention to little details, which enhanced my learning experience in this class.
- It increased my engagement by forcing me to comment on other peoples [sic] blogs even though there was usually nothing beneficial to say.
- It decreased engagement because I think it is difficult to collaborate through the computer. It's [sic] useful if people aren't at the same place at the same time and if everyone knows what each other is talking about, but here we are all in the same place. Why not just meet up face to face? It think that would be more effective at learning and collaboration.

5.2 Impact of blogging on student learning

The ultimate outcome of most educational endeavors is increased knowledge and skill development; in this case it appears the blog served as a tool for promoting students to undertake more complex

tasks such as peer review, revision, and synthesis of the content. Many of the students remarked in some manner about how having access to other student's thinking assisted them in their own work. In essence, what happened through blogging was that students also became the teachers. This allowed for a much greater pool of knowledge for problem solving and critical thinking. The selected comments below represent this taking place, again with one negative comment showing the alternative view:

- By reading comments by others and discussing others' comments on our group blog I was able to actively implement new ways to solve my circuit problems.
- I think that the blog comments helped me realize errors in understanding I may have had by not paying enough attention during lectures.
- The blogging can help increase your learning by being able to see what other groups did for their lab and what their results were. By having discussions on the blog as well, students are able to feed ideas off each other and learn more.
- I don't think it affected my learning in any way. It was just an extra thing to do. I would have wanted a bit more lecture to help explain things before we tried to do them.

5.3 Impact of blogging on student collaboration

Quantitatively, collaboration was clearly the highest rated category by students as a result of blogging, and their comments very clearly support that. Of all the different groupings of students' comments, examples showing collaboration among students was easily the most represented. What is very powerful about the examples is that students were not only able to ask questions of each other but they displayed higher-order thinking by providing feedback and applying their conceptual knowledge into assisting their peers. Below are a few examples of this phenomena taking place (these quotes come from student blogs, not the survey):

The student is encouraged to make his/her project more complex.

- I can't believe you incorporated a catapult into your Rube Goldberg! At first I thought your schematic looked simple, but the ping pong ball launcher is awesome and unique! It makes me feel *the need to make mine cooler*. Is the string strong enough to pull the rod? Since you haven't gotten the motor to run, have you tried the motor with just a power supply to see if it and the catapult function together?

The student who could not succeed in the lab learns from another blog entry how it would have worked.

- Thanks for the explanation of how you altered your high pass filter to be a low pass filter. Very helpful for those of us that had an incorrect result! Also love that in #2 you measure the pitches by annoyingness! Great blog.

Students discuss their results.

- I'm confused, I thought we had the peak to peak values listed for B 3 and 4.
  - How did you measure the peak to peak value with the DMM? It was my understanding that the DMM could not accomplish that.

Two different students notice a group made wrong measurements. Also, he/she ensures the group that they also had some issues in the same lab.

- Hey guys, I think you may have done something to measure the resistance of the speaker wrong. It should be between 6 and 8 ohms, but something relatively close to that is still fine. And I notice you had some difficulties getting the filters to work correctly and if it makes you feel any better many other groups are as well. I am unsure of this issue, but it is unfortunate so many of us are having similar problems. Your measured resistance of your speaker seems very high. Most other groups have measured the resistance at around 8 ohms, I would take another look at measuring it.
- Your measured resistance of your speaker was high compared to ours and other groups. From what we've seen everyone was measuring theirs to be around 8–10 ohms. You guys should go back to that and remeasure it.

5.4 Strengths and limitations

Writing reports in a blog setting and knowing that peers will be looking at their work, students were motivated to communicate better in writing. Our results corroborate work that has been done in this area. As the students in EGR 393 noted, other authors such as Chemishanova have noted the ways in which students adapted their work for different audiences and purposes [20]:

> "The students claimed that audience consideration together with purpose for writing guided aspects of their writing process such as brainstorming, drafting, and finalizing the final copy of their written products. They also used audience analysis to determine the writing style and vocabulary they use in the presentation of the information. The participants revealed their audience awareness in the discussions of their writing process and approach to writing in general. They have internalized audience and purpose consideration as a dominant feature of engineering communication and were attempting to engage in a literacy practice that took into account the conventions of their disciplinary community."

In addition to the sense of audience that blogging provided, we noted similar benefits to Wheeler and McDonald: the writing enhanced group discussions, created unique products for assessment, and created a synergy through review and response [21]. Similarly, using collaborative cloud technologies encourages students to further elaborate their thinking process with their teammates and ultimately develop themselves further as professionals [22].

Students at first struggled with blogging. For instance, many were not able to get a photo from their phone into their blog post, at least initially. The instructor had taken many of their digital literacy skills for granted and assumed that students were technology savvy. Also, choosing a particular blogging software (Blogger) to create their writing slightly limited student creativity. Blogging helped students develop digital literacy as they learned how to upload media to a particular platform from their smart phones. Blogging also helped create a learning community that engaged them in writing and fostered collaboration.

In this sense, the opportunity to use digital writing—to move from "writing-by-the-way" into more complete, complex blog posts—helped students learn. This meant that students created more substantive responses to the revised lab manual questions, incorporated images and videos into their posts, and responded to the work of others. We know that, in their pairs, some students did take on a primary role as writers in the blogging process, while others may have taken on a more active role in the experiment itself. So, it is impossible to claim that *all* students became better writers. Still, the instructor does feel confident in stating that, overall, student learning and engagement in the course improved when compared to previous semesters.

Another observation by the instructor was the way that knowledge moved, quite literally, during the class sessions. Students who had read other blogs could go consult with those who came up with the original idea. In lab classes, instructors often see collaboration or knowledge shared among groups that are sitting next to each other; however, broader collaboration within the classroom space is not as common. In part due to reading the blogs and commenting, proximity in the classroom was not a limiting factor. Students became aware of multiple groups and they sought help or shared their experiences both on the blog as well as through face-to-face interaction by moving about the room, at least more so than observed in previous semesters.

As a final note on strengths, students were able to gauge, through reading, if they were performing in the average or below the average by comparing their own writing with that of their classmates. While there is no causal evidence to suggest a correlation, the instructor strongly suspects that students tried harder and were motivated to do better. This overall attitude raised the bar naturally, which led to much better assignment submissions as seen in the final project example.

Finally, we note a similar trend about the value that students placed on the responses from their peers. Much like Halica et. al., we see that a "[s]ense of community emerged as a significant predictor of perceived learning, with higher levels of community being related to higher levels of perceived learning" [23].

While all these factors are important, in the future, we may need to look at other measures of their learning such as their results on the fundamentals of engineering exam or other program assessment outcomes.

6. Conclusion

In this study, we investigated the effects of using online blogging as a replacement of traditional lab reports. Aligned with online blogging, lab assignments were also aligned with deeper thinking strategies such as open-ended questions. Given this was only a single class with 18 students, we are only able to speculate on what the benefits and challenges are but we have identified some promising future avenues that should be explored further. We analyzed the survey results from three different perspectives:

1. Collaboration: Of all the perspectives, our data indicated that the blogging had the greatest effect on collaboration. Students felt more connected with their peers, that they were more effective in exchanging information, and that they developed more skills.
2. Learning: Students were more positive than negative about the role of blogging in their learning. Many students felt that the comments of their peers were not important but we think this was due to the fact that many of the comments were surface level such as "nice work" and not more substantive. Students did report that the blogging helped them see new perspectives and enhance their learning experience.
3. Engagement: Students had the lowest rating of the effect of blogging on their engagement but it was still generally more positive than negative. Students did report that they interacted with others more as a result of the blog but they did not feel that they were motivated to learn more about the content as a result of the blogging.

With all three perspectives, what is most exciting is that all students, regardless of GPA, seemed to

benefit from this intervention. It did not appear to be the case that only the strongest or weakest students, on the basis of GPA, benefited. Much more data and deeper analysis of the final products will be needed to confirm or deny this finding but we are optimistic that this could be an intervention that benefits all students. Still, the role of implementing blogging as a teaching strategy to help students to transfer applied engineering theory into practice was, for students in this course, a success.

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Appendix A - Student Questionnaire

Questionnaire on blogging in your course

About you

This section will ask you to provide some background information

What is your gender?

- Male
- Female

What is your race/ethnicity?

- Non-Hispanic White or Euro-American
- Black, Afro-Caribbean, or African American

- Latino or Hispanic American
- East Asian or Asian American
- South Asian or Indian American
- Middle Eastern or Arab American
- Native American or Alaskan Native
- Other :

What is your grade level?

- Freshman
- Sophomore
- Junior
- Senior
- Other :

What is your major?

- Computer Engineering
- Electrical Engineering
- Other :

What is your OVERALL GPA? (All courses)

- Above 3.75
- 3.51 to 3.75
- 3.26 to 3.50
- 3.01 to 3.25
- 3.00 or less

What is your MAJOR GPA? (Courses in your major)

- Above 3.75
- 3.51 to 3.75
- 3.26 to 3.50
- 3.01 to 3.25
- 3.00 or less

What job do you intend to hold after graduation? (Please be specific—include job title and company or industry)

Learning from Blogging

[Likert Scaled 1 to 6 where 1 = Strongly Disagree and 6 = Strongly Agree]

The blog discussions help me to share my knowledge and experiences with my peers.
I believe that incorporating blogs with teaching can enhance my learning experience in general.
Other students' comments on my blog posts are important.
Blog discussions help me understand other points of view.
Blog discussions have made me think about project development concepts outside of this class.
My point of view has been acknowledged by my peers and/or the course instructor in this course.
Overall, using the blog has helped me learn.

Impact of blogging on your engagement

[Likert Scaled 1 to 6 where 1 = Strongly Disagree and 6 = Strongly Agree]

I visit our group blog more than required by my instructor.
The blog helps me feel connected to other students in this course.
Due to the class blog, I feel that I am an important part of our classroom community.
I have been stimulated to do additional readings or research on topics discussed on the blog.
In comparison to my other classes, the amount of interaction with other students in this class has increased due to the blog.
In comparison to my other classes, the quality of the interaction with other students in this class has increased due to the blog.

Blogging and Collaboration

[Likert Scaled 1 to 6 where 1 = Strongly Disagree and 6 = Strongly Agree]

The collaborative learning experience in the blog supported environment is better than in a face to face learning environment.
I felt part of a learning community in my group.
I actively exchanged my ideas with group members.
I was able to develop new skills and knowledge from other members in my group.
I was able to develop problem solving skills through peer collaboration.
Collaborative learning in my group was effective.
Collaborative learning in my group was time consuming.
Overall, I am satisfied with my collaborative learning experience in this course.

[UNIVERSITY] Goals—Specific questions about blogging

[Likert Scaled 1 to 6 where 1 = Strongly Disagree and 6 = Strongly Agree]

My writing skills improved as a result of the blogging in this course.
My quantitative reasoning skills improved as a result of the blogging in this course.
My technology skills improved as a result of the blogging in this course.
I had a hard time implementing the media content into the blog.
Please explain how blogging increased or decreased your engagement in this course.
Please elaborate on how blogging in this course helped increase or decrease your learning in this course.

Appendix B - Full tables

Question	N	Mean	SD
Learning from Blogging			
The blog discussions help me to share my knowledge and experiences with my peers.	18	4.72	0.96
I believe that incorporating blogs with teaching can enhance my learning experience in general.	18	4.17	1.10
Other students' comments on my blog posts are important.	18	2.61	1.46
Blog discussions help me understand other points of view.	18	4.39	1.04
Blog discussions have made me think about project development concepts outside of this class.	18	3.94	1.55
My point of view has been acknowledged by my peers and/or the course instructor in this course.	18	4.44	1.20
Overall, using the blog has helped me learn.	18	4.11	1.53
Learning Average	18	4.06	1.01
Impact of blogging on your engagement			
I visit our group blog more than required by my instructor.	18	3.50	1.86
The blog helps me feel connected to other students in this course.	18	3.39	1.69
Due to the class blog, I feel that I am an important part of our classroom community.	18	3.50	1.38
I have been stimulated to do additional readings or research on topics discussed on the blog.	18	3.33	1.91
In comparison to my other classes, the amount of interaction with other students in this class has increased due to the blog.	18	4.17	1.54
In comparison to my other classes, the quality of the interaction with other students in this class has increased due to the blog.	18	3.94	1.51
Engagement Average	18	3.64	1.39
Blogging and Collaboration			
The collaborative learning experience in the blog supported environment is better than in a face to face learning environment.	18	2.94	1.47
I felt part of a learning community in my group.	18	4.39	1.14
I actively exchanged my ideas with group members.	18	4.83	1.38
I was able to develop new skills and knowledge from other members in my group.	18	4.72	1.27
I was able to develop problem solving skills through peer collaboration.	18	4.56	1.20
Collaborative learning in my group was effective.	18	4.89	1.23
Collaborative learning in my group was time consuming.	18	4.89	1.23
Overall, I am satisfied with my collaborative learning experience in this course.	18	4.56	1.04
Collaboration Average	18	4.47	0.86

CMU Goals			
My writing skills improved as a result of the blogging in this course.	18	3.17	1.86
My quantitative reasoning skills improved as a result of the blogging in this course.	18	3.33	1.78
My technology skills improved as a result of the blogging in this course.	18	3.72	1.74
I had a hard time implementing the media content into the blog.	18	2.89	1.64

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