Using Trained Tutors to Improve Mechanical Engineering Technology Student Writing

Dr. David Clippinger, Pennsylvania State University, Behrend

Dr. David Clippinger is a faculty member in Mechanical Engineering Technology at the Pennsylvania State University, Erie–the Behrend College. His interests are ship dynamics, measurement & instrumentation, and assessment, especially of student writing.

Ms. Ruth Camille Pflueger, Pennsylvania State University, Behrend College

Ruth Pflueger has been the director of the Learning Resource Center at Penn State Behrend for 20 years, where she is also an affiliate instructor of English. She has been involved in a number of federal grants, including two NSF STEM grants, an EU-Atlant

Dr. Steven Nozaki, Pennsylvania State University, Behrend

Ph.D. Engineering Education - The Ohio State University

Johanna Bodenhamer

Graduate Research Assistant

Introduction:

The impact of tutors on STEM student writing has been the subject of multiple recent studies, for example, [1-4]. In a series of earlier papers, the authors describe (a) the measurement of different writing registers or 'diatypes' in various STEM disciplines [5], (b) the results when these measurement techniques are applied to student writing samples from a Mechanical Engineering Technology (MET) program [6], and (c) the preliminary results when an intervention consisting of specially-trained tutors as part of the "Writing Assignment Tutor Training in STEM" (WATTS) program [7]. In this last work, the positive effect of the WATTS-trained tutors on student writing relative to the effect obtained from tutoring interactions without WATTS-trained tutors was measured using the voice-development-style-diction methodology introduced in [8].

The present work expands on that presented in [7] to include an AAC&U Value rubric to assess student writing. Additionally, a Likert-scale survey was administered to the tutors to capture their impressions of the tutoring interactions in the "control group" year of the study (tutors not provided with WATTS training) as well as in the "experimental" year of the study (tutors provided with the WATTS training).

Background:

The students in the study were senior-year students enrolled in the capstone design sequence of an MET program. The course sequence meets once a week during the fall and spring semesters and is taught by the same instructor both semesters. Students are assigned to work on industry-sponsored design projects in teams of three or four. Each team's project work is facilitated by a faculty advisor drawn from the MET department faculty. During the course of the semester, the students are tasked with applying the design skills learned in other MET courses to their design project. Each student must select a component or aspect of their team's design, model it using suitable approximations, and then analyze that component using appropriate methodology. The results of these analyses are then developed into a report using an instructor-provided template document (cover sheet, section headings, etc.) for formatting.

Each team member's report is unique, as the designs all have multiple components requiring analysis. The design work is considered complete when the proposed design has been analyzed in its entirety and shown to successfully satisfy the industrial sponsor's specifications. As noted above, each report has a sole author who was the team member responsible for that analysis. In the interest of efficiency of effort within the team, redundant analyses (i.e. multiple team members analyzing the same component) are discouraged. The analyses are written approximately mid-way through the course sequence (early in the Spring semester). The reports are one of approximately six that the students will prepare over the course of the semester. At the semester's end, the individual reports written by the team members are compiled into one single report that is submitted to the project sponsor.

The tutors are undergraduate students from a variety of majors. To become a tutor, students must have a minimum GPA of 3.0, an "A" in a writing course, two faculty recommendations, and submit a writing sample for review. Those selected are provided with "generic" writing tutor training. From this group, those who have completed at least one semester of writing tutoring are eligible for WATTS training. Eligible tutors are invited to participate and can decline. Since the beginning of project, nine WATTS tutors were humanities majors, six were engineering majors, four were science majors, three were business majors and one was a social science major. Only three of the 23 tutors were male. With the exception of two, all of the tutors stayed with the project until they graduated.

Methodology:

In each year of the study, the same assignment (the "analysis" report) was collected. In the first year of the study, the students had no tutor interaction. In the second year, (the control year) the students interacted with "generic" tutors. In the final year, the tutors were given a training session by the course instructor to highlight pitfalls, explain report expectations, and reinforce expectations. This training session—the "WATTS" training session—was delivered to the tutors the week immediately prior to the student tutoring visits.

In the years when tutoring was employed, the students submitted a 1st draft of their analysis reports to the course instructor to ensure completeness, but these first drafts were not scored. The students then made individual appointments with the writing center tutors the following week and met with a tutor for approximately 30 minutes each. Feedback provided by the tutors during these sessions was then available to be incorporated into the students' reports before submission as the final draft for score. After the tutoring sessions, the tutors participated in the Likert scale survey summarized in table 1.

Table 1: Survey Questions for Tutors

Question	Scale Used
1. To what extent do you agree with the following: a) The student took notes during the session b) The student asked questions during the session c) The student felt that specialized knowledge was needed to understand the paper's content d) The student seemed receptive to my* suggestions e) The student wanted to understand the reasons/rules behind my* suggestion *the tutor's	7-level scale: 1. Strongly agree 2. Agree 3. Somewhat agree 4. Neither agree nor disagree 5. Somewhat disagree 6. Disagree 7. Strongly disagree. *the tutor's
2. To what extent do you agree to the following statements about student(s) interest in your* suggestions about: a) Grammar b) Style c) Content d) Format e) Citations *the tutor's	7-level scale: 1. Strongly agree 2. Agree 3. Somewhat agree 4. Neither agree nor disagree 5. Somewhat disagree 6. Disagree 7. Strongly disagree. *the tutor's
3. With 1 being the lowest and 10 the highest, please assess the overall quality of the report in its current form, before the students make any revisions	1-10 scale
4. The length of the tutoring session was:	3-level scale: Too long, about right, too short

The reports submitted by the students were assessed using an adaptation of the AAC&U VALUE rubric [9], which is shown as table 2.

Table 2: AAC&U VALUE Rubric for writing assessment

Criteria	0	1	2	3	4
Context of and Purpose for Writing	Not present or demonstrated.	Demonstrates minimal attention to context, audience, purpose, and to the assigned tasks(s) (e.g., expectation of instructor or self as audience).	Demonstrates awareness of context, audience, purpose, and to the assigned tasks(s) (e.g., begins to show awareness of audience's perceptions and assumptions).	Demonstrates adequate consideration of context, audience, and purpose and a clear focus on the assigned task(s) (e.g., the task aligns with audience, purpose, and context).	Demonstrates a thorough understanding of context, audience, and purpose that is responsive to the assigned task(s) and focuses on all elements of the work.
Content Development	Not present or demonstrated.	Uses appropriate and relevant content to develop simple ideas in some parts of the work.	Uses appropriate and relevant content to develop and explore ideas through most of the work.	Uses appropriate, relevant, and compelling content to explore ideas within the context of the discipline and shape the whole work.	Uses appropriate, relevant, and compelling content to illustrate mastery of the subject, conveying the writer's understanding, and shaping the whole work.
Genre and Disciplinary Conventions	Not present or demonstrated.	Attempts to use a consistent system for basic organization and presentation.	Follows expectations appropriate to a specific discipline and/or writing task(s) for basic organization, content, and presentation.	Demonstrates consistent use of important conventions particular to a specific discipline and/or writing task(s), including organization, content, & presentation, and stylistic choices.	Demonstrates detailed attention to and successful execution of a wide range of conventions particular to a specific discipline and/or writing task(s) including organization, content, presentation, formatting, and stylistic choices.
Sources and Evidence	Not present or demonstrated.	Demonstrates an attempt to use sources to support ideas in the writing.	Demonstrates an attempt to use credible and/or relevant sources to support ideas that are appropriate for the discipline and genre of the writing.	Demonstrates consistent use of credible, relevant sources to support ideas that are situated within the discipline and genre of the writing.	Demonstrates skillful use of high-quality, credible, relevant sources to develop ideas that are appropriate for the discipline and genre of the writing.
Control of Syntax and Mechanics	Not present or demonstrated.	Uses language that sometimes impedes meaning because of errors in usage.	Uses language that generally conveys meaning to readers with clarity, although writing may include some errors (four or more but do not impede meaning).	Uses straightforward language that generally conveys meaning to readers. The language in the document has few errors (three or less).	Uses highly technical language that skillfully communicates meaning to readers with clarity and fluency and is virtually error-free.

Two members of the assessment team, trained in the application of the rubric, evaluated each report. If the level of attainment for each category was not within one by both members, then the members would meet and discuss the score discrepancy and come to consensus.

Results:

The results of the control group assessments of student writing both pre-tutoring and post-tutoring for the five criteria of writing performance within the rubric, as noted in in table 2 above, are summarized in table 3.

Table 3: Results for VALUE assessments of Control Group, both Pre-tutoring (N=14) and Post-tutoring (N=17)

Rubric Score	Context and Purpose		Content Development		Genre and Disciplinary Conventions		Sources and Evidence		Control of Syntax and Mechanics	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
0			1				12	13		
0.5	1		1	1			1	2		
1	4	4	3	5	4	6		1		1
1.5	8	9	5	4	4	2	1	1	3	3
2	1	3	4	7	4	6			2	4
2.5		1			2	2			6	3
3						1			3	6
3.5										
4										
Avg	1.32	1.53	1.36	1.50	1.64	1.71	0.14	0.21	2.32	2.29
StDev	0.372	0.413	0.602	0.500	0.535	0.639	0.413	0.435	0.541	0.663

The results obtained from the experimental group (tutoring with WATTS-trained tutors) are summarized in table 4.

Table 4: Results for Experimental Group (N=29 throughout)

Rubric Score	Context and Purpose		Content Development		Genre and Disciplinary Conventions		Sources and Evidence		Control of Syntax and Mechanics	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
0							20	14		
0.5							3			
1	8	5	10	3	6	1	4	6		
1.5	17	8	13	6	13	6	2	7	4	
2	4	10	6	7	9	10		1	16	9
2.5		6		11	1	12		1	9	16
3				2						4
3.5										
4										
Avg	1.43	1.79	1.43	2.05	1.57	2.06	0.29	0.72	2.09	2.41
StDev	0.320	0.509	0.371	0.572	0.402	0.438	0.491	0.774	0.329	0.329

Responses to the first five survey questions asked of the “generic” tutors are summarized in table 5.

Table 5: Generic Tutor survey results

Question topic	Strongly Agree	Agree	Somewhat Agree	Neither Agree nor Disagree	Somewhat disagree	Disagree	Strongly Disagree
Note taking	1	2	2	4	1	1	0
Asking questions	2	6	1	2	0	0	0
Need for specialized knowledge	1	0	1	3	0	6	0
receptive to suggestions	4	6	1	0	0	0	0
Desire to understand the reasons/rules suggestions	2	3	5	0	1	0	0

The same survey was administered the following year, when the tutors had received the WATTS training, with results shown in table 6:

Table 6: Survey results from WATTS-trained tutors

Question topic	Strongly Agree	Agree	Somewhat Agree	Neither Agree nor Disagree	Somewhat disagree	Disagree	Strongly Disagree
Note taking	14	3	0	0	0	0	5
Asking questions	20	1	0	1	0	0	1
Need for specialized knowledge	2	0	1	0	1	0	19
Receptive to suggestions	20	3	0	0	0	0	0
Desire to understand the reasons/rules suggestions	11	9	0	2	0	1	0

Analysis:

The measure of Context and Purpose of writing increased for both the control group and for the experimental group. However, for the control group, the mean score increased from 1.32 to 1.53 after tutoring. This shift is not statistically significant at 95% confidence with a pooled t value of 1.47 and p=0.076. However, when the tutors were trained using the WATTS methodology, the mean score increased from 1.43 to 1.79. This shift has even greater statistical significance with t = 3.24 and p =

0.0015. While the experimental group did start with a slightly higher pre-tutoring score, (1.43 vs only 1.32 for the control group), this difference was not statically significant ($t = 0.94$ and $p \approx 0.19$).

Similar comparisons for difference in means were conducted for the remaining dimensions of the VALUE rubric. The results are summarized in table 7. Note that while the mean scores increased in all but one of the control group performance dimensions, none of these is significant at the 95% level of confidence. In contrast, for the experimental group, all changes in means were positive, and all were statistically significant at levels exceeding 95% confidence.

Table 7: VALUE Rubric assessments for both Control and Experimental groups

Performance Dimension	Control		Experimental	
	Change in means	*p*	Change in means	*p*
Context and Purpose	+0.21	0.0761	+0.36	0.0015
Content Development	+0.14	0.2425	+0.62	0.00002
Genre and Disciplinary Conventions	+0.06	0.3836	+0.48	0.0001
Sources and Evidence	+0.06	0.3414	+0.43	0.0086
Control of Syntax and Mechanics	-0.03	0.5498	+0.33	0.0004

The survey data was analyzed qualitatively to provide insight into any trends. Figure 1 shows a comparative bar chart illustrating the proportion of responses provided by the tutors after tutoring the control group (tutors not WATTS-trained) and the experimental group (with WATTS training).

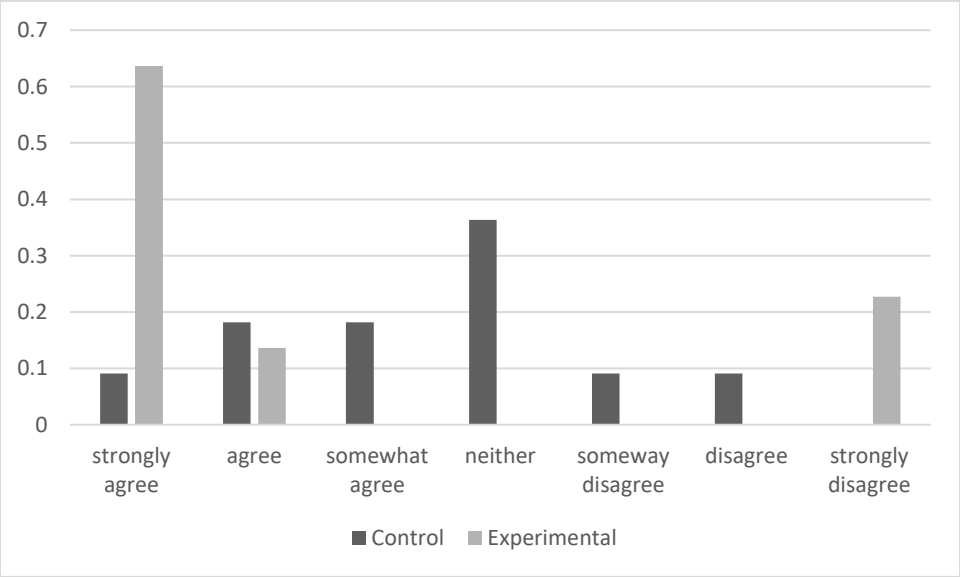

Figure 1: Results of survey question: "Did the student take notes during the session?"

The results for the other four questions were analyzed similarly and bar charts showing the proportion of responses for each question are shown in figures 2 through 5.

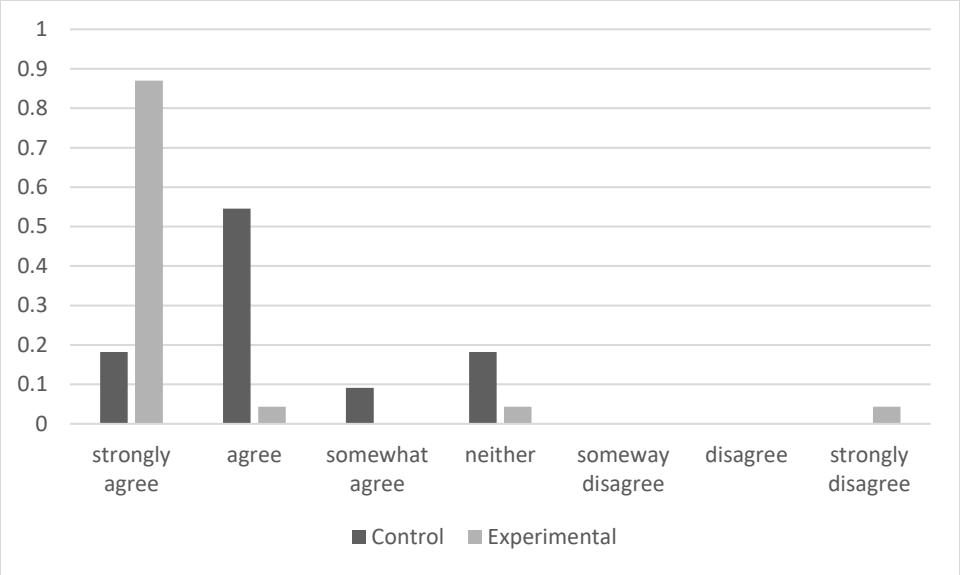

Figure 2: Results of survey question of "Did the student ask questions?"

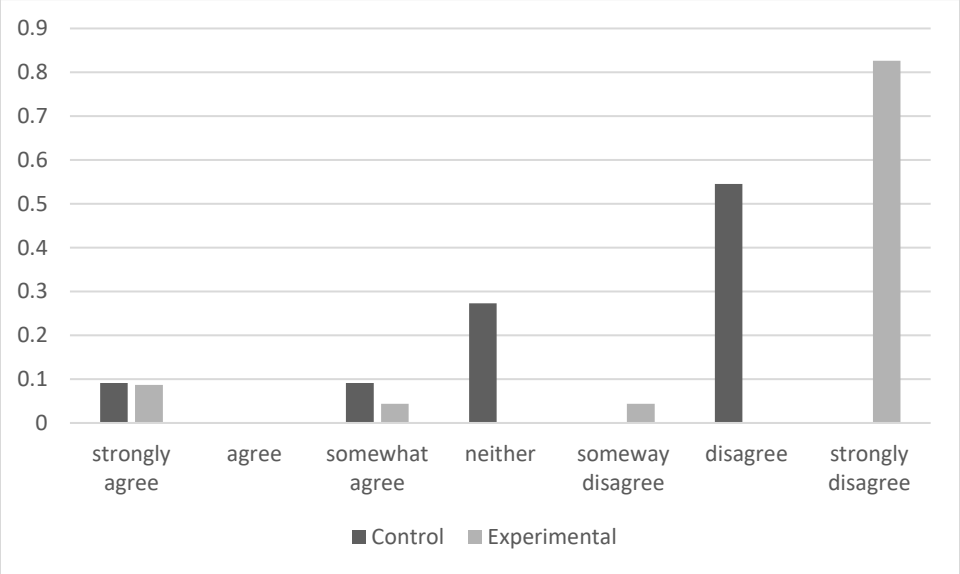

Figure 3: Results of survey question: "Did the students feel that specialized knowledge was needed to understand the paper's content?"

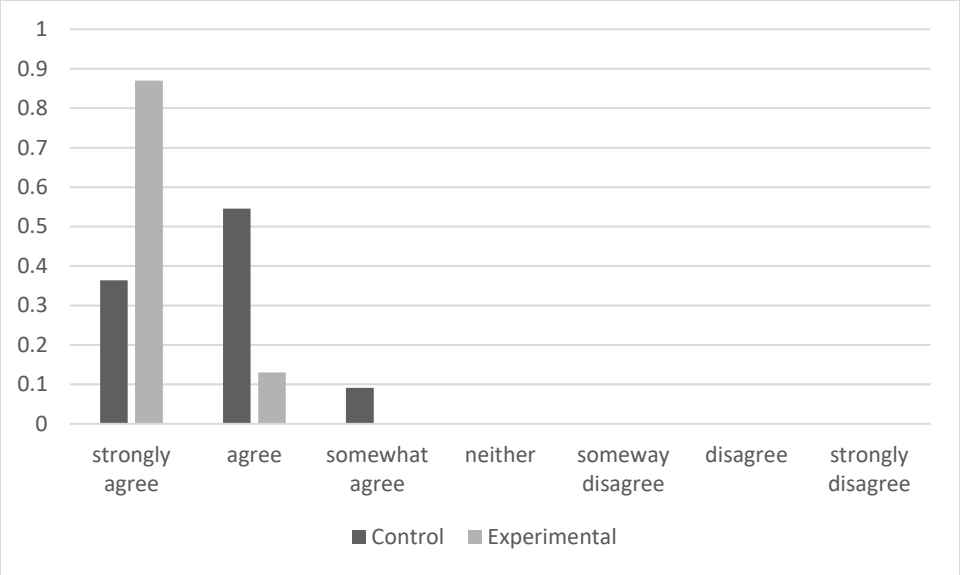

Figure 4: Responses to question: "Were the students receptive to suggestions?"

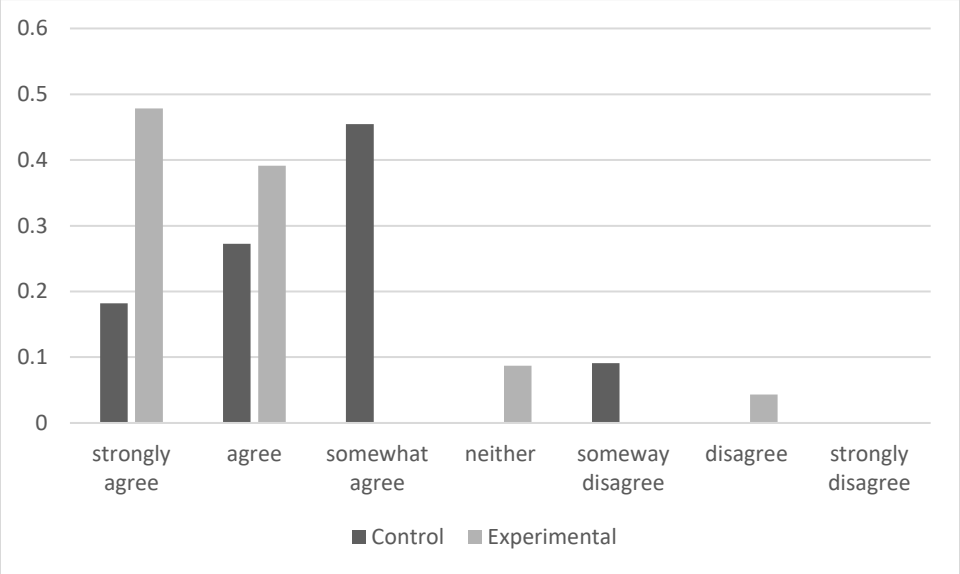

Figure 5: Responses to question: "Did the students desire to understand the reasons/rules for the suggestions?"

Discussion:

Overall, the results indicate that the WATTS training intervention is successful at improving student writing, and that this improvement is not only greater in magnitude, but more meaningful than that obtained by "generic" tutors. Indeed, when the control group was measured by the VALUE rubric, no aspect of student writing improved by a statistically significant amount. In contrast, the improvement in these same dimensions of writing all showed marked improvement when the tutoring was provided by the WATTS trained tutors. The largest *p*-value obtained here ("Context and Purpose") was 0.0015, implying a confidence as high as 99.85% in the results. Other dimensions showed even more significant improvements. Nevertheless, even after tutoring, it is noted that all the dimensions had average scores below a 3.0, with "Sources and Evidence" coming in last at a 0.21 average score. Clearly, all dimensions

of the AAC&U rubric will require additional emphasis to raise student writing to a notionally adequate "3" or better on this scale.

However, the magnitude of improvement alone begs the question: "why?" The qualitative analysis of the survey data provides some insight into two potential reasons. First, the WATTS-trained tutors appear to have a greater level of interaction with the students because they enter the sessions with more confidence in their ability to provide useful feedback to the students. On a post-training survey completed by five tutors, three strongly agreed and two agreed that the training helped them both "better understand the required Engineering content" and helped them "feel more comfortable working with students on engineering content."

The second reason may be the students' own expectations for the process. In the case of the control group, the course instructor merely directed the students to the writing center tutors as part of the assignment. It is possible that students perceived their involvement in the process as little more than an administrative requirement. In contrast, for the experimental group, the tutoring experience was presented as one with "specially trained tutors" with training specific to the expectations of the course. This level of engagement from instructors highlights to students the importance of their written communication skills.

With the exception of the "note taking" question, responses were overwhelmingly uniform. Tutors indicated a dramatic increase in students asking questions, a sharp decline in the belief that specialized knowledge was needed to understand the paper, and strong increases in the proportion of responses indicating student receptivity to suggestions and students' desire to understand the reasons or rules behind the suggestions.

The polarized nature of the note-taking responses is apparent in figure 1, which shows a pronounced spike in the rate of note-taking by the students when interacting with the WATTS-trained tutors. While the modal response to the same question from the generic tutors was "neither agree nor disagree," after introducing the WATTS training the frequency of this response and that of the adjoining responses ("somewhat agree" and "somewhat disagree") went to zero. However, the results also became dramatically more polarized when compared to the control group: The pronounced uptick in the "strongly agree" was joined by a smaller yet nevertheless dramatic increase in the proportion of "strongly disagree" responses.

In an attempt to understand why this polarization occurred, the tutors' strongly disagree responses were examined in relation to their responses to the other questions. With the exception of two surveys, all of the responses to the other questions were positive. In those two surveys, one additional question had a negative response. In the first case, the tutor's response to the question, ""Did the students feel that specialized knowledge was needed to understand the paper's content?" was strongly agree. In the other case, the tutor's response to the question, "Did the students desire to understand the reasons/rules for the suggestions?" was disagree. This would indicate that all of the students were engaged, some to a greater degree than others, however, that is to be expected.

[1] Alley, M., & Cutler, S., & Tise, J. C. (2019, June), *Work in Progress: Embedding a Large Writing Course in Engineering Design - A New Model to Teach Technical Writing*. Paper presented at 2019 ASEE Annual Conference & Exposition , Tampa, Florida. 10.18260/1-2—33610

[2] Ware, R., & Turnipseed, N., & Gallagher, J. R., & Elliott, C. M., & Popovics, J. S., & Prior, P., & Zilles, J. L. (2019, June), *Writing Across Engineering: A Collaborative Approach to Support STEM*

Faculty's Integration of Writing Instruction in their Classes Paper presented at 2019 ASEE Annual Conference & Exposition , Tampa, Florida. 10.18260/1-2—33671

[3] Damron, R., & High, K. (2009, June), *Writing To Learn: The Effect Of Peer Tutoring On Critical Thinking And Writing Skills Of First Year Engineering Students Paper* presented at 2009 Annual Conference & Exposition, Austin, Texas. 10.18260/1-2—5684

[4] Miertschin, S., & Goodson, C., & Schroeder, S. (2010, June), *Online Tutoring Support Service For Stem* Paper presented at 2010 Annual Conference & Exposition, Louisville, Kentucky. 10.18260/1-2—16447

[5] Clippinger, D., Nozaki, S., Jernquist, K., (2020, June), "Using Common Language to Identify Discipline-specific "Dialect" in Electrical, Civil, and Mechanical Engineering" Paper presented at 2020 ASEE Virtual Annual Conference Content Access, Virtual On line . 10.18260/1-2--34515

[6] Clippinger, D., Nozaki, S., Pflueger, R., (2021, July), *Quantitative Assessment of Writing Register in Engineering Technology Students* Paper presented at 2021 ASEE Virtual Annual Conference Content Access, Virtual Conference. https://peer.asee.org/37631

[7] Clippinger, D., Pflueger, R., Nozaki, S., (2022, August), *Using Writing Center Peer Tutors as a Means to Improve Mechanical Engineering Technology Student Writing* Paper presented at 2022 ASEE Annual Conference & Exposition, Minneapolis, MN. https://peer.asee.org/40737

[8] Clippinger, D., Jernquist, K., Nozaki, S., Nitterright, F., (2019) "Improving Undergraduate STEM Writing through Common Language as Tool to Teach Engineering Dialects," Paper & presentation, ASEE Annual Conference Proceedings 2019

[9] Rhodes, T (2010) *Assessing outcomes and improving achievement: Tips and tools for using rubrics.* Washington D.C. Association of American Colleges and Universities