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Introduction

Employers of STEM graduates, especially industries, often emphasize the need for improvement in STEM undergraduate writing skills[1]. Research findings show that students in STEM fields lack strong writing skills[2].Writing is generally recognized as fundamental to the formation and communication of scientific and technical knowledge to peer groups and general audiences. In this aspect, persuasive writing is an essential attribute emphasized by industries and businesses for a successful career in STEM fields. Nevertheless, the current scenario is that students in STEM fields, with their increased demand for more specialized skills in fewer credit hours combined with a lack of emphasis on writing from engineering faculty members, make addressing this need difficult. In addition, students in engineering fields often do not value writing skills and underestimate the amount of writing they will do in their careers. Hence, it is essential to understand and quantify the level of writing skills STEM students exhibit in their technical courses so that mitigation efforts can be designed using commonly available resources to enhance this important skillset among the students, including university writing centers.

To understand this problem thoroughly and to verify the need for improvement required in persuasive writing among engineering students, a study has been conducted at four campuses across three institutions that have varied student demographics. The research methodology and mitigation efforts are discussed in the subsequent sections of this paper.

Project Background

A research question was posed to study this aspect of technical writing: Do student demographics have an impact on the level of engineering writing? The student demographic variation among the institutions, one of which is designated as a Hispanic-serving institution, includes the level of college preparation and the mix of ethnicity. To determine if there are variations among certain groups, a sequential mixed-methods design was used. Although the sample size is small, the goal was to establish a methodology and a preliminary outcome set that could be used in further research with larger populations. This paper will present the results of an assessment of student technical writing across a number of campuses at different universities and determine if the demographics of the various campuses offer any insight into the level of technical writing capability of the students at those campuses.

Determining the level of technical writing capability is accomplished through the use of a standardized rubric from the American Association of Colleges & Universities (AAC&U) on reports submitted by the students at these campuses, establishing a baseline. These reports will then be compared against the results of reports submitted by students who first met with a writing tutor with a draft report, providing control data, and finally compared against the results of reports submitted by students who first met with a writing tutor, also with a draft report, that had gone through training that is outlined later in this paper, providing experimental data.

Ultimately, the authors are interested in whether those tutors who have been trained are able to provide effective feedback that results in better technical report writing from the students.

STEM students are taught writing skills in their first-year composition (FYC) courses; however, they often fail to transfer them to discipline-specific writing, mainly due to a perception that English courses are subjective and unrelated to their majors[3] and their major related courses as fact-based and objective [4,5]. This perception prevents students from honing their skills in writing. Lack of faculty interest in incorporating writing into their courses also undermines the importance of discipline-specific writing skills [6]. Engineering instructors report this resistance as primarily due to large enrollments, lack of time, or the poor quality of student writing[7]. In a recent study of engineering instructors, 60% perceived teaching assistants (graduate or undergraduate) trained to support writing to be the most valuable in helping them to include more writing in their courses[7]. However, the cost can be prohibitive. To positively address these challenges, an innovative and cost-effective Writing Assignment Tutor Training in STEM (WATTS) process was introduced in the participating institutions. The process is focused on training generalist peer tutors to help students write better in the students' own disciplinary genre. This WATTS process is founded on knowledge transfer theory and employs the frameworks of writing in the discipline (WID) and genre theory[8,9,3]. The collaborations between engineering instructors and writing centers enable instructors to provide WID support in their courses without adding substantially to their workloads; WATTS also has the potential to mitigate student misconceptions about writing and potentially produce better short- and long-term writing skill outcomes. The requirement to communicate with peers outside of engineering provides students with a learning opportunity that extends past basic writing skills and promotes WID[10].

Basis of WATTS Training

The basis of WATTS training is to effectively train the writing center tutors and establish a relationship between faculty and writing center personnel. The effectiveness of peer tutoring has been widely recognized[11]. Three main advantages emerge from writing center collaborations: Peer writing tutors 1) are widely accessible, existing at most institutions[3,8]; 2) are trained and experienced[8,5;] and 3) are a low-cost option relative to employing composition instructors or graduate students[12]. One disadvantage is that peer writing tutors come from a variety of disciplines, often without technical backgrounds[5]. While skilled at tutoring writing, these generalist tutors may not be confident working with discipline-specific content and conventions. Specialist tutors (those who are skilled in discipline-specific conventions) develop rapport with engineering students and provide more appropriate feedback than generalist tutors[13]. A principal advantage of specialist tutors is their knowledge of technical vocabulary[14].

Persuasive writing is required in all disciplines; however, differences exist in the discipline-specific conventions of persuasive writing and the genre of technical reports. Since most students seeking tutoring are in FYC courses (where persuasive writing is taught), experience in tutoring freshman composition papers and papers in non-STEM disciplines allows for the knowledge transfer of basic writing and rhetorical strategies to STEM papers, including technical engineering reports.

An additional insight that informed the development of WATTS is that engineering students define the content of a report according to the data presented; however, in writing and rhetoric, a report's content refers to its prose and argument[12]. This contrast can lead to student dissatisfaction with tutoring and tutor misperception of the reasons why they cannot understand a report, which they often attribute to their lack of technical background. In reality, the report may not be understandable due to disorganization, grammatical errors, or lack of sufficient information to support the author's argument.

WATTS Process

The WATTS process includes several collaborations among its stakeholders. The tutor training is conducted by the instructor and tutor supervisor. In preparation, they outline the training date, agenda, and materials; number of tutors required, their availability, and tutoring timeframe; the student scheduling process; and tutoring session documentation. Prior to the training, the instructor provides a copy of the assignment and genre-specific knowledge. During the training, a triad of collaboration occurs between instructor, tutor supervisor, and tutors. The instructor explains the assignment (i.e., lab) and discipline specific technical terms. The tutor supervisor uses knowledge transfer to connect tutors' experiences with FYC papers to WID. Both answer questions and engage tutors as active participants. WATTS tutors must participate in the training offered each semester. Experienced WATTS tutors make valuable contributions during the training and are another resource for new WATTS tutors.

Before tutoring, the instructor prepares students in class by regularly highlighting the importance of writing in their future careers and stressing that the tutor's role is not to provide feedback on the engineering work, but rather how they present their work in the report (e.g., does it follow documentation guidelines, have they supported their conclusions with results, is it logically organized, do they follow genre conventions for persuasive writing, etc.). Finally, collaboration occurs between the tutors and students during the tutoring session. The relationships among collaborators are shown in Figure 1.

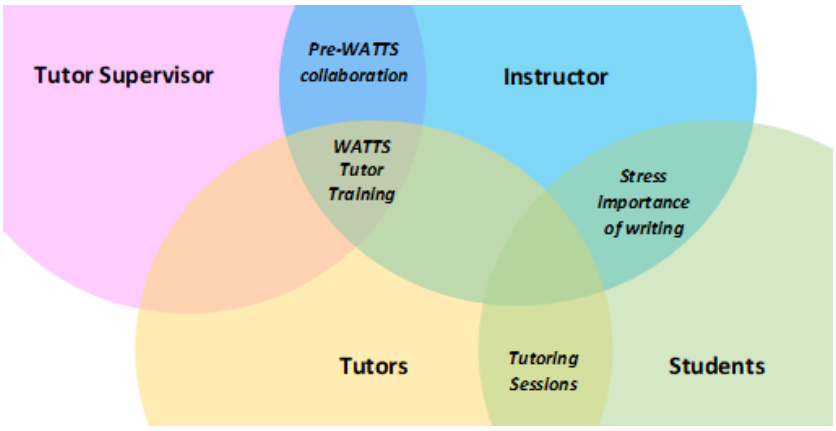

Figure 1. Collaborations among WATTS Stakeholders

The WATTS process has been implemented in both engineering and engineering technology classes: Tutors receive WATTS training just prior to their tutoring sessions with students, like a Just-in-Time method [15,16]. To support the training, the instructor provides tutors with a copy of the lab assignment, examples of good and poor lab reports, a glossary of technical terms, and a checklist of items to consider during the tutoring session. The instructor explains the materials and the assignment, and the tutor supervisor identifies how the elements in the lab report are related to the tutors' experience with FYC papers. To ensure student participation, the assignment must require a tutoring session with a WATTS peer writing tutor.

Research Data Analysis and Findings

This project is being funded by a National Science Foundation grant. Research data continue to be collected and analyzed from all sites implementing the program: Penn State Behrend (PSB), Indiana University Purdue University Indianapolis (IUPUI), Indiana University Purdue University Columbus (IUPUC), and the University of Texas Rio Grande Valley (UTRGV), a minority-serving institution. Collection methods include pre- and post-training tutor surveys. In addition, student writing pre-and post-tutoring are studied. Student reports are analyzed using a modified AAC&U VALUE Written Communication rubric (Figure 2) that was developed by writing and content area experts. Evaluations were made by researchers trained in the use of the rubric.

The scope of this paper is to study the effect of varied student demographics on persuasive writing in the STEM fields. The analysis of baseline student reports, i.e., the reports of students who did not meet with a writing tutor has been completed. Control data, which studies the reports of students who meet with a writing tutor who has not been through WATTS training, has been collected and is currently under analysis. Lastly, experimental data, consisting of reports of students who meet with a tutor who has completed WATTS training, is currently being collected. To assess baseline data, the team collected reports from targeted assignments in participating courses from a prior semester when students did not meet with a writing tutor.

Institutional Settings

IUPUI is Indiana's premier urban public research university. It offers more than 450 academic programs in 17 schools from either Indiana University or Purdue University. The Purdue School of Engineering and Technology has over 3,000 students pursuing degrees from the associate to doctoral level. Within the 19 baccalaureate degree programs are six ABET-accredited engineering programs and 12 technology-related programs, including four ABET-accredited technology degree programs. All engineering and engineering technology students are expected to complete a FYC course along with at least one additional technical writing course within their major.

IUPUC is a campus of Indiana University and an extension of IUPUI. It has more than 1,600 undergraduate and graduate students who can access degrees from both Indiana University and Purdue University. Students engage in rigorous classes of the same academic intensity as all IU students but on a smaller, more close-knit campus. IUPUC students can complete undergraduate degrees in 11 disciplines, including mechanical engineering, and graduate degrees in business

administration, mental health counseling, and family nurse practitioner programs. Students in all programs must complete an elementary composition course in the first year.

Penn State Behrend (PSB) is a four-year and graduate college of Penn State. With 5,050 undergraduate and graduate students, 45-plus academic programs, and an 854-acre campus, PSB is among the largest campuses in the Penn State system. PSB is among the top public colleges and universities in Pennsylvania for student-to-faculty ratio, SAT scores, first-year student retention rate, and graduation rate, based on *U.S. News & World Report* data. The School of Engineering offers 10 bachelor's degrees, two associate degrees, all ABET accredited, and one graduate degree. Bachelor's programs in the school require that students complete a FYC course, a technical writing course, and a writing-intensive course in their major.

The University of Texas Rio Grande Valley (UTRGV) is a public research university with multiple campuses in (state). The main campuses are in Edinburg and Brownsville. UTRGV offers 64 bachelor's, 49 master's, and 4 doctoral programs (in addition to 2 cooperative doctoral programs). The ethnic enrollment is 92.4%. Hispanic (Fall 2019). The College of Engineering and Computer Science (CECS) has over 3,200 undergraduate and graduate students, and 81% of undergraduate students who receive financial aid receive Pell Grants. The CECS offers seven baccalaureate degree programs in engineering and computer science. All six engineering programs are ABET accredited, and the lone Engineering Technology program will be ABET accredited soon. All engineering and engineering technology students are expected to complete two rhetoric and composition courses in communication.

Institutional student demographics and technical writing preparedness

An institutional snapshot of student demographics at the four campuses is provided in Table 1. However, similar information is not available for individual courses selected for the study group. Also, ethnicity demographics are not available in separate gender categories. The adult learners shown in the table are ages 24 and above. A first-generation college student is someone who grew up in a home where both parents did not attend a four-year college, where one parent has an AA only, or where one or both parents attempted some college but did not finish it. It can be noted from the data provided in the table that the student demographics in the four institutions where the study was conducted are varied in nature.

Table 1. Institutional Snapshot of student demographics

	IUPUI	IUPUC	PSB	UTRGV
Year	2022	2022	2022	2022
Ethnicity				
Caucasian	61.62%	82.63%	80.96%	3.38 %
Black	9.71%	0.92%	3.33%	0.84%
Hispanic	9.82%	8.94%	3.69%	90.53 %
Gender				

Male	40.66%	31%	65.50%	40.28.7%
Female	59.34%	69%	34.32%	59.72%
First Generation	25.72%	35.87%	30.48%	60%
Adult Learners	34.88%	32.79%	8.94%	18.4%
Aid-Eligible	22.08%	28.67%	28.00%	84%

The following modified AAC&U value rubric was used to assess the written communication by experts trained for the analysis of student reports collected as part of the baseline study (Figure 2).

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.

Figure 2. Adaptation of the AAC&U VALUE Written Communication Rubric. Rhodes, T. (2010). *Assessing outcomes and improving achievement: Tips and tools for using rubrics.* Washington, DC: Association of American Colleges and Universities.

The baseline data descriptive statistics in four of the institutions are given in Figure 3. The baseline data analysis shows that irrespective of demographics, most of the students do not know how to write effectively in engineering and technical subjects. The analysis invariably finds that there are no statistically significant variations among students across the four institutions, suggesting similar preparation in written communications.

	All Institutions (92 reports)		**YYY1** (19 reports)		**YYY2** (13 reports)		**XXX** (22 reports)		**UUU** (38 reports)	
Criteria	M	SD	M	SD	M	SD	M	SD	M	SD

Context of and Purpose for Writing	1.65	.767	1.50	.688	1.58	.758	1.50	.792	1.84	.767
Content Development	1.63	.827	1.45	.686	1.65	.892	1.48	.976	1.79	.754
Genre and Disciplinary	1.76	.782	1.66	.815	1.96	.720	1.64	.780	1.80	.783
Sources and Evidence	.41	.620	.13	.343	1.00	.693	.11	.321	.51	.663
Control of Syntax and Mechanics	2.05	.696	1.89	.689	2.15	.675	2.30	.668	1.95	.691

Figure 3. *Baseline Data Descriptive Statistics for All Institutions*

As can be observed from the data presented in Figure 3, most of the students fall below the score of 2 out of 4 in all aspects of written communication. It should be noted that these students are competent in their technical knowledge. However, they lack in expressing technical details persuasively to their peers and general audiences. This aspect of under-preparedness in technical writing is pervasive among the student categories ranging from freshmen to seniors. Also, the baseline data analysis finds that the same types of mistakes in technical writing occurs among students at different stages of matriculation. The future assessment of control data is also expected to show similar results, as has been presented in the study conducted by Weissbach[12] et al. The study shows that students are sound in technical and engineering aspects, however, they need training in improving their writing skills in communicating persuasively to general audiences. As noted earlier, experimental data is being collected for future analysis. The authors are optimistic to find substantial improvement in student technical writing skills after the implementation of WATTS training.

Conclusion and Future Work

Persuasive written communication skills of engineers continue to be a concern for employers of graduates. This project helps to advance interdisciplinary or cross-disciplinary undergraduate STEM education for enhanced workforce preparation. The baseline study conducted as part of the project clearly demonstrates that irrespective of demographics and institutional settings, students need improvement in persuasive writing in the fields of engineering and technology. Control group data (where students are required to meet with tutors without WATTS training), which includes pre- and post-tutoring reports and surveys, is currently under analysis and will provide a comparison to better understand the impact of an intervention without tutor training. Experimental group pre- and post-data (where students are required to meet with a WATTS-

trained tutor) is currently being collected. The authors will compare the baseline, control, and experimental data to determine if the WATTS training yields improvements in students' technical reports and if any variance based on student demographics exists.

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