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Effect of Terminology on Student Performance (Work in Progress)

Dr. Nazli Aslican Yilmaz Wodzinski P.E., Virginia Polytechnic Institute and State University

Nazli A. Yilmaz Wodzinski graduated from Clemson University with a Ph.D in Civil Engineering in 2014. She joined Minnesota State University, Mankato as a post-doctoral teaching fellow for 2015-16 Academic Year. She is still serving at the same institution as a tenure-track faculty member. She is offering a wide range of courses to students from various engineering programs including freshman level introduction courses to senior level design courses in water resources area. In addition to engineering education, Nazli is also conducting research in stormwater management practices and agricultural drainage water management practices.

Dr. Pavan Karra, Minnesota State University, Mankato

Pavan Karra is Associate Professor at Trine University where he teaches in the field of Design and Controls. He can be reached at pavan.karra@mnsu.edu

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Abstract

Many instructors know that understanding a few key phrases or terms can make a huge difference in the outcome of students' performance in exams. This is especially prominent for first-generation students and international students. This undermines retention and diversity, equity, and inclusion (DEI) efforts undertaken by universities. This study intends to examine the effect of terminology on students' comprehension of problem statements during an exam. For this, students are tested on simple mathematical concepts that they are familiar with from elementary/middle school. Two different types of questions, using the same mathematical concepts, will be part of the exam given to first year students. The first type of questions will include terminology that is understood by the common population with at least middle school education. The second type of questions will include terminology that is typically used in STEM higher education. The questions will be randomized. Demographic information of students will be collected without identifying information. Conclusions will be made on the impact of terminology on student success. This paper is a work-in-progress, and more data is needed to make the conclusions statistically significant.

Introduction

Higher education institutions in Minnesota are putting substantial energy and effort into making every classroom diverse [1]. To provide equal opportunity to success in engineering classes for every member of the classroom, a substantial effort should also go to making higher education ready for the diverse student bodies. Effective communication (both oral and written) plays a key role in the success of students, especially in the early years of engineering education [2]. Inaccessible language is one of the barriers for success of students from diverse backgrounds.

Inaccessible language may be defined as uncommon language such as discipline specific terminology, non-discipline-specific words that were not explicitly taught, or words that have different meanings in different contexts, cultures, or languages [2, 3]. Use of uncommon language in oral and written communication may create a learning environment that is biased towards students that have the same cultural capital, thus same vocabulary, as the instructor. However, the goal of faculty in engineering courses, especially in introductory-level gateway courses is to set an inclusive learning environment for every student in the room.

While some studies conducted in this field exclusively focused on non-discipline specific terminology that are not explicitly taught or foreign languages [1, 2], in this study we will focus on the discipline specific terminology. Instructors often use discipline-specific terminology at introductory-level gateway courses in various ways to spark an interest in the discipline. It is previously shown that the texts written by faculty, who are experts in their fields, are likely to be too academic and have discipline-specific terminology that need explanation [4]. To create scenarios that mimic real-world examples, instructors may use discipline-specific language in formative assessment methods like written exams, if such terminology is used excessively, students may struggle to understand the question text. Thus, student performances may not reflect their knowledge of the course-specific topics.

Poor oral and written communication due to complex, sophisticated texts and use of uncommon terminology in classrooms especially affects non-Native speaking students, students from underfunded public-school systems, or students from school systems that are built on traditional lectures and passive learning [1]. Students, who are from educational practices that traditionally allow less room for discussion, questioning, and/or expressing opinions will be less prepared for higher education practices like discussions, formative and summative assessment, and modern active-learning practices [1]. This is an important detail that the educators must pay attention to since active-learning practices are more preferred to enhance critical thinking, decrease the opportunity gaps and overall DFW rates.

Without a doubt, giving its students the ability to understand and use program specific technical terminology properly is one of the core educational goals of every engineering program. For instance, high level thinking skills such as synthesis and evaluation require asking the right questions to make necessary relations between requirements, decisions and design concepts [5]. However, building, and internalizing engineering specific language is a gradual process for both faculty and students. Identifying discipline-specific words will help instructors establish clear expectations for each subject. There are several studies in literature that focused on identifying such terminology [2, 3, 6] from which the instructors can benefit. Using several research-proven tools available to them, instructors can detect such terminology and provide their definitions and proper usage explicitly to smoothen the written and oral communication in different subjects. This process will promote a gradual development of the professional language and create. Promoting professional language development carefully over four years will not lead to creating an exclusive environment for students from diverse backgrounds [2, 3].

In this study, we will focus on the effect of discipline-specific language on the success of freshmen in engineering programs. The goal of this study is to quantify how much the use of uncommon language affects the performance of students from diverse backgrounds. To quantify this effect, we created SAT level math questions written with and without uncommon terminology. The questions were then distributed to volunteers as anonymous surveys. We conducted this research with volunteers from Introduction to Civil Engineering and Introduction to Mechanical Engineering courses. Below in the following section we will detail the methodology of the research, the results of the study, the conclusion, and the planned future work.

Methodology

The study was approved by Minnesota State University’s Institutional Review Board (IRB) before the study was conducted.

The data presented in this paper was collected via anonymous surveys. The surveys had open-ended and multiple-choice mathematical questions, multiple-choice vocabulary questions, and open-ended and multiple-choice questions on the participant demographics. The mathematical questions were chosen from concepts that Scholastic Aptitude Test (SAT) cover and were simplified to take less than 2 minutes per question. Two groups of mathematical questions were created, terminology questions and non-terminology questions. Each terminology question had one term in the question body that is frequently used by engineering instructors. For these questions, even though the solution will be a very simple algebraic calculation, the student's ability to solve the problem heavily depends on whether they know the meaning of that term or not. For every terminology question, authors created a no-terminology question. For each no-terminology question, participants performed algebraic calculations that were very similar to the respective question's terminology pair. The only difference between a terminology question and a no-term question was the latter one did not have an engineering/science term that may affect student success. For every terminology and no-terminology question pair, the authors created a multiple-choice vocabulary question. The vocabulary question tested the responder's knowledge on the specific term used in the terminology question. Figure 1 shows example of terminology question (1a), no-term question (1b), and the vocabulary question (1c).

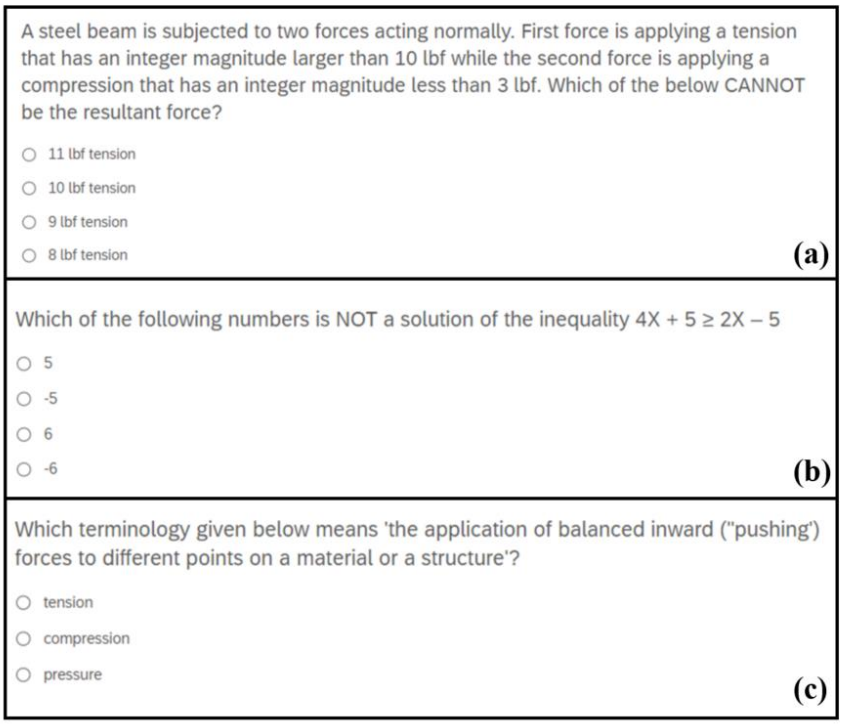

Figure 1. Examples of math and vocabulary questions of the survey that participants filled anonymously.

Authors prepared 10 sets of questions for the anonymous survey (10 terminology math questions, 10 no-term math questions, and 10 vocabulary questions). To prevent survey being time-demanding, the questions were divided into two surveys. Survey A had the first five sets of questions with questions about responder demographics (21 questions in total). Survey B provided the second five sets of questions with the questions about responder demographics (21 questions in total, again). Table 1 provides a summary of survey A and survey B.

The authors preferred to use as many open-ended questions as possible for mathematical questions to prevent data pollution with random guessing. Multiple-choice questions were only preferred when students were asked to make a comparison between options or select one option that does not satisfy the criteria of the problem-statement. On the other hand, all vocabulary questions were multiple-choice to prevent any divergences in the collected data.

Table 1. Summaries of Surveys A and B.

	Survey A	Survey B
Terminology Math Questions	3 open-ended and 2 multiple-choice, total **5**	**5*** open ended questions,
No-term Math Questions	3 open-ended and 2 multiple-choice, total **5**	4 open ended and 1 multiple-choice questions, total **5**
Vocabulary Questions	**5** multiple choice questions	**5** multiple choice questions
Demographics Questions	**6** multiple-choice questions	**6** multiple-choice questions
TOTAL	**21**	**21**
***one of the open-ended terminology math questions of Survey B was provided in the wrong format. The answers to this question are excluded from the results and analysis of the paper.**		

The surveys were offered to the students of Introduction to Mechanical Engineering (ME 101) and Introduction to Civil Engineering (CIVE 101) students. Each group was given 20 minutes to complete the survey. The participants were allowed to use pencils/pens, paper, and calculators. However, they were requested not to discuss the questions with each other or search the text of the questions online.

Results and Discussion

Surveys A and B were filled by 19 and 36 individuals from ME 101 and CIVE 101 courses, respectively. Two responders returned Survey A with all questions unanswered, while this number is five for Survey B. The answers given by these responders are excluded from the analysis. Moreover, as it is given in Table 1, one of the terminology questions of Survey B had a formatting error and the answers to that question are also excluded from the analysis.

Table 2. Participant performances for mathematical questions

Survey A		
	Average Student Performance	Standard Deviation
No-term math questions	67.1 %	18.5 %
Terminology math questions	43.5 %	19.9 %
Survey B		
	Average Student Performance	Standard Deviation
No-term math questions	29.7 %	22.7 %
Terminology math questions	37.9 %	32.2 %
Total		
	Average Student Performance	Standard Deviation
No-term math questions	48.4 %	27.9 %
Terminology math questions	41.0 %	26.2 %

Overall, responders performed better at solving mathematical questions written without terminology as seen in Table 2. Looking at overall results, 48.1% of the responders provided the correct answer for questions written without an engineering or science term, while only 41.0 % of the responders provided the correct answer for question written with a term. A drastic change in participant performances can be observed between Survey A and Survey B. Responders of Survey A performed better compared to Survey B, for both types of mathematical questions. Several factors might cause this difference. For instance, Survey B had one (terminology) question provided in the wrong format and had two (no-term) questions with relatively longer solutions. Authors are inclined to think that these factors might have discouraged participants from putting in their best efforts. When we analyzed the data closely, we noticed that two responders only provided answers to a small portion of the questions. Although we do not know whether the responders skipped the rest of the questions due to their lack of motivation or knowledge, we kept their responses for the analysis. In either scenario, these participants were discouraged from continuing to work on their problems and this fact aligns well with the research idea of this paper. Moreover, Survey B had two no-terminology questions with very low success rates, one inequality question with 0% success rate and one linear algebra question with 6.5 % success rate. The low success rates in these questions might be linked to the concepts of these questions, rather than the question statements.

Table 3. Responder performance for math questions with terminology and the respective vocabulary question.

	Responder performance (in %)									Average (%)
Math question with terminology	3.2	76.5	52.9	87.1	16.1	45.2	41.2	23.5	23.5	41.0 %
Respective vocabulary question	29.0	29.4	58.8	74.2	74.2	77.4	88.2	94.1	100.0	69.5 %

Table 3 shows the performance of students for each math question with terminology and the respective vocabulary question. As the data in Table 2 suggests, the overall results indicate that the participants performed better with questions that did not have engineering/science terminology in its body. On the other hand, the collected data did not propose a correlation between the responders' performance for math questions with terminology and the respective vocabulary questions. Moreover, students performed drastically better for vocabulary questions. These results, again, could be linked to several factors. All vocabulary questions were multiple-choice questions, while only two mathematical questions with terminology were multiple-choice questions. Having the correct answer provided in one of three choices might have improved the performance of responders in vocabulary questions. It is also possible that the students knew the dictionary meaning of the terminology used in the problem; however, could not relate it to the calculations necessary for the solution of the problems.

Table 4 given below provides the performance of responders from traditionally underrepresented backgrounds in undergraduate engineering education in the United States. The data did not provide a remarkable difference between the performances of total responders and the first-gen responders or responders from underrepresented racial and gender backgrounds. A statistically significant difference between the total data and the data from responders from these demographics was not expected. However, as expected the performance of the students change drastically for responders whose native language is not English. While the success rate of the non-native speaker responders is 60.8 % for math questions written without a common engineering terminology, it drops to 37% for questions written with engineering terminology. This drastic difference points out that while mathematical ability of the non-Native speaker responders was much higher than the average, which was 41 %, their performance was affected negatively due to their lack of exposure to the engineering terminology. As given in the multiple studies in literature provided in the introduction section, low performance of students in engineering courses due to linguistic barriers can become discouraging and can cause lower grades or even low retention.

Table 4. Performances of participants from traditionally underrepresented demographics

Responders from underrepresented/marginalized racial backgrounds (n = 20)		
	Average Student Performance	Standard Deviation
No-term math questions	43.3 %	24.1 %
Terminology math questions	37.8 %	34.6 %
Responders from underrepresented genders (n = 7)		
	Average Student Performance	Standard Deviation
No-term math questions	50.0 %	37.9 %
Terminology math questions	40.0 %	35.0 %
International responders (n = 14)		
	Average Student Performance	Standard Deviation
No-term math questions	49.7 %	30.6 %
Terminology math questions	40.1 %	38.8 %
Responders whose native language is not English (n = 14)		
	Average Student Performance	Standard Deviation
No-term math questions	60.8 %	38.6 %
Terminology math questions	37.0 %	36.9 %
First-gen responders (n = 17)		
	Average Student Performance	Standard Deviation
No-term math questions	41.7 %	29.4 %
Terminology math questions	40.7 %	37.3 %

Conclusions and Future Work

The study intended to investigate whether vocabulary used in engineering curriculum can become an obstacle to success of students in general and students from underrepresented in particular. The study included 10 sets of questions. Each set included a question that did not use engineering term(s), another question that used engineering term(s), and finally a question testing whether the participants understood the engineering term. The study also included questions about participants' demographic background.

The study was administered to 1st year engineering students in mechanical and civil engineering students in their first semester at university level. The data was then analyzed to find differences in student performance for questions with and without engineering terminology. Another variable of interest was the effect of students' demographic background, including whether English is their native language, on their performance in these two types of questions and the students' knowledge of the engineering terms.

After analyzing the data, it can be concluded that, even though overall there was no correlation between students' knowledge of an engineering term and their performance in questions with and without those vocabulary terms, differences emerged between students who are international and who were not. International students performed slightly worse on vocabulary questions than the non-vocabulary questions when compared to overall student population. The differences were starker for students who reported English as their native language vs students who reported English as non-native language. The vocabulary questions make the largest impact on students for whom English is non-native, even though the same students performed well in non-vocabulary questions. A significant minority of the student population in the programs are non-native speakers and thus this discrepancy may explain any differences in student success through their graduation.

Even though the study provided conclusions about the effect of terminology on certain demographics, the current study does not provide statistically significant conclusions due to small sample sizes. The number of participants in the study was below what was expected. Further studies with larger sample populations are needed to conclude with statistical certainty that the language barrier is a major obstacle to student success. This could be useful in preparing remedial material for non-native speakers. Since mastering engineering terminology is critical to students' success in their careers, more care should be taken to strength the first three levels of Bloom's taxonomy [7], before approaching problems involving analysis or design. Such material can bridge the opportunity gaps between non-native speakers of English and the rest. This will be crucial in the university's mission to reduce opportunity gaps between different student demographics while producing career-ready graduates who master terminology in their respective fields.

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