Engineering Educators Bringing the World Together
2025 ASEE Annual Conference & Exposition
Palais des congrès de Montréal, Montréal, QC • June 22–25, 2025 ASEE
Paper ID #48065

Work in Progress: First-Year Engineering Students' Confidence in Communicating Mathematical Content

Ms. Ann W. Clifton, Louisiana Tech University

Ann Clifton is an instructor at Louisiana Tech University and co-author of a chapter in Foundations for Undergraduate Research in Mathematics, Volume I, which focuses on making research accessible to students before they take calculus. Her research is centered on understanding and defining the structural properties of graphs that can be partitioned into balanced vertex sets, with a particular focus on equitably dissectible graphs. In addition to her mathematical research, Ann is involved in the scholarship of teaching and learning, exploring innovative methods to enhance student engagement and communication in STEM education.

Mary Fendley, Louisiana Tech University
Dr. Blake Farman, Louisiana Tech University

Blake Farman is an Assistant Professor of Mathematics at Louisiana Tech University. He holds a PhD in mathematics from the University of South Carolina. His research is focused on developing algebraic techniques to study structures in noncommutative algebra via derived categories.

Joshua Coriell, Louisiana Tech University

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Abstract

This Work in Progress study explores the impact of weekly journaling assignments on engineering students' ability to communicate mathematical concepts effectively in design projects. At Louisiana Tech University, first-year engineering students participate in the "Living with the Lab" course sequence, culminating in the First-Year Projects Showcase. While students excel at explaining their product's purpose and hardware, they often struggle to articulate the underlying STEM principles, especially in mathematics.

To address this gap, a targeted journaling assignment was integrated into the calculus sequence to enhance reflection on mathematical concepts and their connection to engineering applications. Using surveys, written reflections, and project presentations, this mixed-methods study evaluates the effectiveness of journaling in improving communication skills and confidence. Initial findings from the fall quarter suggest promising improvements in students' mathematical communication skills, with ongoing data collection in winter and spring quarters.

Aligned with Kern Entrepreneurial Engineering Network (KEEN) principles of Curiosity, Connections, and Collaboration, this intervention encourages students to integrate math into their hands-on work and articulate these connections. Findings aim to offer strategies to develop mathematical communication skills, supporting deeper learning and better preparation for future challenges in engineering.

Introduction

The author has observed that many engineering majors perceive the calculus sequence as a hindrance to their true interests in engineering. This perception is puzzling, given that calculus is a foundational component of any engineering curriculum. However, there is evidence supporting the author's observation that the way calculus is traditionally taught does not always align with the motivations of engineering students [1]. These students are often more responsive to instruction that emphasizes real-world relevance and concrete problem-solving, rather than abstract theory. A lack of such practical emphasis in mathematics courses has been identified as a factor contributing to student attrition in engineering programs [1]. In response, the author sought a low-cost (in terms of time and resources), yet potentially high-impact, intervention to implement in their own calculus courses to better engage engineering students.

Reflective journaling offers a simple yet powerful way to encourage students to think critically

about their learning and make connections between subjects. Research shows that writing activities, such as journaling, can help students internalize concepts, identify real-world applications, and improve their technical communication skills [2] [3]. By asking students to reflect on how calculus concepts relate to their engineering and science coursework, this study aims to help them see the value of these principles in their broader academic and professional pursuits. Moreover, incorporating a weekly journaling activity does not encroach on the already limited class time, nor does it require the author to have detailed knowledge of specific engineering applications. Instead, the goal is to prompt students to draw those interdisciplinary connections themselves.

At Louisiana Tech University, first-year engineering students participate in an engineering course sequence (which is blocked with the calculus sequence), culminating in the First-Year Projects Showcase. This study integrates a weekly journaling assignment into the calculus sequence to foster connections between mathematics and engineering. Cross-curricular teaching has been shown to enhance student engagement, deepen understanding, and promote the transfer of knowledge across disciplines, making it an essential component of modern STEM education [4] [5] [6]. The findings will provide insights into how reflective practices can support deeper learning and better prepare students for the challenges of modern engineering careers.

As this is a Work in Progress study, preliminary findings are based on fall quarter data, with additional data collection ongoing in the winter and spring quarters.

Methods

Participants

Participants were first-year students ($m = 54$, $f = 17$, no response $= 4$) enrolled in the author's pre-calculus course in the Fall 2024 quarter. 74 of 79 students (93.7%) consented to participate in the study. Most participants were engineering majors, with smaller proportions from physics and computer science. These majors align with the disciplines represented in the First Year Projects Showcase, providing a relevant context for evaluating the integration of mathematical communication skills into interdisciplinary design projects.

Study Design

This mixed-methods study evaluates the impact of reflective journaling assignments on students' mathematical communication skills. Weekly journaling assignments were introduced as part of the pre-calculus curriculum. In the fall quarter, journal responses were completed in-class as part of the pre-course and post-course surveys. Intermediate journaling assignments were submitted via the course learning management system (LMS) and tied to a small participation grade to encourage engagement. Our analysis only considers the hand-written journal responses to mitigate the use of generative AI.

Data Analysis

Both qualitative and quantitative methods will be employed to analyze the data.

Student reflections will be thematically analyzed to identify patterns in how they connect mathematical concepts to engineering and science applications. LIWC-22 (Linguistic Inquiry and Word Count), a validated text analysis tool, will be used to analyze the linguistic and psychological features of student reflections. Key LIWC-22 metrics include:

- Cognitive Complexity: Evaluating analytical and reflective thinking in students' responses.
- Emotional Tone: Measuring changes in confidence and anxiety about mathematics.
- Engagement: Assessing the use of causal and insight-related language, relfecting connections between coursework and engineering/science.

We will also analyze the responses to the pre- and post-course surveys found in the Appendix to determine whether there was a change in the students' self-perception regarding confidence in communicating mathematical content as well as their perceived importance of making connections across the curriculum.

For this work in progress paper, analysis focuses solely on fall quarter data, with future analyses planned for winter and spring quarters.

Results

Survey Responses

Our analysis of the survey responses compared responses from each of the individuals ($N = 53$) who responded in the pre- and post-surveys.

Of the 53 participants who provided responses for both surveys, 21 showed a positive change in their confidence in their ability to effectively explain mathematical concepts to a general audience. There were 19 students who indicated an increase in their confidence in their ability to utilize mathematical principles for their First Year Project. In response to their efforts in making connections between what they learn from different parts of their program of study, 10 responses showed an increase. 40 showed an improvement in their view of how mathematics can be applied to what they want to study while 46 increased their agreement that mathematics is useful for their major.

Journal Response

In order to ensure that no conversational generative AI text was included, we excluded the journal entries submitted via the LMS from our analysis. For the fall quarter, only the hand-written journal entries completed in class during the pre- and post-course surveys were analyzed.

We used a group comparison including all of the journal entries from the pre-course survey ($N_{pre} = 74$) and the post-course survey ($N_{post} = 56$).

There are currently three categories of interest in the LIWC-22 analysis: *Analytical Thinking*, *Clout*, and *Authenticity*. The LIWC-22 Analysis page [7] provides the following descriptions.

Analytical Thinking: Assesses how much language reflects structured, logical, and systematic thinking. Lower scores suggest a more instinctive and personal communication style.

Clout: Represents the level of authority, confidence, or leadership expressed through writing or speech.

Authenticity: Reflects genuine and unfiltered communication, often seen in candid conversations or uninhibited speech.

Table 1 contains summary statistics for the first journal entry of the course which was included in the pre-course survey while Table 2 contains summary statistics for the last journal entry of the course which was included in the post-course survey.

Table 1: Summary of Percentile Scores for LIWC-22 Measures of Pre-Course Surveys

Measure	**Average Percentile**	**Median Percentile**
Analytical Thinking	47.21	49.96
Clout	29.34	23.05
Authenticity	70.92	86.14

Table 2: Summary of Percentile Scores for LIWC-22 Measures of Post-Course Surveys

Measure	**Average Percentile**	**Median Percentile**
Analytical Thinking	75.06	80.96
Clout	49.98	53.64
Authenticity	68.83	75.82

The word clouds in Figures 1 and 2 visually illustrate the differences in word usage between pre-course and post-course journal responses, as analyzed by LIWC-22. In these visualizations, the size of each word corresponds to its relative frequency within the respective data set, with larger words indicating more frequent usage.

The pre-course word cloud (Figure 1) highlights initial patterns in students' language, reflecting their baseline perspectives or understanding of the course topics. We see words such as "contrapositive" and "conditional" because the first course in the calculus sequence at Louisiana Tech begins with a discussion of formal logic. We can also see students already making connections with words such as "circuits" and "resistors." In contrast, the post-course word cloud (Figure 2) captures shifts in language use, showcasing changes in thought patterns or content focus following course completion. We can see there is more variety in the language used highlighting the myriad connections the students were making at the end of the quarter. Together, these figures provide an accessible summary of the linguistic evolution observed, complementing the quantitative analysis presented in the study.

Discussion

This project originated from a professional development workshop sponsored by KEEN. The author recognized a recurring challenge in their calculus courses, which primarily serve

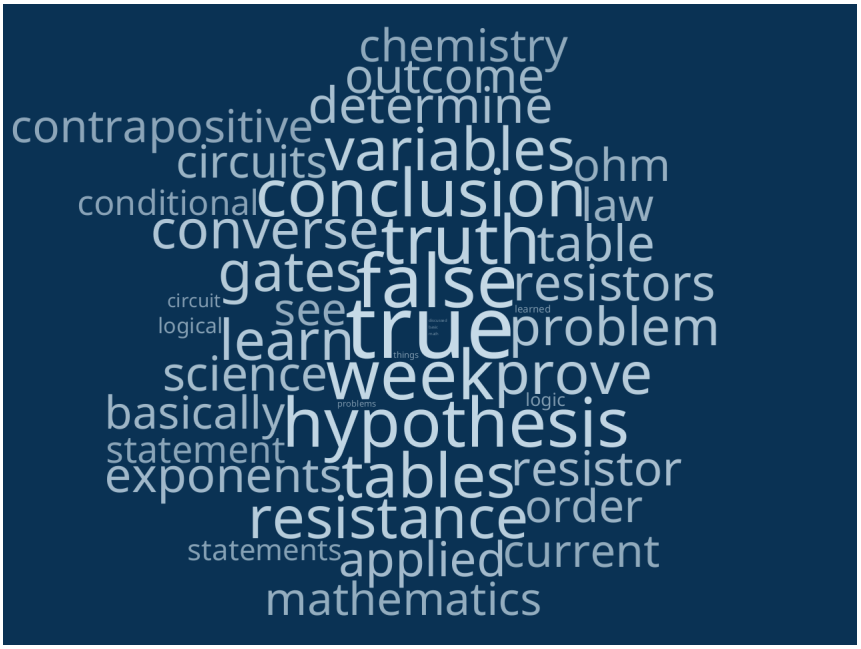

Figure 1: Pre-course reflections.

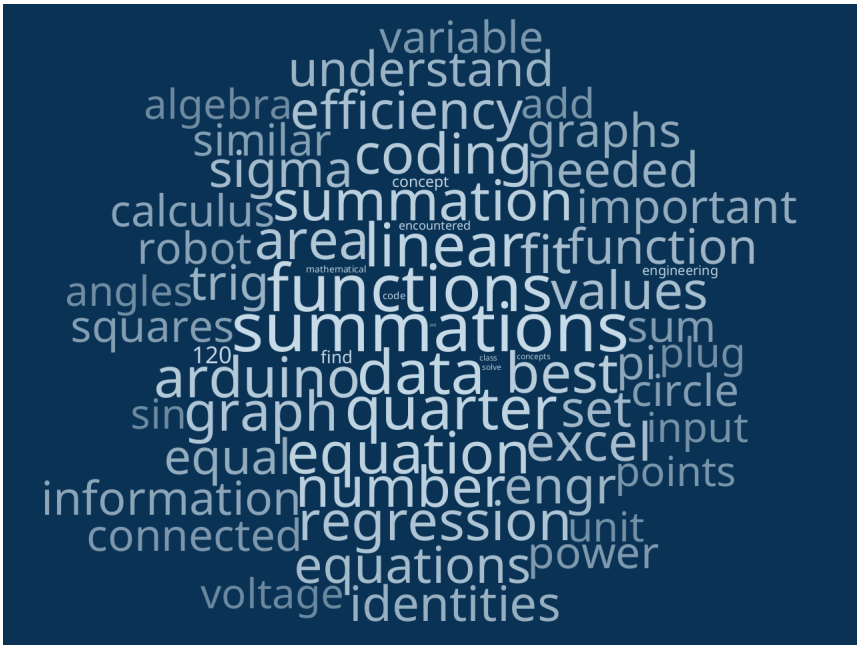

Figure 2: Post-course reflections.

engineering majors, and saw an opportunity to enhance the quality of freshman presentations at the First-Year Projects Showcase. As a full-time teaching faculty member, the author sought an intervention that was both low-cost and high-impact. Drawing on insights from the literature, weekly reflections were selected as the approach.

The trends observed in the data point to several promising developments while also highlighting areas that warrant further exploration. Many participants showed increased confidence in explaining mathematical concepts to general audiences and applying mathematical principles to their First Year Projects, indicating progress in their ability to communicate and integrate mathematical ideas. The notable rise in participants recognizing the relevance of mathematics to their academic goals and its broader applicability is an encouraging sign of the intervention's impact.

The low *Clout* scores in the pre-survey journal analysis suggest a mismatch between students' self-reported confidence and how that confidence was expressed in their writing at the beginning of the course. In contrast, the high *Authenticity* scores indicate that students were engaging with the journaling activity in a sincere and unguarded way. This may be partly attributed to the timed nature of the task, which likely limited their ability to revise or carefully craft their responses. In LIWC-22, for instance, a casual letter to a friend typically scores high in Authenticity, whereas a prepared speech tends to score lower. Over time, as students completed multiple iterations of the activity, their responses may have become more routine or structured, potentially explaining the slight decline in *Authenticity* scores. Interestingly, the *Analytical Thinking* scores hovered around the 50th percentile. This could be due to the framing of the prompt, which encouraged students to write informally, as if addressing a friend, possibly discouraging more analytical or structured writing.

Encouragingly, we did observe a remarkable increase in both the *Analytical Thinking* and *Clout* rankings generated by LIWC-22 for the post-course journal responses. These preliminary findings suggest that the writing assignment helped students develop deeper analytical reasoning, confidence, and elaboration in their explanations. In future implementations, we will need a control group to ensure that this increase is not just due to maturity through course participation and is, in fact, impacted by the journaling intervention.

This study is ongoing and we have already made some adjustments in an effort to address some preliminary concerns. In the winter quarter, the weekly reflection journals will be completed in class with pen and paper and no longer linked to a participation grade. This adjustment aimed to standardize the completion environment and minimize external influences. Since the assignment will be completed on paper during class, the instructor can visually ensure that external tools such as large language models are not used. In future implementations, a statement such as "The use of AI is not permitted in the completion of this assignment" will be included in the prompt. We also plan to develop a rubric to help guide the students in making connections across their curriculum.

We plan to continue incorporating the weekly reflections as an in class activity through the spring quarter. Written reflections from winter and spring quarter will be manually transcribed to digital format with support from an internal mini-grant. This will enable the authors to track changes in students' responses over time. At the end of the spring quarter, final project scores will also be

collected from the First Year Projects Showcase. Comparisons will include students exposed to journaling assignments versus those who were not, as well as students who completed multiple courses with journaling assignments versus those who took one or none.

We welcome feedback from the community for future implementations and study design.

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Appendix

Pre-Course Confidence Survey

First and Last Name: **Intended Major:**

For each statement, please indicate the extent to which you agree or disagree by selecting the appropriate response on the provided scale.

Instructions:

1. **Read each statement carefully** before selecting your response.
2. **Choose only one response** per statement that best reflects your opinion.
3. **There are no right or wrong answers** - we are interested in your honest opinions.
4. If you feel **neutral** or have no opinion about a statement, select the "Neutral" option.
5. Please ensure that you **complete all the questions** before submitting the survey.

Your responses will remain **confidential**.

	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
I am confident in my ability to effectively explain mathematical concepts to a general audience.	◯	◯	◯	◯	◯
I am confident in my ability to utilize mathematical principles for my First Year Project.	◯	◯	◯	◯	◯
I try to make connections between what I learn from different parts of my program of study.	◯	◯	◯	◯	◯
Mathematics has very few applications to what I want to study.	◯	◯	◯	◯	◯
I don't see how mathematics is useful for my major.	◯	◯	◯	◯	◯

What is your gender identity?
Woman **Man** **A gender identity not listed here** **Prefer not to answer**

What is your race/ethnicity? (Circle all that apply.)
Hispanic, Latinx, or Spanish Origin **Black or African America**
Southeast Asian (Hmong, Laotian, Cambodian, Vietnamese) **Other Asian**
Native American or Alaskan Native **Hawaiian Native or other Pacific Islander**
White
Some other race, ethnicity, or origin_____

Has either of your parents earned a four-year college/university degree? **Yes** **No**

Please respond to the following prompt:
Imagine you are writing to a friend who has not yet taken calculus. Explain a mathematical concept you encountered in your engineering/science course this week. How is the concept connected to ideas we have discussed in this course?

If you did not encounter any mathematical concepts in your engineering/science course this week, pick one of the concepts we discussed in this class to explain to your friend.