Writing as a Method to Build Better Engineers: Examining Faculty Perceptions of Writing's Importance

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Abstract
Writing is a critical skill for professional communication, providing a way to develop and examine ideas, and a method to test learning. When perceived as meaningful by the writer, writing is fundamental for identity formation in disciplines, such as engineering. The formation of an engineering identity is an area of increasing interest in engineering education research due to its link to student retention, particularly for those underrepresented in the profession.

In addition, industry demands that engineering graduates possess improved abilities to communicate in a variety of mediums and cross-culturally. Improved integration of writing into the technical curriculum could serve as a concrete method to develop these critical skills and attributes while potentially improving student retention. Despite these numerous benefits and efforts to increase engineering writing through efforts like Writing Across the Curriculum, it seems most engineering programs do little to engage their students in meaningful writing. This study investigates faculty perceptions regarding the role and importance of writing in undergraduate engineering curricula as a factor in writing's integration in engineering educational practices.

This study examined faculty perceptions of writing in the Norm Asbjornson College of Engineering at Montana State University , gauged where and in what capacity writing assignments occurred across the curricula in the college, and examined faculty opinions held on writing and its relation to the technical aspects of engineering education. This study provides a baseline for understanding areas of future improvement and integration of writing into the engineering curricula.

Keywords—writing; engineering faculty; student retention;

Introduction
Writing is a critical skill for professional communication, a way to develop and examine ideas, and a method to test learning. "A central tenet of writing across the curriculum and in the disciplines, is that the use of writing goes far beyond improvement of students' skills. Instead, writing is essential to learning and the process of development that higher education aims to foster"[1]. Simply performing writing, however, does not guarantee higher-level student learning. In order for writing to have significant and lasting value to students, it must be perceived as meaningful by the students performing it [2]. Meaningful writing has been shown to be fundamental to identity formation across disciplines, a topic recently linked to issues of retention and representation in engineering. Therefore, the performance of meaningful writing in engineering curricula has the potential to help address chronic representation issues, to improve the writing competencies of graduates, and to help encourage the growth of future engineers.

How faculty in the Norm Asbjornson College of Engineering (NACOE) at Montana State University (MSU) conceptualize writing influences the way that it is taught, and thus student outcomes and student perception of its meaning. This examination of faculty perceptions on writing is a first step in identifying and cataloguing whether meaningful writing is occurring. How instructors think about writing, and then teach and structure writing assignments (or do not assign

writing) influences engineering students' mechanical writing competencies as well as their perceptions of writing and the role it plays in their future profession.

This research examines the perspectives of NACOE faculty and the integration of writing in the engineering curricula at MSU, a research intensive, mid-sized, land grant university in a rural community [3]. The study employed a mixed methods approach. First a survey was issued to all NACOE faculty. This survey investigated how writing assignments were being used within the NACOE, faculty perceptions of writing, and requested future participation in small focus groups. In focus groups, faculty were asked to further articulate their paradigms of writing by responding to a series of questions. In addition, a few members of other faculty programs on campus were interviewed for their insights working with engineering faculty and writing. The mixed methods approach is used in an attempt to capture a more complete and nuanced picture of faculty perceptions about a variety of roles of writing in engineering.

Background and Literature
In the writing community writing is viewed as valuable across disciplines not only as a skill necessary for professional growth and communication, but as developmentally instrumental. Initiatives such as Writing Across the Curriculum "value writing as a method of learning"[2]. Meaningful writing is known to be key for how students develop identities as "fledgling members of their disciplines"[3]. This development of identity through meaningful writing is of interest to engineering education because of the link between identity formation, critical for entry and retention into a discipline, and the lack of diversity in United States engineering: "undergraduate engineering education is dominated by [w]hite males. The majority of all bachelor degrees awarded in engineering are to [w]hite males"[4],[5]. Thinking about students' meaningful writing experiences as related to enagement may be a way to further examine engagement as a "precursor to persistence"[6].

Defining meaningful writing is important to understand its distinction. In the *Meaningful Writing Project,* Eodice, Geller, & Lerner [3] define meaningful writing as
  - **Agentive:** develop[s] a sense of agency about [students] as writers, learners, and thinkers
  - **Engaging**: writing is a key contributor to [students] sense of engagement with course material and with peers and faculty
  - **Learned for transfer:** can be transferred for later application of skills or acquisition of knowledge

In order for writing to develop individuals it must be integrated with careful thought and planning – not only with respect to learning outcomes, but with structure to provide students agency and engagement. Simply adding more writing assignments does not guarantee self-actualized students or a more valuable educational experience. Instead, "faculty who teach courses in which meaningful writing takes place often deliberately build these qualities into their teaching and curriculum, expressing their goals and values for writing through specific practices" [3]. Meaningful writing is the careful integration of writing, not merely "Informative writing to the teacher-as-examiner in the genre of a short-answer exam [which] does little to truly initiate students to the primary purposes and audiences in the writing of their disciplines" [7]. The initial baseline of writing perceptions built in this work serves as a step to examine whether and how

writing might be incorporated into the NACOE curricula and can provide a model for others to follow.

Project Motivation and Approach
This research project did not begin as an examination of writing in engineering. Rather, it began as an investigation into the learning practices of two different communities the lead author operated in – as a peer writing tutor in the university writing center and as an engineering undergraduate student in the college of engineering. As a peer writing tutor, the lead author was immersed in understanding writing epistemology and pedagogy to engage with other community members and students. As an engineering student, they experienced engineering epistemology and pedagogy as a learner where practices were intended to be imparted onto them.

The type of work done in engineering and a more humanities-and-collaboration-centered Writing Center were very different, and these informed many of the practices and underlying values of each community. For example, in a more humanities-oriented space such as the Writing Center, students were encouraged to participate in personal inquiry and a more open classroom style where students challenging material and questioning as they engaged in inquiry was viewed as normal. Resistance to "correctness" and discussion of institutional norms occurred regularly.

This was in contrast to many experiences as an engineering undergraduate student, where instruction was based on note-taking and examination, homework practice, and feedback that was generally final, among other small but additive experiences. Some of the aspects of flexibility in the humanities began to appear increasingly attractive, even if the prospective impact of future work was not as desirable as engineering. The primary author began to wonder how many other engineering students – particularly minorities such as women who in addition to the often-unpleasant education paradigms were likely also experiencing some number of micro-aggressions – might have examined the different communities and found a social science or a humanity field more immediately attractive and transferred.

An examination of the elements of engineering work causing distress began to show that these were not necessarily aspects of engineering education that needed to stay. In fact, it was difficult to identify where these elements had come from other than tradition. The high workload of engineering focused on student production without respect to other course loads (often expressed as the "difficulty" of engineering [8]), the sometimes transactional interactions with overwhelmed and overworked faculty, the dismissal of experiences as personal and therefore irrelevant in the bigger scheme of data, and the hierarchy of students as lesser and the teacher as examiner, were not aspects necessarily inherent to the engineering profession, especially not a modern one, but aspects that seemed abundant in engineering education.

While engineering programs attempt to make sweeping redesigns of their curriculum to promote flexibility to attract students, the issue experienced by the lead author in their institution with these redesign efforts is that they failed to examine daily practices and instead focused on high level curricula [9-11]. Rearranging courses to allow students freedom to select more of their classes is helpful in that it may give students the ability to sample a wider range of discourses but does not necessarily address what may be ineffective engineering education practices within an institution or curriculum.

This examination of education practices prompted the lead researcher to dig into one concrete element of practice: writing, and how it was taught in the different environments. How engineering faculty perceive writing could be a larger indicator of how they perceive ideas related to the humanities and of their larger frameworks of understanding. In addition, writing is often a way for marginalized voices to be heard. Perhaps better integration of writing in engineering curricula would give students an opportunity to voice their needs from their education and a platform to communicate equally with their faculty. However, writing is often viewed as an annoyance and as extraneous by students when assigned in the NACOE, a belief that is likely influenced through the ways faculty conceptualize writing communication and present, assign, and discuss it. This created the corresponding interest in engineering faculty perceptions of writing and its instruction explored in this work.

Research Question and Methods

The core research question this work sought to answer was: *How do faculty in the MSU NACOE perceive writing and writing instruction, and how might those perceptions influence the existence, instruction, and belief systems around writing in engineering?* This question requires the use of qualitative approaches to capture a comprehensive and fair scope of faculty perceptions; therefore, a mixed methods strategy was used.

First, a cross-sectional, single data collection survey was issued to NACOE faculty via email. This survey sought to understand fundamental information about participant's use of writing assignments, their perceptions of student writing skills and the importance of writing. It also sought volunteers for the qualitative phase of the work.

Survey Design

After agreeing to the IRB consent form, faculty members were asked 11 questions designed to measure the four variables shown in Table 1. These variables captured the criteria for writing to be meaningful as defined in *The Meaningful Writing Project,* (Agency, Engagement, and Learned for Transfer) and considered assignment type from the work of Melzer [3],[7].

In addition to the criteria of writing to be meaningful, variables on *Personal Relation to Writing* and *Value of Writing* were created to measure faculty relationships with writing practice. This examined not just whether and how faculty assigned writing work in their courses, it also gauged independent perceptions that could influence writing instruction. *Perceived Writing Competencies of Engineering Undergraduate Students* measured faculty perception of student writers before entering the program and as graduates, with the intent to compare those perceptions to teaching practices. The variable *Teaching Writing in Engineering* measured faculty attitudes around writing instruction and whether they believed they had an impact on writing competencies of engineering undergraduate students.

As an example, *Teaching Writing in Engineering* contained questions to gauge faculty's perceptions of agency in their assignments – "I believe that there are opportunities in my course(s) for students to write about topics that interest them" [12], as well as a question with options to select as many forms of writing faculty believed occurred in their course(s). "Writing in my

course(s) is in the form of…" where options for reflection, homework, professional communication, examinations, etc. are listed with definitions in a mouse-over component. A complete relation of variables, their definition, and questions are shown in Table 1.

Table 1: Number of questions per variable measured and variable definition

Variable Name	Question Count
1. Teaching Writing in Engineering	4
Frequency and type of writing that instructors may offer in their courses, as well as faculty attitudes about writing instruction in engineering education. For example, "I think writing is a valuable learning tool in engineering education."	
2. Perceived Writing Competencies of Engineering Students	2
Questions about the perceived writing capabilities of students before and after education in the institution's NACOE, structured as a Likert scale, "Most students who enter the MSU College of Engineering have strong writing abilities."	
3. Value of Writing	2
How important NACOE faculty believed writing to be, e.g., using a Likert scale to answer "I think it is important for engineers to learn how to write well" as well as an open response question "Where and when do you see communication and writing as important to engineering?"	
4. Personal Relation to Writing	2
Sought to measure NACOE faculty's perceptions of their own writing abilities, asking questions such as "I feel that I am an effective writer."	
Demographic information & Teaching Experience	9
Demographic information such as teaching experience, COE department, and the number of courses taught annually were gathered as well for investigation of any differences based on these measures.	

Quantitative Analysis Methods

Since the data collected in the survey is Likert type ordinal data, primary data analysis was completed using Spearman correlations using Minitab 17 [13]. This analysis is used to provide an understanding of the relationship between multiple questions in the survey. While these correlations do not imply causation between one behavior and another, the relationships are informative with regard to how practices, beliefs, and perceived competencies are intertwined. For example, faculty can believe that they are strong writers and answer the question as such, but it does not necessarily mean that their peers or the profession agrees. However, this measure of respondent perceptions should not be interpreted as a weakness, as self-reported measures of performance have been widely shown to align with actual performance in engineering education research [14-17].

Focus Groups and Qualitative Data Use

From respondents who completed the survey and indicated interest in further study participation, two focus groups and two individual interviews were completed. Focus groups were run with the intent to encourage faculty to discuss what they felt was relevant with minimal prompting from the interviewer. Questions followed the list found in Table 5 in the Appendix. The findings from focus group discussions are used to enrich survey findings, with direct quotes from participants of focus groups incorporated to provide examples of phenomenon discovered in the quantitative analysis of the survey data.

Findings and Analysis

The combination of quantitative data from the survey and qualitative data from focus groups gives a robust set of information that enables a deeper understanding of writing practices and perceptions at MSU and the NACOE. In the following sections, this understanding is explored across several dimensions aligned with the literature in this space.

Survey Respondent Demographics

In order to provide context for later findings, we first explore the demographics of survey respondents. In 2016, the last year of reported data before this study was performed, the NACOE faculty was composed of 75 professors including those in tenured positions and assistant professorships, 17 females and 58 males [19]. A total of 28 respondents entered the online survey. Five respondents were removed either because they were not a member of the NACOE faculty or they did not complete the entire survey. Figure 1 contains survey participant demographics.
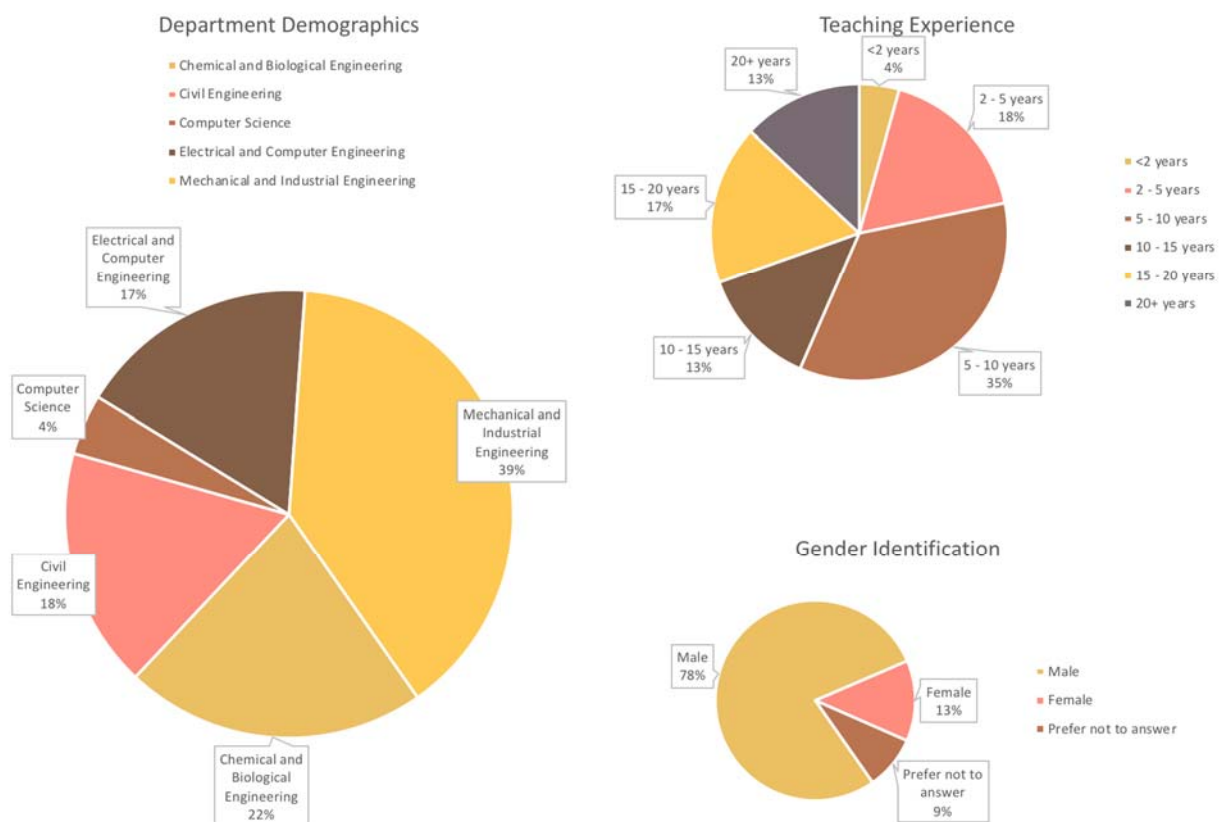

Figure 1: Participant Demographics

Use of Writing Assignments

One of the key indicators for MSU COE faculty's frequency of assignment type in the survey was an investigation of Melzer's assertion that most writing that occurs across the curriculum is at a low level, examination or homework answers to a "teacher as examiner" [7]. Table 2 shows faculty response to writing assignment type where respondents could select multiple forms of writing. It

is important to remember that these are categories identified by faculty belief and classification, and that the success and structure of the assignments may differ.

Table 2: Responses to Q7; "Writing in my courses is in the form of..."

Answer for Assignment Type	Count
Homework: Explaining concepts or answering questions for a grade based on content correctness.	13
Lab Reports: Technical communication with formal constraints whose primary intention is to inform an audience to repeat the experiment, evaluated on methodology.	13
Professional Communication: Writing that occurs in context to an audience that is formal (e.g., emails or communication with a client, real or fictional).	11
Other Assignments: Writing that falls outside the above categories.	10
Examinations: Short answer responses that are graded for an audience of teacher as examiner, evaluated on content correctness.	5
Essays: Writing that falls outside of typical technical communication, commonly asking students to perform analysis or take a stance on an issue.	5
Reflection: Writing that involves assigning meaning to an experience from personal relation or critical thinking (e.g., journaling).	4

The most frequent response for assignment type is homework, followed by lab reports. It is briefly reassuring that 'Lab Reports' is the second most frequent writing assignment, under the assumption that lab reports generally require a more critical analysis of findings and discussion of error, as well as the work's relevance to a real problem. However, the level of thinking required for lab reports can vary – based on both the lead author's personal experience and focus group input, lab reports are often repeat assignments where findings are known. Since Lab Reports are often set up to prove the same learning objectives for each course, these assignments often do not change much year to year, or the results of the experiment are pre-determined, it is easy for students to mimic or copy expected results or previous years' versions of assignments and miss out on the benefits of learning this genre of writing. Rather than engaging in critical thought about inputs into an experiment and how to appropriately explain expected or unexpected outcomes, outcomes and explanations fit a predetermined outcome and often are simply regurgitated, if not simply copied from another.

As one faculty member expanded, "…[the] most common place you see [writing] is in lab notebooks and memo reports. So, students will go in and do a lab exercise, build [something] and measure these quantities, and then they record their experimental setup in their lab notebook, they write up their results and their measurements in the lab notebook, so they are physically writing with a utensil, then those get turned in and graded…". An important note in this language is the emphasis the faculty member places on *"physically"* writing because they are aware that that students may not necessarily be engaging in the process of writing, just using the utensil with little thought.

Upon further discussion of these types of assignments in their own undergraduate career, the interviewer asked whether the faculty member had learned anything from this assignment type.

The faculty response, "… for me, going back, it wouldn't change your grade if you looked at it anyway. So, you get it, and… oh you should do this, this, this, [then you] throw it in the garbage, it was very superfluous, it was an add-on, it wasn't a lot of points, the only reason I guess you'd look at the feedback would be to improve for the next one, but there were so few anyway that it didn't really matter. It wasn't meaningful in terms of the reward system."

This quote is laden with information, this faculty explains that they (perhaps as a result of this experience) do not give writing assignments in any of their courses, and that they are unsure how successful other faculty, those that do assign writing, are with this form of assignment. This is a faculty member who recognizes a chronic issue – writing assignments as added on, without much thought or intention, that are not serving students in any fashion. Instead, these assignments are another drain on faculty and student time and energy.

It is a positive indicator that faculty expressed different genres of writing occurring, particularly the high frequency of "Other Assignments." However, it is disappointing that some of the potentially more intellectually engaging forms of writing – essays and reflection – are among the least common. While Table 2 shows a happy diversity in assignment type and frequency of assignments among faculty, it is not necessarily an indicator of engagement with writing for students, or the applicability of such assignments. Based on the input from focus groups, many assignments are known to be trivial or given only to fulfill a writing requirement in the NACOE curriculum.

Understanding the Relationships Between Survey Measures
As described in the methods section, to understand the relationship between the concepts measured in the survey, correlation analysis was performed in Minitab 17. This analysis explores for the existence of any linear relationships between different survey questions, as measured by the ordinal responses. This analysis found nine significant ($\alpha < 0.1$) relationships, summarized in Table 3, with abbreviations to define the questions. The appendix contains full question text.

Faculty Believe Students Possess Writing Competencies and are Learning to Write
The survey revealed faculty perception of positive educational outcomes of writing instruction for the NACOE. Respondents who believed that they were effective writers showed a relationship to students leaving their courses with an increased understanding of writing in engineering. This is a positive indicator that instructors who believe they are effective writers are attempting to pass these skills onto graduates [Q6 and Q13, $p = 0.050$, Corr +0.414].

In addition, faculty who indicated they often engage in professional writing also expressed a belief that the university's NACOE undergraduates are strong writers. It is a positive metric that instructors that engage more frequently in professional writing, likely qualifying them to assess the competency of other writers, indicated a perception of strong student writing skills at MSU [Q14 and Q10, $p = 0.062$, Corr +0.395]. This reinforces faculty perceptions of seeing undergraduates of the university as competent writers upon graduation, something that those faculty who see themselves as effective writers believe to have an influence on and ability to assess.

Table 3: Question Correlations and Significance

Question Relation 1	Question Relation 2	Spearman's Rho Correlation
Q6: improved writing	Q13: faculty write effectively	Corr +0.414**
Q14: faculty engages in writing	Q10: graduates write well	Corr +0.395*
Q3: courses taught per year	Q5: courses provide writing opp.	Corr +0.394*
Q3: courses taught per year	Q6: improved writing	Corr +0.357*
Q3: courses taught per year	Q11: important engineers write well	Corr +0.427**
Q4: writing valuable in engineering	Q14: faculty engages in writing	Corr -0.452**
Q11: important engineers write well	Q14: faculty engages in writing	Corr +0.479**
Q13: faculty write effectively	Q8: opp. to write on interests	Corr -0.498**

Number of Courses Taught is most Frequent Variable to Correlate

The survey question that most frequently correlated with other responses was the number of courses respondents taught. Faculty who taught fewer courses correlated with increased opportunities for writing, a belief in a positive impact on students' understanding of writing in engineering, and whether respondents believed it was important that engineering students knew how to write well.

The first relationship between respondents teaching fewer courses and having increased opportunities for writing overlaps closely with what was frequently articulated in focus groups – that writing is time consuming to assign, support, and evaluate. "I think I used to require more writing than I do now, and I think it's just I got tired… of staying up late grading lab reports."
With the knowledge of writing as a time consuming educational integration, it makes sense that faculty who teach fewer courses were also those who offered more writing in these courses. Teaching more courses did not make respondents more likely to say that one or more of their courses provided some form of writing. This implies that increasing the opportunity for writing to exist by a 'larger' sample of courses does not necessarily make it more likely for writing to exist in classes. This may also have positive indications for the quality of writing occurring in the NACOE; those with fewer course responsibilities may devote more resources to writing instruction, support, and evaluation [Q3 and Q5, $p = 0.063$, Corr +0.394].

The next significant correlation, the number of courses a respondent instructed and whether the professor believed they had a positive impact on students understanding of writing in engineering, builds on the first relationship. The fewer courses that an instructor taught, the more likely they were to believe they were able to successfully inform or expose engineering students to writing. This could again be due to the expressed resource devotion writing demands and could also just be a general belief for faculty who are able to dedicate more to their fewer courses demanded and may, in general, believe they have a positive impact on student's learning outcomes [Q3 and Q6, $p = 0.095$, Corr +0.357].

One of the more complex outcomes for the number of courses that faculty teach showed a relationship between instructing fewer courses and believing it was important for engineers to write well. This could be that the faculty teaching fewer courses, those where writing is more likely to exist, also see an importance in successfully teaching engineering undergraduate students to write. It could also express a concern raised by many faculty during focus groups – that writing is viewed as nonessential by students because it is often added in addition to technical competency instruction to the curriculum. "Unless you can embed the learning objectives that are requisite in that course within that writing assignment, then it's kind of superfluous." Similarly, this relationship could show that as instructors handle more responsibility and instruct more courses, a corresponding devaluation of engineers learning to write well occurs – it implies the superfluous perception not just among students, but among faculty as well [Q3 and Q11, $p = 0.042$, Corr +0.427].

Frequent Writing Correlates with Assigning Less Value to Writing as a Learning Tool
A correlation in the survey that is counterintuitive was the relationship between whether respondents believed that writing is a valuable learning tool in engineering education and how often the instructor engaged in professional writing. Instructors who wrote less than their peers more frequently indicated they believed writing was a valuable learning and instructional tool for their students. This is concerning for teaching undergraduate students to learn to write – if the faculty who frequently engage in professional writing value it less as an engineering instructional tool than faculty who write less often. The view of writing as 'less useful' by those who perform it more frequently does not bode well for its thoughtful inclusion in the curricula. This is furthered by the next survey response correlation [Q4 and Q14, $p = 0.030$, Corr -0.452].

While faculty did not generally believe that writing was an effective tool for engineering education, they did show a relationship for their engagement in professional writing and their belief that it is important for students to write well. The faculty who often engage in professional writing see an importance in correctly educating engineering undergraduates how to perform it, but do not view writing itself as a powerful educational tool in engineering education. This places writing in an interesting location, where it is important for engineers to learn how to do (and master), but not something that is seen as beneficial reciprocally – in educating engineers to be better at their own professional competencies [Q11 and Q14, $p = 0.021$, Corr +0.479].

Roots of this disconnect may be seen in the follow focus group comments: "I truly believe that the majority of the grammar and the editing can be done via some program. So for me, it would be like, mandating that students upload their documents to these programs, actually make the corrections that these programs suggest, so the bulk would be more on the students than having like another faculty be bogged down by 100 papers a semester."

This highlights issues of faculty workload associated with writing. However it misses the larger picture, addressing grammar with a computer program may make grading easier, but it fails to address the deeper goal of writing in the engineering context (as expressed by faculty): clear communication. Clarity is not achieved solely by correct grammar. As a writing tutor, grammar was generally far less important than higher-level concerns such as organization, language or word choice, awareness of audience, or content.

As a writing tutor and as a student, the lead author believes that students are aware of whether or not faculty read their writing assignments [18]. The suggestion that faculty use an online software platform to evaluate and grade writing means that students are going to learn how to successfully game the system – that is what their grade will be tied to. One cannot outsource teaching or learning of writing to computer software. Engineering professors expect that engineering students learn structural fundamentals in addition to learning to use CAD software; in the same way, students must learn structural fundamentals of language in addition to learning to use grammar checks.

Agency and Effective Writing

The next significant correlation was between faculty who felt that they were effective writers and the amount of agency they offered students in the writing assignments in their courses. Faculty who identified as effective writers did not indicate they offered opportunities for agentive writing [Q13 and Q8, p=0.015, Corr -0.498]. The meaning of this correlation is difficult to ascertain, as agency was a difficult factor to capture in focus groups. The student perspective is required to assess whether assignments are agentive to them, as they are the participants that ultimately determine relation to the subject matter and the value of an experience.

Survey Free Response Analysis

In the open-ended question, "Where and when do you see communication and writing as important to engineering?" respondents shared their conceptions, varying from one-word answers to paragraph length concerns over engineering student writing competencies and lack of writing as a critical skill among engineering students.

It was seen repeatedly among respondents' free response answers and in the survey data (see Figure 2) that strong writing and communication skills are valuable to engineering: "communication is critical in all areas of engineering" and "Writing as a form of communication is indispensable to any technical profession." This was articulated across fields, through research, engineering specific communication – "Primarily in professional communications (to management, among peers, to clients or vendors, etc.) and in technical reports", and in daily communication – "Communicating with colleagues, customers, and company owners"; "reports, memos, emails, labs, conversations with management, conversations with operators, technical manuals, progress reports, etc."
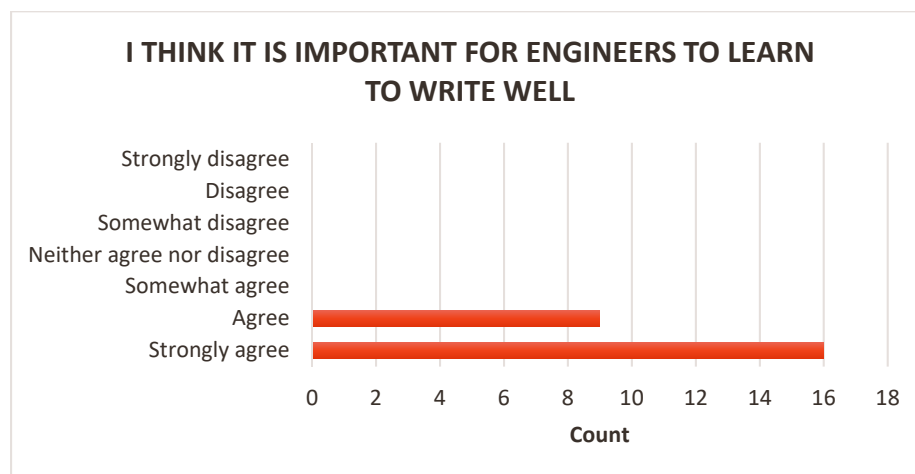

Figure 2: Q11 - I think it is important for engineers to learn how to write well.

Faculty viewed writing as a tool for engineers to communicate, show research, or convey instructions. There is subtlety in this response, as it shows the articulation of writing as valuable, but centers around writing as a tool to accomplish an end result:

- "Engineering is problem solving; if you cannot communicate your solution, it is useless. So, communication is critical in all areas of engineering."
- "When engineers need to communicate the results of our analysis, writing is critical."

Unfortunately, this conceptualization often fails to take the next step toward a broader understanding of writing. In fact, only one respondent indicated a view of writing as valuable to engineers as a part of process of problem solving: "In the formulation of engineering problems and their proposed solutions, including the reasoning process that was applied in developing the best solution" and one other indicated writing as part of "assessment and interpretation of results obtained."

This gap parallels some of the components of the definition of meaningful writing. Perhaps students are more likely to view their writing assignments in engineering as meaningful if writing is a tool to bring necessary meaning to their engineering projects. However, that seems unlikely given other faculty's articulation that "[u]ndergraduate engineering students tend to underestimate the importance of communication in engineering." The way that writing is currently integrated is failing to show students that these experiences are applicable to the remainder of their professions. This communication of ideas often is felt, from the perspective of students, as tacked on, despite all of the faculty in the survey vocalizing writing's "importance" to engineering education.

Some of the feedback in the open-ended section of the survey gave advice on communication and writing structure and integration into engineering education practices. The articulation of scaffolding – "It should be an area of focus with planned progressions in various writing styles: project report, research paper, memo, etc." – showed faculty conceptualize the progression of writing learning [19]. However, this conception focused on learning "how" to perform particular engineering documents rather than the higher level critical thinking skill of rhetoric – understanding why there are genre distinctions, and how to determine these underlying "value systems" to adjust writing for future unfamiliar genres. This is a far more valuable skill than learning how to write a memo report, because it develops a learner's critical awareness of audience and purpose and strengthens their ability to communicate across situations rather than only in specific situations that may change as the profession does. Yet faculty express concern at inadequacies in engineering writing: "One of the most difficult things to do is to communicate a technical idea or concept to a non-technical audience" and "if an engineer can't write well, then successful communication of information is at risk."

Implications, Conclusions, and Future Work
The results from the survey show a numeric valuation of writing, a positive indicator for the future of writing in engineering in the NACOE. Most respondents believed that MSU both graduated engineers with strong writing competencies, and that the faculty were able to positively influence these competencies in their courses. Though most faculty believed it was important for engineering undergraduates to learn to write well, both the survey and focus groups indicated that with workload increases for faculty, writing became secondary. Faculty discussed the additional time and grading difficulty of writing assignments, particularly in large engineering classes, as well as

their own varying comfort and desire to integrate writing teaching and evaluation. Faculty expressed their perceived need for engineering students to have writing competencies, but with poor integration into the curriculum writing disappeared when other demands increased.

These results indicate support for a common finding in the literature – that engineering faculty value technical competence against professional skills, even when it is the other skills that are more highly valued by industry and even society in general [20-23]. This is both concerning, and disappointing, as writing offers one of the more concrete and tangible ways for engineering students to develop professional skills and demonstrate robust problem solving within an engineering curriculum. Perhaps more concerning is the fact that the engineering faculty in this group do not appear to recognize the role writing can play in opening the profession to traditionally underrepresented groups. Since those involved with the focus groups also tend to be regularly engaged in engineering education projects, this seems to indicate a failure of those engaged in efforts like *The Meaningful Writing Project* to pierce the world of engineering education and show engineering educators the value writing can play in alleviating some of the professions most intractable problems. This points to the need for future work both within MSU and within the field of engineering education.

As MSU's NACOE moves forward with their efforts to meet the demands of both their accrediting institution and those of the engineering profession, writing integration is essential. The recommendations to improve student writing will not be met simply by assigning more writing. There must be a change to the thought that "I don't think I do teach writing. I give writing assignments." In order for students to learn how to write effectively and take away any ability to use writing to communicate, the way that writing is integrated, and the way faculty conceptualize it, is critical.

Successful writing integration takes expert disciplinary knowledge, not just structural planning and knowledge of engineering curricula. The model of the university writing center, one of multidisciplinary collaboration, encourages work between field experts to hybridize knowledge and expectations and improve student learning outcomes and student experiences. Without collaboration, it is likely that the cycle of writing integration into engineering education will repeat – engineering faculty will make a hard push to integrate writing as their stakeholders ask for improved student writing competencies. Faculty will throw more work onto students and exponentially more work onto themselves, in an attempt to "crank it out." This will last for a few years before this form of writing integration is recognized to be unsustainable and once again writing will disappear in frustration and exhaustion of both students and faculty. While successful writing integration into the engineering curriculum is possible, it may require a shift in perception in how engineering faculty value writing, experts in writing, and student input. A shift away from thoughts like "I like the idea of somehow incorporating the humanities… but again I don't know what the students are going to get out of that."

The next phase of this project will begin to forward this thinking with a complete analysis of the qualitative data gathered in focus groups. Through content analysis of these transcriptions, the team intends to develop a more complete picture of both the barriers and boosters to successful integration of writing within the NACOE. This would set-up future work to better understand student perceptions of writing in engineering employing a similar method to that used with faculty.

In addition, The MSU Writing Center is now embarking on funded work to build models of writing integration within the NACOE and other STEM programs at MSU. These models are expected to provide further data not only on best practices, but also on the true support needed to resource the execution of these best practices.

However, intentional integration of writing will not come easily; in fact, due to the collaborative nature of the team required, the planning and incorporation is likely to be initially more difficult than assigning and grading additional writing assignments. However, the benefits of collaboration, as almost universally recognized in the engineering discipline, offer a chance at success. MSU is in an exciting position to change and design what writing in their curricula looks like – if they're open to the reevaluation and work it entails.

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Appendix

Figure 3: Interview Questions

Interview Introduction:
   a. Ask what members understand about the research project thus far.
   b. Follow with an explanation of the purpose of the interview/ research program as far as possible; explain the anonymous nature of the research;
   c. Answer any initial questions

Primary Goals: Listen to how professors incorporate writing and observe how they think about this integration and of writing itself. The intent is to have a forum where faculty are comfortable sharing and feel as though the interviewer wants to hear what they have to say and think, and that the interviewer recognizes that the topic is complex / sensitive.

1. How would you define writing?
   a. What do you consider good writing?
   b. Do you think that students who begin school are strong writers? What about those who leave and graduate?
2. Where do students write (if they do) in your courses?
   a. What form does that writing usually take?
   b. How do you decide when and where to incorporate writing into your course curriculum?
   c. What are some of the most difficult aspects of incorporating writing into your courses?
3. How did you learn to write in engineering contexts?
   a. Positive and negative experiences
4. If you had to imagine creating engineers who are stronger writers, how would you suggest doing so?
5. What is your role as an engineering teacher?
   a. Intent to articulate teaching philosophy surrounding writing (or philosophy in general)
6. What are some of the greatest challenges in teaching engineering students? What is challenging about teaching writing?

Table 4: Variable with Question list

Variable	Questions
1. Teaching Writing in Engineering	Q4, Q5, Q6, Q7, Q8
2. Perceived Writing Competencies of Engineering undergraduate students	Q9, Q10
3. Value of Writing	Q11, Q12
4. Personal Relation to Writing	Q13, Q14
Demographic information & Teaching Experience	Q1, Q2, Q3, Q15, Q16, Q17, Q18, Q19, Q20

Table 5: Question List

Question	Response Option
Q1: Role at university	
Q2: Years taught at university	
Q3: Numbers of courses per year taught at the university.	
Q4 I think writing is a valuable learning tool in engineering education.	*
Q5 One or more of my course(s) provide opportunities for writing, whether in the form of reflection, homework, professional communication, examinations, or other assignments.	*
Q6 When students leave my course(s) they have an improved understanding of writing in engineering.	*
Q7 Writing in my course(s) is in the form of...	Φ
Q8 I believe that there are opportunities in my course(s) for students to write about topics that interest them.	*
Q9 Most students who enter the MSU College of Engineering have strong writing abilities.	*
Q10 MSU undergraduate engineering students graduate from MSU with strong writing abilities.	*
Q11 I think it is important for engineers to learn how to write well.	*
Q12 Where and when do you see communication and writing as important to engineering?	+
Q13 I feel that I am an effective writer.	*
Q14 I often engage in professional writing.	*

Response Option Key:
*Likert scale, seven points, Strongly agree (1) Strongly Disagree (7)
+ Free Response
Φ See Table 2 for choices and definitions of each writing type