Examining engineering writing instruction at a large research university through the lens of writing studies

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Abstract

Recognizing challenges to developing undergraduate engineering students’ writing, the University of Illinois at Urbana-Champaign College of Engineering invited instructional innovation proposals to tackle this issue. Bringing together faculty and graduate students from engineering and writing studies, our team proposed first researching current undergraduate writing instruction in engineering at our large research university. We applied a mixed-methods approach, including administering surveys, conducting discourse-based interviews, collecting course documents, and analyzing curricular pathways. Our team also examined best practices found in writing studies research. We found that current writing assignments are rarely well aligned with professional genres, that current writing instruction often does not employ best practices from the writing studies literature, and that departmental curricula do not distribute writing across the four-year programs. Our findings suggest the potential for substantive writing instruction improvements in our College of Engineering. In this paper, we document our findings and propose a path to improving writing instruction for undergraduate engineering students, beginning with educating our engineering faculty about best practices and helping them implement those practices in their classes.

I. Introduction

The ability of engineers to express ideas effectively and persuasively, in both written and oral communications, is a critical competency that has been emphasized by both the National Academy of Engineering [1] and ABET [2]. In addition to its importance in communication, writing can also be used to improve critical thinking. Substantial scholarship exists on the value of writing-to-learn in the physical sciences and engineering, e.g., [3]–[8]. Educators in both the engineering [9]–[11] and communications [12]–[15] disciplines have tackled the problem of better preparing engineering students for the kinds and volume of communication required by professional practice [16]. Our team has approached this problem through intensive collaboration between writing-studies and engineering and science faculty, in the context of a large research university where instruction at scale is a crucial consideration.

Several decades of research in writing studies provide a rich basis for our work but can be summarized only briefly here. Cognitive theories of writing suggest writing should be seen—and evaluated—as a process that informs and enables critical thinking [17], rather than as a final product [18], [19]. Social theories put greater emphasis on the purpose of writing as a means of communication and on the social contexts and interactions that influence writing [20], [21]. In parallel with research in these areas, Writing-Across-the-Curriculum (WAC) programs have been widely implemented in universities to support writing instruction across disciplines, and Writing-in-the-Discipline (WID) research and pedagogies have particularly worked to describe and develop specialized genres and practices within a discipline.

As we work to improve writing instruction in engineering, three fundamental principles stand out from these literatures: i) writing is a complex and social process rather than just a product; ii)
writing is a matter of quite specific genres rather than of general skills and broad academic or disciplinary styles; and iii) writing is a way to understand and remember technical material and engage in critical thinking (writing-to-learn) rather than just a means of communication. These principles can be integrated into technical courses using a variety of evidence-based best practices.

The writing process can be modeled by using scaffolded assignments [22]–[27] and by employing effective response systems for providing feedback and guiding revision [28]–[30], including peer evaluation [31], [32]. Effective response strategies foster dialogue with student writers, providing them with a small number of high-priority, focused points and highlighting specific examples to illustrate those points, and including encouragement to balance the criticism. Rubrics can also reflect this perspective by putting more emphasis on higher-level skills such as rhetorical effectiveness (consideration of audience, purpose and context), logical organization, thoughtful selection and summarizing of references, appropriate tone and balance, effective use of language, and persuasive argument [33].

Research on writing in the disciplines has documented the centrality and diversity of specific genres [20], [34]–[37]. Genre is a concept that defies simple definition, but for the purposes of this paper, it can be considered a type of writing, encompassing the typical audiences, purposes, style conventions, writing practices, and formatting constraints associated with that type. For example, lab reports are a common instructional genre. However, research [38]–[42] has also established that genres do not stand alone. Instead, they occur in genre systems that encompass the range of visual, written, and oral genres, whether formal or informal. These genre systems lead up to and follow on from the production of a written product, reflecting the view that writing is a process. For a lab report, the genre system would typically include written and verbal elements such as the lab manual, verbal instructions given before the lab, conversations between lab partners and between students and TAs, lab notebooks, representations of data in visual or tabular form, and so on. To understand the full genre system, it is critical to understand the varied purposes of a lab report.

Writing-to-learn activities can involve relatively minor adjustments to instruction, such as asking students to explain why they selected a particular equation on a homework problem or soliciting two-minute papers asking students what they learned in a class period or what they found most confusing. Larger changes could include widespread incorporation of reflective writing [43], [44] and/or the use of portfolios, where the students are expected to explain the evolution of their understanding during the course and illustrate their points with samples of their work [45]–[50].

Many of these strategies have been effectively incorporated into engineering classes, e.g., see [7], [11], [26], [45], [51]. Reflecting our sense that the most effective strategy is to thoughtfully integrate writing instruction and practice throughout all four years of engineering curricula, we focus here on cases where writing instruction and practice have been implemented in entire curricula. The most common model for increasing writing instruction within an engineering or science discipline is to hire specialized writing studies or communications faculty, who then co-teach with engineering faculty [52]. Examples of this approach that include evaluation of its effectiveness include programs at MIT [53] and the Materials Science and Engineering
Department at Virginia Tech [54]. While this model can be effective, it is resource-intensive and difficult to scale up.

An alternative model is to develop the skills of engineering faculty so that they can effectively incorporate writing instruction and practice into their existing technical courses. The Davis Educational Foundation has supported a project following this faculty-development model for engineering curricula at the University of New Haven. The first cohort to go through this program just graduated in 2016, so assessment of its effectiveness is not complete [55]–[57]. However, this approach is less resource-intensive and therefore may be more amenable to scaling up for universities having larger student bodies. An interdisciplinary team of researchers at Purdue is working to adapt techniques for writing in large-scale engineering classes, which could also help make this approach feasible for large research universities [8], [26], [58].

In this context, our team first sought to understand the current status of undergraduate writing instruction and the associated institutional strengths, weaknesses, and constraints within the College of Engineering at the University of Illinois at Urbana-Champaign. We applied a mixed-methods approach, described in the next section. Our results are presented in section III and are followed by challenges and recommendations in section IV.

II. Research Methods

Taking a mixed-methods approach, we collected a range of data on perceptions and challenges concerning writing instruction within the engineering departments of the College of Engineering at the Urbana campus. Data were collected from both departments and instructors. Twenty-seven surveys and five discourse-based interviews were administered. Course documents and curricular pathways in departmental programs were also collected for analysis.

Institutional Context

The twelve departments included in our study are Aerospace Engineering, Agricultural and Biological Engineering, Bioengineering, Chemical and Biomolecular Engineering, Civil and Environmental Engineering, Computer Science, Electrical and Computer Engineering, Industrial and Enterprise Systems Engineering, Materials Science and Engineering, Mechanical Science and Engineering, Nuclear, Plasma, and Radiological Engineering, and Physics.

The cross-disciplinary nature of our team, composed of researchers in both engineering and writing studies, is an important element of our methodology. Our team includes three members (two faculty and one graduate student research assistant) from the Center for Writing Studies (CSW) and five members from the College of Engineering (three faculty, one academic professional, and one graduate student research assistant). CSW is an interdisciplinary academic unit at our university that offers Writing-Across-the-Curriculum (WAC) workshops for faculty and graduate teaching assistants; provides one-to-one writing tutorials for undergraduates, graduates, faculty and staff; and supports a cross-disciplinary graduate concentration in writing studies.
Illinois requires all undergraduates to meet a first-year composition and an advanced composition requirement. The first-year composition courses are taught outside the engineering departments, and students can receive credit for first-year composition based on their ACT, SAT, or AP English exam scores. The advanced composition requirement is typically fulfilled in the third or fourth year of study. Engineering departments vary on how they advise their students to fulfill the advanced composition requirement. Some require students to complete a specific course within the major, while others provide suggestions for courses that are offered within and/or outside the major.

Surveys

Two written surveys were developed. The first survey, hereafter referred to as the instructor survey, was given to faculty who taught courses identified by our team as having a significant writing component. The second survey, hereafter referred to as the department survey, was given to faculty having key department administrative roles in every engineering department of the university. Both surveys contained multiple-choice, select-all-that-apply, rate-on-a-scale, and short-answer questions. The instructor survey consisted of four sections: i) participants’ perceptions of writing within their discipline and expectations for their students after graduation, ii) instructional practices and assignment design related to writing, iii) participants’ perceptions of challenges related to writing instruction, and iv) participants’ current best practices. The survey contained 30 questions and took approximately an hour to complete. Fifteen instructor surveys were completed and 10 (of 12) departments were represented. The department survey also consisted of four sections. The first, third, and fourth sections were similar to the instructor survey. The second section concerned curricular design and departmental support for writing instruction. The survey contained 24 questions and took participants approximately thirty minutes to complete. All twelve departments provided a response to this survey.

Document Collection

Instructor survey participants were asked to provide course materials pertaining to their writing instruction. We received materials from 13 courses, provided by 12 of 15 participants. These materials included syllabi, assignments, guidelines, rubrics, templates, and slides for lectures. Some participants referred to their course websites as well. Department survey participants were also asked to provide departmental (i.e., not course-specific) documents related to writing and communication. Only one participant provided departmental materials related to writing (see lack of vertical integration finding). To supplement the department surveys, curricular maps were collected from all twelve departments, and college enrollment statistics were obtained.

Interviews

Five instructors who completed the instructor survey were also selected for follow-up interviews. The instructors were chosen so that a variety of course types were included. The interviews were discourse-based [59], [60], where interviewees were asked to discuss course documents that they had previously provided to us and elaborate on their survey responses. In addition, some interviewees brought samples of graded student work to the interview. Instructors explained the reasoning behind their grading and their overall response techniques.
Analysis

Data analysis has involved quantitative measures from the surveys, transcription of interviews, intertextual analysis (e.g., comparing responses on surveys to documents collected from the same class), and interpretive analysis. For the thirteen writing-intensive courses for which course materials were submitted, we categorized the genres that are taught or represented. The possible genres used for categorization included the 30 genres listed in the surveys as well as genres we classified from course documents as classroom-specific. For some assignments, the team conferred on categorizations, considering to what extent the task approximated professional genres in form, content, and rhetorical situation (i.e., context, use, and audience). Based on these analyses, we visually mapped the genre data in several ways to support analysis. Considering the engineering curricula, for the 48 courses identified on the department surveys as containing writing, we used the curriculum maps to identify when a typical undergraduate would take each of the courses. If the course was not on the map, we used the course number (1xx, 2xx, 3xx, or 4xx) to place it.

III. Findings and Discussion

Survey Participants’ Perceptions of Challenges

Participants of both surveys were given a list of challenges to teaching writing-intensive courses and asked to rank the top four. Fifteen and sixteen options were provided in the department and instructor surveys, respectively. The department survey challenges included instructor and student perceptions, as well as curriculum concerns. The instructor survey focused on teaching and course development.

Participants of both surveys report that a major challenge concerns the time required to teach a writing-intensive course (Figure 1). “Time constraints of grading/responding to student writing” was the most common challenge chosen by instructor survey participants (10 of 15 respondents). “Time constraints of grading” was also the second most common challenge chosen by department survey participants (6 of 12 respondents). Additionally, the time-consuming nature of writing instruction contributes to many of the other challenges chosen by more than three instructor survey participants. These challenges include “training TAs to work with student writers,” “getting students engaged,” and “designing/revising lessons for writing instruction.” Constraints on the time that instructors can devote to writing instruction is a major theme in our writing as product vs. process and response findings, presented below.

Another major challenge revealed in the surveys is preparation of TAs for teaching writing skills and responding to student writing. “Training/supervising TAs to work with student writing/writers” was the first and second most common challenge chosen by department and instructor survey participants, respectively. Eight of eleven department survey respondents said their TAs of writing-intensive courses were not specifically trained to teach writing skills. Of the remaining three respondents, two were unsure, and the last respondent mentioned that TAs come from the English Department. Thus, none of our engineering departments appear to prepare their TAs for writing instruction in their disciplines.
Figure 1. Bar graphs showing department (Figure 1a) and instructor (Figure 1b) survey participants’ perceptions of challenges. The graphs show both the number of participants selecting a particular challenge and the breakdown of how often the challenge was ranked 1st, 2nd, 3rd, or 4th (no rank refers to participants who selected challenges without ranking, e.g., put x’s instead of numbers).
Participants’ choices and rankings suggest additional challenges related to perceptions of writing. The most common challenge chosen by department survey participants was “students’ attitudes towards the value of writing.” “Getting students engaged with writing” was the most commonly selected challenge by instructors. Changing students’ attitudes begins with the faculty, who must model writing as an important part of their professional identity. Because our surveys targeted instructors of writing-intensive classes, the survey results are likely to over represent engineering faculty’s perceptions of the importance of writing.

The data also indicate challenges related to departmental coordination. This includes departmental investment in disciplinary writing instruction and coordination among writing-intensive courses within departments. Only 4 of 12 instructor survey respondents felt their course supplemented or connected to other courses in the major. Currently, many instructors of writing-intensive courses are working in isolation. Intense and challenging efforts are often required of these instructors to successfully teach students both course content and writing skills. As shown in Figure 1b, the second most common challenge chosen by instructor survey participants was “difficulty balancing writing instruction with content delivery.” Departments can address both instructor complaints by distributing the task of developing student writers over multiple courses and years (see the lack of vertical integration finding below).

Genre Disconnect

Both the department and instructor survey participants were asked to select from a list of 30 possible genres the genres they expect their students will use after graduation when they take jobs in industry, business, or academia (Figure 2). The range of genres identified as necessary was striking. Every genre was selected at least once, and 22 genres were selected by at least half of the participants. Email, project report, and progress report were the most frequently selected genres—23 of 27 survey participants selected them. On average, 17 genres were selected by each participant.

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<th>Instructional Genres</th>
<th>Genres expected to use after graduation</th>
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<tr>
<td>Presentation</td>
<td>Email</td>
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<td>Lab Reports</td>
<td>Project Reports</td>
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<tr>
<td>Exam Outline</td>
<td>Progress Reports</td>
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<td>Essay</td>
<td>Conference Presentation</td>
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<td>Interview Review</td>
<td>Conference Proceedings</td>
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<td>Executive Summaries</td>
<td>Abstracts</td>
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<td>Quizzes</td>
<td>Documentation of Protocols</td>
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<td>Literature Review</td>
<td>Journal Articles for Specialized Audiences</td>
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<td>Instruction Manual</td>
<td>Research Highlights for the Web</td>
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<td>Government Documents</td>
<td>Professional Uses of Social Media</td>
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<td>Lab Reports</td>
<td>News Articles</td>
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<td>Research Highlights</td>
<td>Press Releases</td>
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Figure 2. Word cloud demonstrating the disconnect between genres that our engineering undergraduates are assigned (left side) in classes and those that they are expected to use after graduation (right side). Font size scales with how many courses teach the genre or how many survey participants selected the genre. Light blue font color indicates a genre that is present on both sides, i.e., both an instructional and professional genre. Three genres surveyed are not shown (webpages, press releases, and other), as they were selected by fewer than six participants.
Using course documents collected from the instructor survey participants, we categorized the genres of all writing assignments assigned in thirteen writing-intensive courses (Figure 2). Categorizations were not always obvious or singular (i.e., a single assignment might involve more than one genre) so the research team worked to reach consensus on categorizations. The genres identified included the professional genres from the survey as well as instruction-specific genres that we had not included on the survey (e.g., outlines, quizzes, and essays). We found that, on average, students are assigned six genres in a course, with a range from 3 to 14. Based on our informal observations and given that the instructors selected for our surveys were those identified as teaching writing-intensive courses, we expect that if more courses from our college were examined, the average number of genres assigned would decrease. In the examination of genres based on course documents, three common genres assigned in these courses were classroom-specific: presentations, notebooks, and quizzes (found in nine, six, and five courses, respectively). Finally, there was almost no attention given to genre systems in the course materials we examined.

Overall, our faculty clearly anticipate that students will use many and varied genres after graduation. However, the students are typically instructed in relatively few genres compared with the number needed in the workplace. Moreover, the genres assigned most often are classroom-specific, having no clear analog with professional genres. We did not find evidence that students are explicitly taught genre awareness or flexibility, both critical for learning how to learn new genres. This genre disconnect represents an important opportunity to improve students’ preparation for the workplace and their awareness of the importance of writing in their chosen professions.

**Writing as Product versus Process**

According to survey responses, instructors generally ranked writing process components (including outlining, restructuring/reorganizing, revising ideas, and proofreading) as highly important to student writing, with the individual process-related items all having averages ≥4.33/5. However, they perceived student mastery of writing processes to be lacking (all averages ≤3.33/5). Considering pedagogical practice, survey and interview data both point to a dearth of process-focused and writing-to-learn activities. For example, 9 of 13 instructor survey respondents (two participants did not respond) marked that assigned writing is “never” used only by a student or group of students, while 14 of 15 marked that the writing is “always” collected and graded. Few opportunities are structured for students to use writing to communicate with other students or to write through course concepts in low stakes ways that promote learning before officially setting those ideas down in more formal products.

Similarly, when instructors were asked about the purposes of student writing in their courses, the two least-marked purposes were “learning course concepts” and “planning” (marked by 7 and 8 of 15, respectively). In contrast, the purposes of “improving writing” and “informing/reporting” were each marked by 14 of 15 respondents, and “displaying knowledge” by 12 of 15. The results suggest that instructors see a sharp divide between learning engineering and learning to write in engineering, as well as between learning a concept and learning to communicate a concept. In written responses to the question “how do you factor writing process into overall
assignment or course grades?”, instructors report taking a variety of approaches. While some require intermediate deliverables, such as interim reports, outlines, or drafts and give points and/or feedback for such components, other instructors note that grades are based on final products only and point out that this focus on final products is a result of time constraints.

We expect again that a broader look at writing across the college would find even less teaching of writing-as-process. That is, courses that are not commonly recognized as writing intensive, and thus were not included in the survey, are more likely to include written responses to homework, exam problems and lab reports without offering opportunities for the student to engage in, or reflect on, extended writing processes. To illustrate this point, we’ve represented the organization of writing processes, writing instruction, and feedback on writing in a comparison of two particular courses, a lab course and a design course, from our data (Figure 3).

While students in the lab course receive intermittent instructor feedback on written products, they receive very little instruction on writing or the writing process (Figure 3a). In an interview, the instructor of this lab course noted online submissions occurring at the last minute as possible evidence that students are not revising or proofreading their work. While there are no required revisions in the course, students are required to append new data to one of their lab reports. However, the course does not discuss revision during this process, and students generally do not revise any of their initial text.

Packed with content and stretched for time, we believe that this course is representative of lab courses across the college. The focus in these courses tends to be on displaying knowledge, and assignment structures typically do not embody writing-as-process principles. In contrast, students in the senior design course outlined in Figure 3b are responsible for and receive direct instruction regarding writing and multiple stages of their writing processes, from planning through revisions.

Overall, our data suggest that while faculty do recognize the processes that underlie written products, they tend to assign writing in ways that obscure or ignore those processes and focus instead on finished products. Thus opportunities exist to apply more writing-to-learn approaches, as well as incorporating a more process-based approach in which the planning and organizing work of the writing process is structured into the assignments. This approach may be particularly well suited to design or project-based courses, in which a typical genre system includes proposals, objectives, presentations with feedback, progress reports, and a final report. In some cases, the in-process writing may not require individualized responses from the instructor, which can also help with the time-constraints on grading and response. For laboratory courses where the flow of the experimental work does not allow for extensive revisions, one approach could be rolling response techniques that focus instruction, feedback, and assessment on specific sections (e.g., methods) or elements (e.g., tables and figures) for each lab report across the semester. Asking students to reflect, in writing, on how the feedback from their previous laboratory report has influenced their current submission can also promote recognition of writing as a process, build genre awareness, and encourage more attention and uptake of feedback.
The weekly activities prepare students for the major assignments. The lab course reflects the typical writing-as-product structure, with underlying, processual, and writing-to-learn activities absent or obscured. The senior design course, on the other hand, contains more writing-as-process concepts, with required revision and scaffolding of the major assignments. Students also receive instruction and feedback during multiple stages of their writing processes.
Response Practices

The course sketches described in Figure 3 are indicative of the major differences between writing-as-product courses versus writing-to-learn and writing-as-process based courses in both their response practices and the course constraints that elicit those practices. A principal difference between the courses is that *scaffolding of instruction* and *response to process writing* is included throughout the senior design course, while it is largely absent from the lab course. This difference is particularly concerning in the context of our College of Engineering. Whereas explicit attention to revision is normally required in a course meeting the advanced composition requirement, some lab courses that count as advanced-composition courses have been allowed to waive the requirement for revisions, based on the argument that the repeated genre would give students opportunities to refine their writing over a series of similar writing tasks. However, the sketch shown in Figure 3a reflects response practices in lab courses across our data set. Students might be expected to use feedback from prior lab reports in drafting their next report, but they are not given explicit guidance on how to take up and incorporate earlier feedback, nor are they assessed on their ability to do so.

Major dynamics at play in the response practices of these and other courses are faculty time constraints and available TA support, as previously mentioned in the survey participants’ perceptions of challenges section. In both written survey responses and follow-up interviews, instructors pointed to instructional activities they would incorporate if they had more time (or fewer students). Instructors also identified time constraints on their ability to provide feedback on writing assignments, leading, for example, to the practice of responding only to final drafts. Eleven of the fifteen courses represented in the survey data had instructional support in the form of TAs, faculty advisers, or designated support staff from the sciences or occasionally the English Department. However, the division of labor for response to student writing varied widely. For instance, though the lab course sketched in Figure 3a had TAs assigned to it, the instructor chose to do all instruction and response to student writing unaided. Alternatively, in the senior design course sketched in Figure 3b, the instructor generally tackled writing instruction, while the teaching assistants and faculty advisers who were assigned to a group of students responded regularly to in-progress reports and drafts. The course depicted in Figure 3b is consistent with our collected assignment data from other senior design/thesis courses taught by survey respondents; the greatest volume and most varied forms of response tend to be in these senior-level courses having strong instructional support, while less supported instructors or those having TAs unprepared to respond to student writing report difficulties with time constraints that squeeze their instruction and response practices.

In terms of who is responding to student writing in what ways and the preparation those instructors have for giving feedback, the results are mixed. The majority of survey respondents indicated that students receive both formative and summative response from both TAs and instructors (13/15 formative from instructor, 10/15 formative from TAs, 10/15 summative from instructor, 9/15 summative from TAs). Regarding faculty training, only 4 of 15 instructors responded that they had attended professional development activities related to teaching writing. Multiple respondents indicated that they would like to see their department provide support for learning to teach with writing, as well as opportunities for conversing with other engineering instructors about their practices of teaching writing. While instructors noted a range of tools and
strategies for training TAs to respond to student writing, the issue of training and supervising TAs was still noted as the third most pressing major difficulty (Figure 1b). None of the departments surveyed provide training for TAs in responding to student writing; responsibility is left to individual course instructors. Formative feedback from peers was marked by only 8 of 15 participating instructors, despite the ability of peer review to scale up with class size. Though not specifically noted in the surveys, anecdotally we find that instructors are frustrated by attempts to facilitate peer response. Many instructors comment that they find peer response time-consuming in their already overscheduled classes, and they do not feel students are benefitting from it, so they are not likely to take class time to facilitate it. Resistance to peer response practices is therefore also likely related to the second major difficulty noted by instructors on the survey: difficulty balancing writing instruction with content delivery (Figure 1b).

We observed a tight focus on structure and correctness over content in response to student writing. This was evident in several aspects of our study, including: some written survey responses; rubrics and course materials collected that are heavily weighted toward or emphasize issues of mechanical correctness, particularly regarding formatting; interviews detailing instruction with a tight focus on formatting; and anecdotal responses from faculty and TAs. Assignments, lectures, and writing guides collected frequently lay out content expectations section-by-section, and response practices often play out as a hunt for errors in formatting and mechanical correctness. These practices could communicate to students that the cleanliness of their texts is more important than other engineering concerns, such as critical thinking and providing appropriate support for a conclusion or design decision. This focus seems to derive in part from the desire for consistency in grading, particularly when feedback and assessment are distributed over several faculty and/or TAs.

Regarding the lack of opportunities for low-stakes writing mentioned in the previous section on writing as a process, instructors’ self-reported response practices were consistent with placing a value on product over process; 14 of 15 instructors responded that writing assignments in their courses are “always” collected and graded, and 7 of 14 responded that assignments are “never” given feedback from an instructor without a grade.

The data from instructor surveys, interviews, and course materials, then, point to constraints on response to student writing, which instructors see as linked to the type of course they are teaching (lab, senior design/thesis), departmental and staffing support structures, and the major practical difficulties experienced by instructors, including the top three highlighted here: faculty time constraints, difficulty balancing writing instruction with content delivery, and issues related to training and supervising TAs. We believe an interdisciplinary faculty learning community model that helps engineering faculty integrate writing-studies best practices in their local contexts could mitigate these difficulties.

Lack of Vertical Integration

As mentioned in the institutional context section, undergraduates in our College of Engineering are required to complete a first-year composition course. However, students may receive credit for this course by scoring above a certain threshold on a college-admission standardized test. According to college enrollment data from Fall 2016, 60% of our engineering undergraduates
tested out of the first-year composition course. Department survey participants were asked if they felt these students were prepared for the advanced composition course. Half of the respondents felt the students were not prepared, and 5 of the remaining 6 participants said they did not know.

Forty-eight courses from our twelve departments were identified by department survey participants as having a significant writing component. Every department identified at least one writing-intensive course, and 4.5 was the median number of courses having a writing component per department. The timing of these writing experiences is plotted in Figure 4. We found that the courses were heavily skewed towards the later years of undergraduate study, with 3, 4, 20, and 21 of the 48 courses occurring in the 1st, 2nd, 3rd, and 4th year, respectively.

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<th>1st year</th>
<th>2nd year</th>
<th>3rd year</th>
<th>4th year</th>
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<td>- Writing is not specifically taught</td>
<td>- Writing is minimally taught</td>
<td>- Writing is specifically taught</td>
<td>- It is unknown if writing is specifically taught</td>
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Figure 4: Timing of engineering courses reported to have a significant writing component across all surveyed departments. Each box represents one course, with the color and pattern coding indicating the level of writing instruction that accompanies the expected writing.

Seven of the twelve engineering departments reported that there is no writing component associated with any of their technical classes during the first two years. It was also striking how few of the courses having writing components were reported to include any writing instruction (blue cross and green solid boxes in Figure 4). All of these courses having more than minimal attention to writing instruction (green solid boxes) occurred in the 3rd or 4th year.

We also found little coordination within departmental curricula around writing instruction and development. Eight of ten department survey respondents were not aware of any coordination among faculty to build student writing skills across the curriculum. Of the two participants who were aware of coordination, one did not provide details of the coordination, and the other respondent cited only use of a common template for lab reports across classes. From all department survey participants, this template was the only department-level document related to writing that was provided to us. On the instructor side, eight of twelve instructor survey respondents felt the writing in their course did not connect to other courses in the major or to students’ previous experiences with college writing.

These results paint a rather bleak picture of our engineering undergraduates’ education as writers. As Figure 4 indicates, many students will likely receive no disciplinary writing instruction until their 3rd year of study. All of our students will be required to write at some point in their undergraduate careers. However, considering the rate at which students place out of the first-year composition course and the lack of writing instruction in engineering courses having writing components, some students may never receive any writing instruction, disciplinary or otherwise, during their entire college career.
Ideally, writing would be integrated throughout the curriculum by incorporating writing instruction and practice in select courses to ensure that all students receive some disciplinary writing training during every year of their undergraduate careers. This “vertical integration” of writing training would allow students to develop as writers over time. However, any vertical integration of learning objectives requires a concerted effort from the department. As discussed in the survey participants’ perceptions of challenges section, the incorporation of writing in engineering curricula has unique challenges. Engineering faculty are often not well prepared to teach writing, and engineering students are sometimes resistant to the idea that writing will be part of their identity as engineers; these attitudes present particular challenges to the vertical integration of writing instruction and practice in engineering curricula.

IV. Challenges and Recommendations

In summary, we found that our undergraduate engineering students are primarily experiencing writing in laboratory or design classes and near the end of their curricula. The instructors for these classes, while dedicated and often innovative in their approaches, face serious challenges. Neither they nor their teaching assistants have typically had any education in best practices from writing studies; the students come in ill-prepared for extensive professional writing; the courses are overflowing with technical content, leaving little time for writing instruction; and the size of the classes often makes it impossible to provide extensive individual feedback. Although departments vary, as an institution our college generally lacks supportive structures for these instructors. Coordination of writing instruction across classes is rare, and none of our engineering departments has coordination across a curriculum. We suspect that this situation is not unique to Illinois, but rather that it represents a fairly typical situation at large engineering schools, e.g., see [61].

Considering broader challenges to improving engineering student’ writing skills, four areas stand out:

1. Information about professional genres used by practicing engineers and access to examples of such professional writing is limited for most fields of engineering, often because of client confidentiality or proprietary content. Notable exceptions include civil engineering [62], [63].

2. Continued sharing of knowledge and innovations is needed to adapt best practices from writing studies into engineering contexts and classes and to provide instructional strategies that are effective for improving writing in large courses. The evidence-based, resource-intensive models used in writing studies rarely translate directly to effective implementation in an engineering context, and they are impractical at the operational scale of many engineering colleges.

3. Research in this area is hampered by the intrinsic difficulty in assessing the quality of writing, which complicates assessment of educational innovations.

4. Major challenges related to improving the writing skills of engineering students are common to any effort to promote pedagogical or curricular change. These challenges
include identifying effective means of disseminating information to faculty, encouraging and supporting adoption and educational innovation within the context of a research university, effectively bridging disciplines to advance both writing studies and engineering education, achieving critical mass of supportive faculty in any particular department or college, and ensuring initial and ongoing buy-in and support from administrators.

In our college, we believe that the most impactful short-term investment will be to educate our engineering faculty about best practices from writing studies and help them implement those practices in their classes. While delegating writing instruction to writing-studies faculty has benefits, especially when implemented in a collaborative model where these faculty co-teach with faculty from the technical discipline, such out-sourcing suffers from well-documented problems of knowledge transfer [64]–[66]. Out-sourcing also contributes to student perceptions that engineers do not actually need to develop their own writing skills [53]. Finally, at the scale of our college (~10,000 students), out-sourcing is cost-prohibitive. Instead, we favor a model of developing engineering faculty to better incorporate their professional identities as engineering writers into their courses. We will draw on support from dedicated writing-studies faculty for faculty development, training programs for teaching assistants, and individualized support for undergraduate students in need of extra support in communication skills.

Faculty development programs can include content similar to many existing WAC workshops, but will likely be more effective if they are tailored to the engineering audience and context. Incorporating more professional genres and an awareness of genres in our courses will foster students’ genre flexibility and better prepare them for the workplace. To effectively develop students’ writing skills, both instructors and students must also shift their principal conception to writing-as-process [18], [24], and writing instruction and assignments must embody that concept. Adaption of well-established, efficient response practices [24], [30], [67], such as prioritized, selective feedback and collective feedback, will benefit both faculty and students. In some cases, implementing these best practices in existing disciplinary courses may even reduce the instructional workload in parallel with improving the effectiveness of writing practice for students. We are currently using a faculty learning community model, co-led by faculty from engineering and writing studies and meeting regularly over the semester, to promote this type of targeted faculty development.

We also recommend enriching TA training for writing-intensive classes. As classes become larger, typically TAs are given greater and greater responsibility for responding to and assessing student writing, so their training is particularly critical for implementing these best practices at large scale. In addition to improving the quality of instruction and assessment, such training is likely to benefit the graduate students both in their own writing and in their attractiveness to potential employers.

Over the longer term, we believe that writing instruction and practice should be thoughtfully incorporated into existing technical classes across all four years of an undergraduate education. We acknowledge the serious challenges to implementing and sustaining this type of transformative curricular change, particularly at large scale. However, both our survey results and national data [68]–[70] suggest that employers and institutions are increasingly recognizing
communication skills as vital for the success of our engineering students and our society, providing strong motivation for change.

To promote such curricular innovation, we envision using the faculty learning community model described above to foster conversations within a core group of faculty from the same department. In addition to providing information about best practices from writing studies, the leaders would facilitate conversations about i) what the department’s learning objectives related to writing are for their students, broken down for each year of their curriculum; ii) what existing courses would be most suitable for incorporating those learning objectives and reaching all their majors; and iii) strategies for coordinating and building knowledge of writing from one course to the next. In the second phase, the community would support each other as they develop course materials and implement pedagogical changes in their approach to writing instruction.

At an institutional level, this approach would require support for the leaders of and participants in the faculty learning community. This approach will also require an investment in the faculty that are developing new materials to integrate writing learning objectives in their classes (e.g., by providing additional TA support or lower teaching or service loads during the implementation). Engagement of alumni in this work could make the curricular changes more effective by making them more relevant to students’ professional interests.

Sustaining such a program, as with any pedagogical change, would require continued recruitment of new faculty to the community to sustain critical mass. Depending on the culture and the level of independence faculty are accustomed to having over their course material, careful attention is also likely to be required to maintain use of the materials, or at least incorporation of the same learning objectives, as courses switch to other faculty members.

V. Conclusions

We sought to examine the current state of writing instruction in the College of Engineering at the University of Illinois at Urbana-Champaign. Using a mixed-methods approach, we found that i) time constraints, training of TAs, and departmental support/coordination are major challenges reported by faculty; ii) a disconnect exists between the genres students practice in course assignments and those expected to be used in the professional world; iii) writing is viewed primarily as a product, not a process, by faculty, and this conception guides the design of writing assignments and courses; iv) instructors’ current response practices often do not incorporate evidence-based practices from writing studies; and v) vertical integration of writing is absent—there is little coordination within departments to foster students’ writing skills. These findings suggest the potential for substantive improvements.

Recommendations for engineering instructors, departments, and institutions are given in the previous section, along with a deeper discussion of challenges identified by our team. In the second year of our project, we are continuing the research and expanding our community of practice to other engineering faculty who teach courses that have a significant writing component. Specifically, we have organized weekly meetings for faculty to learn about and implement effective and scalable practices for writing instruction in engineering. We intend to
use this faculty-learning-community approach as a basis for implementing vertical integration of writing across all four years in two large test departments.

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